

ANL/EAIS--1

DE91 000500

ANL/EAIS-1

Markets for Small-Scale, Advanced Coal-Combustion Technologies: A Screening Analysis of OECD Countries

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December 1988 (published September 1990)

Work sponsored by United States Department of Energy, Assistant Secretary for Fossil Energy

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ACKNOWLEDGMENTS

This project was sponsored by the U.S. Department of Energy (DOE), Office of Fossil Energy, with direction and support from Denise Swink, the DOE project officer. An earlier version of this report was published by DOE under the title *Potential Markets for Small Coal-Fired Combustors in OECD Countries: Country Screening*, Report DOE/FE-0109 (August 1988).

The authors are indebted to Jan Vernon of the International Energy Agency, Coal Research, London. She provided much of the information on the environmental issues that affect coal use and on the research and development efforts in the countries we evaluated, and she also conducted an extensive review of this document. The reviews provided by Markus Amann of the International Institute for Applied Systems Analysis in Laxenburg, Austria, and Franco Gariboldi of Gariboldi Engineering Corp. in Milan, Italy, are also appreciated. Patricia Clark and Phyllis Panek of Argonne National Laboratory's Environmental Assessment and Information Sciences Division; Barbara Douglas of the Division of Educational Programs; and Marita Moniger, David E. Nadziejka, and the word processing staff of the Office of Energy, Environmental, and Biological Research are sincerely thanked for their efforts in producing this report.

ABBREVIATIONS

| | |
|-----------------|--|
| ACT | advanced coal technology |
| AFB | atmospheric fluidized-bed |
| AID | Agency for International Development |
| ANZUS | Australia, New Zealand, United States (alliance) |
| CWM | coal/water mixture |
| DH | district heating |
| EEC | European Economic Community |
| FBC | fluidized-bed combustion |
| FGD | flue-gas desulfurization |
| FRG | Federal Republic of Germany |
| GDP | gross domestic product |
| IEA | International Energy Agency |
| IGCC | integrated gasification/combined cycle |
| NATO | North Atlantic Treaty Organization |
| NO _x | nitrogen oxides |
| OECD | Organization for Economic Co-operation and Development |
| OPEC | Organization of Petroleum Exporting Countries |
| PFB | pressurized fluidized bed |
| R&D | research and development |
| SO ₂ | sulfur dioxide |
| TPER | total primary energy requirement |

UK United Kingdom
USSR Union of Soviet Socialist Republics

UNITS OF MEASURE

Btu/h British thermal units per hour
GW 10^9 watts (= 1 gigawatt)
GWh 10^9 watt-hours
kt 10^3 metric tons
Mt (ce) 10^6 metric tons of coal equivalent (27.8×10^{12} Btu)
Mt (oe) 10^6 metric tons of oil equivalent (39.7×10^{12} Btu)
MW 10^6 watts
Tcal 10^{12} calories (= 1 teracalorie)
TWh 10^{12} watt-hours (= 1 terawatt)
yr year

**MARKETS FOR SMALL-SCALE, ADVANCED
COAL-COMBUSTION TECHNOLOGIES:
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ABSTRACT

This report examines the potential of using U.S.-developed advanced coal technologies (ACTs) for small combustors in foreign markets; in particular, the market potentials of the member countries of the Organization of Economic Co-operation and Development (OECD) were determined. First, the United States and those OECD countries with very low energy demands were eliminated. The remaining 15 countries were characterized on the basis of eight factors that would influence their decision to use U.S. ACTs: energy plan and situation, dependence on oil and gas imports, experience with coal, residential/commercial energy demand, industrial energy demand, trade relationship with the United States, level of domestic competition with U.S. ACT manufacturers, and environmental pressure to use advanced technology. Each country was rated high, medium-high, low-medium, or low on each factor, based on statistical and other data. The ratings were then used to group the countries in terms of their relative market potential (good, good but with impediments, or limited). The best potential markets appear to be Spain, Italy, Turkey, Greece, and Canada.

1 INTRODUCTION

This report evaluates the potential of foreign markets for U.S.-developed advanced coal technology (ACT) in residential, commercial, and light industrial applications. In this report, ACT refers to any coal technology that offers distinct advantages over conventional coal combustors (from a technical, economic, environmental, or aesthetic standpoint) and that can compete successfully with an oil- or gas-combustion technology. In this context, ACT refers not only to technologies already developed but also to technologies under development or that could be developed in the future. This study examines the potential for using ACTs in small combustors, i.e., those firing about 50×10^6 Btu per hour (Btu/h) or less.

The 24 countries that are members of the Organization of Economic Co-operation and Development (OECD) were selected for this analysis for two reasons. First, information about their government energy policies and their historical and

projected energy-use patterns was readily available. Second, since the trade relationships between the United States and the OECD countries are well established, penetrating the markets in these countries could be easier than penetrating the markets in less developed nations or in the centrally planned economies, where institutional barriers to trade and lack of technology-transfer mechanisms might exist. This choice is not meant to imply that the OECD countries represent the largest foreign market for U.S. ACTs. Developing or newly industrializing countries may have a higher overall demand for U.S. ACTs, since a large increase in the demand for energy is usually associated with development and industrialization. This examination of market potential in OECD countries simply represents the first application of this screening methodology. We used this analysis to select three countries for a subsequent study that involved gathering detailed, facility-specific data and on-site interviewing of energy decision makers. That more detailed analysis of the markets in Spain, Italy, and Turkey will be the subject of another report.

Our methodology is based on factors that influence energy technology choices, factors such as historical and projected energy-use patterns in various sectors, fuel availability and fuel-use infrastructure, the level of trade and competition with the United States, the environmental regulatory climate, and the prevailing disposition toward or against increased coal use. With minor modifications, this methodology could be applied to the study of other countries.

2 METHODOLOGY

Our goal was to identify OECD countries in which the potential market for coal-combustion technologies appears to be large. Estimates of current energy use can indicate the potential size of the replacement/retrofit market, and estimates of projected energy growth can indicate the size of the potential market for new coal-fired combustors. Therefore, the first step in the screening process was to eliminate countries with low current or projected energy use in the residential, commercial, and industrial sectors.

Table 1 shows the 24 OECD countries and their current (1985) and projected (2000) residential, commercial, and industrial energy use. The initial screening eliminated the United States and any country in which these sectors did not have (1) a total energy use of 25×10^6 metric tons of coal equivalent [Mt (ce)] or more in 1985 or (2) a projected increase in energy use of 1 Mt (ce) or more between 1985 and 2000. These requirements eliminated eight countries with a low market potential.

The next step was a detailed analysis of eight important factors that would influence a country's decision to import U.S. ACTs. The factors can be grouped as follows:

- General Energy Situation
 - *Factor 1: Energy Plan and Situation.* The availability of coal in the country (through either imports or domestic production) and the extent to which the national energy plan of the country favors the use of coal.
 - *Factor 2: Dependence on Oil and Gas Imports.* The degree to which a country is dependent on imported oil [especially from members of the Organization of Petroleum Exporting Countries (OPEC)] or, to a lesser extent, on natural gas imported from the Union of Soviet Socialist Republics (USSR).
 - *Factor 3: Experience with Coal.* Past or present experience in the use, handling, and transportation of coal.
- Energy Demand
 - *Factor 4: Residential/Commercial Energy Demand.* The current level and the rate of increase of total energy use and coal share in the residential/ commercial sector.
 - *Factor 5: Industrial Sector Energy Demand.* The current level and the rate of increase of total energy use and coal share in the industrial sector.

TABLE 1 Current and Projected Industrial, Residential, and Commercial Energy Use in the OECD Countries

| Country | Initial Screening Indicators ^a | | Energy Use [Mt (ce)] | | |
|----------------------------|---|---------------------|----------------------|-------------------|-----------------------------|
| | 1985 ^b | Growth ^c | 1985 | Projected in 2000 | Projected Growth, 1985-2000 |
| Australia | + | + | 46.1 | 65.7 | 19.6 |
| Austria | | | 22.3 | 24.3 | 2.0 |
| Belgium | + | | 37.3 | 37.1 | -0.2 |
| Canada | + | + | 159.6 | 210.0 | 50.4 |
| Denmark | | | 16.0 | 17.9 | 1.9 |
| Finland ^d | + | + | 23.7 | 28.4 | 4.7 |
| France | + | | 141.6 | 141.5 | -0.1 |
| FRG | + | | 218.9 | 216.3 | -2.6 |
| Greece | | + | 11.6 | 17.5 | 5.9 |
| Iceland | | | 0.7 | 1.1 | 0.4 |
| Ireland | | | 7.1 | 8.4 | 1.3 |
| Italy | + | + | 110.9 | 125.4 | 14.5 |
| Japan | + | + | 275.7 | 363.0 | 87.3 |
| Luxembourg | | | 3.5 | 4.8 | 1.3 |
| Netherlands | + | | 59.9 | 56.4 | -3.5 |
| New Zealand | | | 8.5 | 9.8 | 1.3 |
| Norway | | | 20.2 | 23.6 | 3.4 |
| Portugal | | + | 9.6 | 16.1 | 6.5 |
| Spain | + | + | 48.0 | 66.9 | 18.9 |
| Sweden | + | | 38.7 | 40.1 | 1.4 |
| Switzerland | | | 19.0 | 22.5 | 3.5 |
| Turkey | + | + | 35.4 | 94.3 | 58.9 |
| UK | + | + | 147.0 | 154.8 | 7.8 |
| United States ^e | + | + | 1,194.5 | 1,494.3 | 299.8 |

^aCountries with a plus sign in either column were chosen for further screening.

^bThe symbol "+" means 1985 energy use was 25×10^6 Mt (ce) or more.

^cThe symbol "+" means energy use in 1985-2000 is projected to increase by 5×10^6 Mt (ce) or more.

^dAlthough Finland fell just below the required level for both current and projected energy use, it was chosen for further screening.

^eShown for comparison purposes only.

Source: Ref. 1.

- Trade and Environmental Issues

- *Factor 6: Trade Relationship with the United States.* The current level of trade between the United States and the country and the incentives to increase trade, especially trade related to energy technology.
- *Factor 7: Lack of Competition.* The current level of domestic ACT research and development (R&D) and the extent to which domestic suppliers of ACT are absent in the country.
- *Factor 8: Environmental Pressure for ACT.* Environmental regulations or other incentives that favor the use of ACT instead of conventional, uncontrolled coal combustors.

Each country was given one of four ratings -- high, medium-high, low-medium, and low -- for each of the factors. Higher ratings indicate a more favorable disposition toward the use of U.S. ACT. The rating procedure was guided by a list of questions, the answers to which were provided by statistical or other data. For example, a great deal of statistical information about energy use is available for the countries in this study in various OECD publications.¹⁻¹¹ These data were supplemented with information from U.S. Department of Energy and U.S. Department of Commerce reports and other sources (primarily for the trade issues).¹²⁻²⁴ The information compiled can be found in Appendixes A-H (one appendix for each factor).

The ratings were used to segregate countries into three groups: (1) those with good potential as a market for U.S. ACT; (2) those with some potential but which have some serious impediments (i.e., for which several low or low-medium ratings were given); and (3) those with low potential because of many impediments. Generally, to be categorized as being a good potential market, a country was required to have high or medium-high ratings for most of the factors. Section 3 reports how each country was assigned to one of the three groups and describes for each country the conditions favoring or discouraging use of U.S. ACT.

A considerable amount of professional judgment was applied in rating the countries on each factor and in grouping them by market potential. Although the screening did not employ a rigorous method such as decision analysis to weight the ratings, some types of information influenced the ratings more than others. The following sections more fully describe the eight factors, list the questions used to guide the rating procedure, and explain which questions most strongly influenced the final ratings.

2.1 GENERAL ENERGY SITUATION

Factors 1, 2, and 3 address the general conditions influencing energy choices, indicating whether a country is disposed toward increased coal use, but each looks at a different aspect of the energy situation.

2.1.1 Factor 1: Energy Plan and Situation

The energy strategy of a country, as described in its government's energy plan, is one of the important factors affecting the likelihood of increased coal use in that country. For example, the energy plans of some OECD countries explicitly state that increased coal use is a primary goal. Other plans may stress reliance on domestic energy resources; in those countries, therefore, coal is emphasized only if it is already produced there. Beyond explicit statements, the willingness of a country to import coal can be viewed as an indication of its commitment to use coal. In addition, because OECD countries will probably import less coal from certain countries (e.g., South Africa and Poland) in the future, a high level of imports from such coal-supplying countries now may indicate a potential opportunity for the United States to export coal and advanced coal-combustion technology as a package there. A reliance on or desire for growth in nuclear energy would tend to promote electricity use rather than coal use. Finally, government actions that either subsidize or tax the domestic production of certain fuels demonstrate a desire to promote or discourage the use of those fuels.

Recently, European countries have shown an increasing interest in the use of natural gas, an inherently clean fuel, both for power generation and in smaller combustors. The development of international gas pipelines and grids is also being widely promoted. As a result, natural gas will be coal's major competitor in industry and in commercial applications where environmental considerations apply.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix A.

1. Does the energy plan of the country state that increased coal use is a primary goal? (See Table A.1.)
2. Does the country rely on any domestic renewable or unconventional forms of energy (e.g., peat, geothermal, hydroelectric, wood, waste, or solar), including energy used in the production of electricity that supplies the residential, commercial, or industrial sectors? Are any of these sources being heavily promoted in the energy plan? (See Table A.2.)
3. Does the government alter the market price of any fuel in any way (e.g., via taxes or subsidies)? (See Table A.3.)
4. Is coal produced in the country? How much was produced in 1985? By what percentage has coal production been increasing (or decreasing) over the last decade? (See Table A.4.)
5. What percentage of nonmetallurgical coal is supplied by domestic sources? (See Table A.5.)
6. What percentage of metallurgical (coking) coal is supplied by domestic sources? (See Table A.6.)

7. How much coal was imported in 1985? What are the primary sources (countries) of coal imports? By what percentage have coal imports been increasing over the last decade? (See Tables A.7 and A.8.)
8. What percentage of the country's electricity is generated by nuclear power? By what percentage is nuclear power projected to grow between 1985 and 2000? For those countries with high levels of nuclear generation, what percentage of total residential, commercial, and industrial energy use was supplied in 1985 by electricity and what percentage is projected in 2000? (See Tables A.9 - A.11.)

The ratings for this factor were influenced most strongly by the level of coal production or imports, the change in the level of production or imports over the last decade, and the attitude of the government toward increased coal use as expressed in the energy plan. One element that could alter a country's rating slightly was taxes or subsidies affecting coal use. The presence of taxes on coal tended to lower a country's rating, whereas taxes on oil were seen as promoting coal use. The information on nuclear power was used primarily when the energy plan was not explicit about goals for coal use. In such cases, projections of nuclear power growth were used to gauge whether the country was leaning more toward nuclear or coal-fired power plants, because the industrial, residential, and commercial sectors are more likely to use coal in countries that are committed to coal in the electric power sector. If a country imports coal from South Africa, its rating was generally shifted slightly upward.

2.1.2 Factor 2: Dependence on Oil and Gas Imports

The energy plans of almost all OECD countries call for a reduction in the use of oil imports for national security reasons. A high level of oil imports, especially from OPEC countries, can therefore be viewed as a potential opportunity for greater coal use (because the oil supply from OPEC may be viewed as more interruptible than supplies from other countries, such as OECD countries). In addition, dependence on gas imported from the USSR may be a factor in future decisions to increase coal use, because as Soviet use of gas increases in the future, the amount of gas the USSR will have available for export may decrease. Price considerations aside, this factor helps indicate how likely the substitution of coal-based technology for oil and gas would be in the residential, commercial, and industrial sectors.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix B.

1. What percentage of the total primary energy requirement (TPER) was supplied by imported oil over the last decade? (See Table B.1.)
2. What are the principal countries supplying the oil imports? (See Tables B.2 and B.3.)

3. What percentages of total natural gas use and of the TPER are imported from the USSR? What percentage of the TPER was supplied by natural gas from the USSR over the last decade? (See Table B.4.)
4. Does the country have a domestic oil or gas supply? (See Table B.5.)

The ratings for this factor were most heavily influenced by the percentage of the country's TPER that was supplied by imported oil and whether or not the source of the oil was OPEC. High levels of imported gas from the USSR influenced the rating less, especially if a country (e.g., Finland) has a strong relationship with the USSR. The existence of a domestic oil or gas supply tended to lower a country's rating.

2.1.3 Factor 3: Experience with Coal

Coal use is more likely to increase in countries that have experience with coal and coal handling. Although the use of coal in power plants is not explicitly examined in this study, a recent trend of converting power plants to coal or building new coal-fired plants indicates both a commitment to coal and a lack of transportation and institutional constraints on coal use. In countries that use little or no coal or that have not increased coal use in recent years, the coal transportation infrastructure may be insufficient or attitudinal barriers to coal use may exist.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix C.

1. What percentage of the country's TPER was supplied by coal over the last decade? (See Table C.1.)
2. How much of the energy consumed in the production of electricity was supplied by coal, oil, and nuclear power over the last decade? (See Table C.1.)
3. What is the current capacity of ports receiving coal shipments? Are additions to this capacity planned? (See Table C.2.)
4. Does an infrastructure exist to transport coal to major residential, commercial, and industrial centers? (See Table C.3.)

The trend over the last decade in the percentage of the TPER supplied by coal and the existence of an adequate infrastructure for coal transportation were the most influential factors in the rating. A high existing coal share and an increase in the coal share were seen as good indicators of a country's coal-handling experience and potential to increase coal use, leading to high or medium-high ratings. The lack of an adequate transportation infrastructure was seen as a fairly strong impediment and tended to move a country toward a lower rating. Coal's share of electricity production was also weighted quite strongly in the ratings.

2.2 ENERGY DEMAND

Factors 4 and 5 address the current and projected levels of residential, commercial, and industrial energy demand. In addition, other factors such as district heating (DH) experience and demographic statistics were considered in the ratings.

2.2.1 Factor 4: Residential/Commercial Energy Demand

Coal use could increase in the residential/commercial sector in several ways, including the following: (1) small coal-fired combustors could be used increasingly in institutional settings, multifamily housing, office buildings, large commercial operations such as shopping malls, etc.; (2) the use of DH to supply heat (and sometimes electricity) to individual dwellings or buildings could become more widespread; and (3) coal/water slurry or coal-refining technology could be used to produce oil substitutes for any application that currently uses oil. These coal applications could occur in both retrofit situations and new installations. Therefore, the existing residential/commercial energy demand and the projected growth in that demand are both important to this analysis.

The current ratio of oil use to gas use is also an important factor, because coal may be viewed as a more likely substitute for oil than for natural gas, especially when an energy plan calls for reduced oil imports. Highly urbanized countries may be more inclined to increase their residential/commercial use of coal, since large residential buildings are more likely to be found in those countries and coal distribution would be simplified by the concentrated demand. Countries that now use or plan to use DH may also be candidates for increased residential coal use.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix D.

1. What was the total use of energy (including coal, oil, natural gas, electricity, and miscellaneous sources) in the residential/commercial sector (including agriculture) over the last decade? (See Table D.1.)
2. What is the projected growth in energy use in the residential/commercial sector between 1985 and 2000? (See Table D.1.)
3. What is the current ratio of oil consumption to natural gas consumption in this sector? (See Table D.1.)
4. What is the growth in coal use in these sectors projected to be? (See Table D.2.)
5. What percentage of the total residential/commercial energy use was supplied by coal over the last decade? What percentage is projected to be supplied by coal in 2000? (See Table D.2.)

6. By what annual average percentage is the population expected to increase between 1985 and 2000? (See Table D.3.)
7. What percentage of the population lives in the largest city, in cities of 500,000 or more people, and in other urban areas? (See Table D.3.)
8. Is district heating used in the country? If yes, what is the installed DH capacity and what percentage of that capacity is coal-fired? (See Table D.4.)
9. Do institutional factors (including government policy goals) favor the use of DH plants in the future? (See Table D.5.)

The strongest influence on the ratings for Factor 4 was the projected growth in total residential/commercial energy demand, because this growth indicates the number of new combustors that may be required in the future. Countries rated high or medium-high generally project high growth in energy demand. Existing energy demand carried somewhat less weight in the ratings because it represents the potential retrofit market, and replacing existing combustors with new coal-fired ones is more problematic than installing new combustors in "greenfield" sites.

A high share for coal of current demand had a fairly strong upward effect on the rating, since it indicated that the country already had some experience with coal use in this sector. An increase in the coal share over the last decade also increased the rating, because it indicated a disposition toward increasing coal use. A projected increase in the coal share also tended to move ratings upward. However, because the projections used in this analysis were made by governments, they were influenced by the biases for or against coal held by those governments (e.g., whether or not the government wished to promote an optimistic view of coal production potential). Therefore, they appear to be reliable indicators of whether or not coal is being promoted by the government in this sector but do not necessarily reflect an impartial analysis of the feasibility and desirability of increased coal use. In addition, projections of low future coal use may not consider advanced and innovative technologies and the advantages they may have over conventional coal combustors. The availability of advanced technologies in the future could raise coal use projections. Therefore, projections of the coal share did not influence the ratings as much as did total energy demand growth and historical coal share.

Coal-fired DH experience generally moved ratings upward; several countries that were rated low based on the answers to the other questions were increased to low-medium based on the DH question. A high degree of urbanization tended to move the ratings very slightly upward.

2.2.2 Factor 5: Industrial Energy Demand

Advanced and innovative coal-combustion technologies may replace the use of oil, natural gas, and electricity (via cogeneration) in the industrial sector. The level of existing industrial energy use can indicate the size of the potential replacement market, and projections of future energy use can indicate the size of the potential market for new coal-fired combustors. In addition, an examination of recent trends in the fuel mix in industries such as cement manufacturing, in which coal has been able to replace gas and oil effectively, can help to determine to what degree these industries have already switched to coal and the remaining potential for switching.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix E.

1. What was the total industrial use of energy (including electricity, but excluding metallurgical coal use in the iron and steel industry*) over the last decade? (See Table E.1.)
2. What is the projected growth of energy use in this sector between 1985 and 2000? (See Table E.1.)
3. What percentage of total industrial energy use was supplied by coal (excluding metallurgical coal) over the last decade? (See Table E.1.)
4. What percentage of total industrial energy use is projected to be supplied by coal (excluding metallurgical coal) in 2000? (See Table E.1.)
5. What is the current ratio of oil consumption to natural gas consumption in the industrial sector? (See Table E.1.)
6. What percentage of total annual energy use was supplied by coal over the last decade in the following industry groups: cement (nonmetallic minerals); chemicals and petrochemicals; transportation equipment and machinery; food, beverages, and tobacco; and other industry (excluding iron and steel). What was the total annual energy use in those industry groups over the last decade? (See Table E.2.)

*Fuel use in the iron and steel industry is treated as a separate question. Most of the "fuel" used in the iron and steel industry is metallurgical coal that is used in coking ovens to produce coke, a feedstock in steel production. A potential for ACT does exist in the iron and steel industry in the form of a melter-gasifier, which would be used instead of a coke oven to provide coke for steel production. Small steel mills may constitute a market for melter-gasifiers that have firing rates of about 50×10^6 Btu/h.

7. What are the major industries in the country? (See Table E.3.)
8. What was the total annual energy use in the iron and steel industry over the last decade? What percentage of total annual energy use in the industry was supplied by coal over this period? (See Table E.4.)
9. How many small steel mills are there in the country? (See Table E.5.)

The ratings for this factor were most strongly influenced by the growth projected for total energy demand. Existing demand, which indicates the potential retrofit market, and the current and historical coal shares were also strongly weighted. The projected coal share influenced the ratings less than the projected energy demand and the historical coal share. The trend of the coal share in specific industry groups also slightly influenced the ratings; a historical decrease in the coal share, particularly in the cement industry, generally tended to lower the rating. However, since such a decrease can also be interpreted to mean that the industry might be inclined to reconvert to coal, this element was not given a strong weight. The presence of small steel mills in the country and a high energy use and coal share in the iron and steel industry influenced the rating slightly upward.

2.3 TRADE AND ENVIRONMENTAL ISSUES

2.3.1 Factor 6: Trade Relationship with the United States

A favorable trading environment between the United States and a foreign country could strongly contribute to the successful export of U.S. coal technology. The United States has established trading relationships with all the countries included in this study. As members of the OECD, all the countries examined are committed to fair trade, expressly encourage foreign investment, and have agreed to exchange ideas and positions relating to international trade among themselves. Licensing of U.S. technology and the formation of joint ventures and distributorships between the United States and these countries are common. While each country maintains its own sovereign laws, no major impediments exist that would preclude U.S. entry into any of these markets.

Nevertheless, the historical trading relationship of the United States with some OECD countries is stronger than with others, and incentives to increase imports from the United States differ among the nations. Several representative measures have been chosen as indicators of trade relations: the current U.S. percentage of imports from and exports to an OECD trading partner; the balance of trade between the United States and the country; the overall trade and current account balances of the country; the level of U.S. investment in the country; the extent to which there are national security ties with the United States; the level of U.S. coal or coal technology exports to the country; the extent to which cooperative agreements exist relating to coal and coal technology; and the extent to which U.S. boiler and gas-turbine manufacturers currently license their technologies to manufacturers in the country.

Trade imbalances between nations theoretically provide incentives for increased trade in order to reach trade equilibrium. The existence of a U.S. trade deficit with another nation (i.e., the situation in which U.S. imports from the country exceed U.S. exports to the country) may provide an impetus for negotiations aimed at increasing U.S. exports to the other nation. Examples of such negotiations include United States-Japan Trade Committee meetings and negotiations for a United States-Canada Free Trade Agreement. On the other hand, a U.S. trade surplus with a foreign country may have the reverse effect, and the foreign partner may want to decrease its imports from the United States.

Similarly, the overall "trade account" balance of a country (which is the difference between the value of goods imported from and goods exported to *all* of its foreign trading partners) can indicate its inclination to alter its existing trading practices. A nation with an overall trade deficit would generally be disinclined to increase imports and inclined to increase exports and domestic production. Another statistic, the "current account" balance, measures trade in both goods and services between the nation and all of its trading partners. Similar to imbalances in the trade account, deficits and surpluses in the current account provide disincentives and incentives, respectively, for increasing imports. The trade situation deemed to most strongly encourage increased U.S. exports is one in which the foreign nation has a trade surplus with the United States, in combination with overall trade-account and current-account surpluses.

The level of U.S. investment in a country may also be viewed as an indicator of U.S. bilateral trade relations. The level of investment indicates the relative ease with which U.S. companies can enter into business relationships in the country. A high level of investment indicates a generally positive and secure trading environment.

High levels of U.S. coal imports into a country may indicate a potential for increased imports of U.S. technology designed for use with the coal. Current imports of U.S. energy technology (e.g., boilers) indicate that U.S. manufacturers have already succeeded in entering a foreign market to some extent. Similarly, the existence of licensing agreements between U.S. boiler or turbine manufacturers and firms in another country suggests that future licensing of U.S.-developed ACT may be a potential avenue of entry there.

Aside from specific trade issues, other conditions that encourage trade with the United States are strong mutual defense agreements or commitments (e.g., North Atlantic Treaty Organization [NATO], U.S. military presence or involvement), bilateral R&D agreements related to coal technology, and support through various U.S. development/assistance programs. These conditions indicate a general spirit of cooperation between the United States and the other country.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix F.

1. What share of the country's imports comes from the United States? What share of total exports go to the United States? (See Table F.1.)

2. What is the trade imbalance with the United States? (See Table F.1.)
3. What are the overall trade and current account balances of the country? (See Table F.1.)
4. Does the country currently import energy products (e.g., coal) or energy technology (e.g., boilers) from the United States? (See Table F.2.)
5. Are there any cooperative agreements with the United States that encourage bilateral energy R&D? (See Table F.3.)
6. What is the cumulative level of private U.S. investment? (See Table F.4.)
7. Do U.S. boiler and turbine manufacturers currently license technology in the country? (See Table F.5.)
8. Does the United States have a defense agreement with the country? (See Table F.1.)

The current U.S. percentage of total imports, the trade imbalance with the United States, and the overall trade-account balance were the most important elements in the rating process for Factor 6. Because this study is directed primarily toward U.S. exports of technology, which are merchandise (not service) exports, the overall trade-account balance was weighted more heavily than the current-account balance. The level of U.S. investment and the existence of licensing agreements were also factored in fairly heavily. Current imports of U.S. coal or boilers tended to increase the rating. In a few cases, cooperative agreements on fossil-energy R&D projects with the U.S. Department of Energy influenced the rating. A strong U.S. presence in the country for reasons of security or development assistance sometimes slightly increased the rating.

2.3.2 Factor 7: Lack of Competition

Countries that have no domestic advanced coal-combustion industry would be much more likely to import U.S. ACT. The level of government and private spending on ACT R&D can also indicate whether the country has developed or is interested in developing such an industry. Of particular interest to this analysis is R&D on small combustors (particularly atmospheric fluidized-bed [AFB] combustors), coal/water mixtures (CWM), cogeneration, and district heating.

The answers to the following questions helped determine a country's rating; details are found in Table G.1 of Appendix G.

1. Does the country have its own energy-technology industry with which U.S. ACT producers would have to compete?
2. What percentage of the government R&D budget is directed toward the development of advanced coal technologies? Is any private coal-related R&D being undertaken?
3. Toward which technologies is most of the R&D directed?

These questions were weighted about equally in determining the ratings.

2.3.3 Factor 8: Environmental Pressure for ACT

Oil and gas are often favored over coal, especially in the residential, commercial, and industrial sectors, because of environmental concerns, particularly concerns about emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulates from coal combustion and about the disposal of solid wastes. ACT may offer a way to use local or imported coal in countries in which there are existing stringent regulations or a growing environmental awareness.

The answers to the following questions helped determine a country's rating; details are found in the tables of Appendix H.

1. What environmental regulations apply to the combustion of coal or coal products in small boilers? in major urban areas? (See Table H.1.)
2. Is the country committed to a reduction in acid-rain precursor emissions as part of the "30% protocol," the EEC Large Combustion Plants Directive, or a similar domestic policy? (See Table H.1.)
3. If the country has no existing emission regulations affecting small coal-fired boilers, are any such regulations being considered because of poor air quality or increased environmental awareness? (See Table H.1.)
4. Would ACTs be able to comply with existing or planned emission regulations? (See Table H.1.)
5. Can the domestic or currently imported coals meet the standards of environmental policies without requiring further cleanup or the use of ACTs? (See Table H.1.)

6. What regulations or policies affect the disposal of solid wastes from combustion? (See Table H.2.)

The questions related to air quality issues were generally weighted more heavily than those related to solid waste. The existence of stringent regulations and plans for emission reductions in the future were weighted more heavily than a perceived need for regulations as a result of existing air quality problems.

3 RESULTS

An overview of the factor ratings is given in Sec. 3.1. Section 3.2 profiles all 15 countries, grouped according to their prospects for using U.S.-developed ACTs. In Sec. 3.3, a brief description is provided of the reasons for the selection of the three countries chosen for further study.

3.1 OVERVIEW OF RATINGS

A summary of the ratings of each country is given in Table 2.

3.1.1 General Energy Situation

Only five of the 15 countries (Belgium, France, Japan, the Netherlands, and Sweden) were rated low-medium for Factor 1, energy plan and situation (Fig. 1). In the

TABLE 2 Summary of Ratings by Country

| Country | Number of Factors Classified at Each Rating Level | | | |
|---------------------|--|-----------------|----------------|-----|
| | High | Medium- High | Low- Medium | Low |
| Australia | 2 | 3 | 0 | 3 |
| Belgium | 0 | 3 | 4 | 1 |
| Canada | 1 | 5 | 1 | 1 |
| Finland | 0 | 2 | 4 | 2 |
| France | 0 | 6 | 2 | 0 |
| FRG | 3 | 3 | 1 | 1 |
| Greece | 3 | 2 | 3 | 0 |
| Italy ^a | 2 | 4 | 2 | 0 |
| Japan | 4 | 2 | 1 | 1 |
| Netherlands | 1 | 2 | 3 | 2 |
| Portugal | 2 | 1 | 3 | 2 |
| Spain ^a | 2 | 5 | 1 | 0 |
| Sweden | 1 | 1 | 3 | 3 |
| Turkey ^a | 3 | 3 | 2 | 0 |
| UK | 1 | 4 | 1 | 2 |

^aCountries chosen for further analysis.

| Country | General Energy Situation | | | Energy Demand | | Trade | | Environmental |
|-------------|-------------------------------------|-------------------------------------|--------------------------------|---|-----------------------------|---------------------------|-------------------------------|---------------|
| | Factor 1: Energy Plan and Situation | Factor 2: Oil/Gas Import Dependence | Factor 3: Experience with Coal | Factor 4: Residential/Commercial Demand | Factor 5: Industrial Demand | Factor 6: Trade Relations | Factor 7: Lack of Competition | |
| Australia | ● | ○ | ● | ● | ● | ● | ○ | ○ |
| Belgium | ⊗ | ● | ● | ⊗ | ○ | ● | ⊗ | ⊗ |
| Canada | ● | ○ | ● | ● | ● | ● | ⊗ | ● |
| Finland | ● | ⊗ | ⊗ | ⊗ | ○ | ⊗ | ○ | ● |
| France | ⊗ | ● | ● | ● | ● | ● | ⊗ | ● |
| FRG | ● | ⊗ | ● | ● | ● | ● | ○ | ● |
| Greece | ● | ● | ⊗ | ⊗ | ● | ⊗ | ● | ● |
| Italy | ● | ● | ⊗ | ● | ● | ● | ⊗ | ● |
| Japan | ⊗ | ● | ● | ● | ● | ● | ○ | ● |
| Netherlands | ⊗ | ⊗ | ● | ○ | ○ | ● | ⊗ | ● |
| Portugal | ● | ● | ○ | ○ | ⊗ | ⊗ | ● | ⊗ |
| Spain | ● | ● | ● | ● | ● | ⊗ | ● | ● |
| Sweden | ⊗ | ⊗ | ○ | ⊗ | ○ | ● | ○ | ● |
| Turkey | ● | ● | ⊗ | ● | ● | ● | ● | ⊗ |
| UK | ● | ○ | ● | ⊗ | ● | ⊗ | ○ | ● |

● High ● Medium-High ⊗ Low-Medium ○ Low

FIGURE 1 Ratings for Each Country by Factor

other 10 countries, coal is either being promoted in the energy plan, readily available through domestic sources, or being imported at significant or increasing levels; none of the 15 countries were rated low. High ratings for Factor 1 are not always linked with a high dependence on oil and gas imports (Factor 2). For example, although Australia, Canada, Finland, the Federal Republic of Germany (FRG), and the United Kingdom (UK) are rated low or low-medium for Factor 2, they are viewed as favorably disposed toward coal, as indicated by their ratings for Factor 1. On the other hand, in Belgium, France, and Japan, oil imports are fairly high, but the ratings for Factor 1 are only low-medium because energy resources other than coal (primarily nuclear and renewables) are being promoted more than or just as much as coal.

Many of the countries that are rated high or medium-high for Factor 1 also have considerable experience with coal and are therefore rated high or medium-high for Factor 3; this is the situation in Australia, Canada, the FRG, Spain, and the UK. However, some countries favor coal even though they have not had much experience with it or may not have a transportation network that is adequate to transfer the coal to demand centers (Finland, Greece, Italy, Portugal, and Turkey). This inadequacy could constrain increased coal use in those countries. When Factors 1, 2, and 3 are considered together, nine countries appear to have general energy conditions that favor increased coal use: Australia, Canada, the FRG, Greece, Italy, Japan, Spain, Turkey, and the UK.

3.1.2 Energy Demand

Residential/commercial energy demand (Factor 4) and industrial energy demand (Factor 5) were rated high in countries that have either high projected population and industrial growth or high current energy demand. Considering Factors 4 and 5 together, 10 countries appear to have a currently high or rapidly increasing energy demand: Australia, Canada, France, the FRG, Greece,* Italy, Japan, Spain, Turkey, and the UK.

3.1.3 Trade Issues

Countries with a high or medium-high rating for trade relations (Factor 6) currently import a significant portion of their goods from the United States or have other conditions favoring trade with the United States. However, the presence of a domestic ACT industry could thwart U.S. efforts to export such technologies to that country, even if trade relations are strong. A high level of domestic ACT manufacturing or R&D exists in Australia, Finland, the FRG, Japan, Sweden, and the UK. Competition was seen as a possible impediment (indicated by a low-medium rating for Factor 7) in Belgium, Canada, France, Italy, and the Netherlands. When Factors 6 and 7 are considered together, the

*Although Greece is rated low-medium on residential/commercial sector energy demand because of the low absolute amount of energy consumed and the low current coal share, the projected growth rate of energy use in this sector is almost 3% per year. Therefore, the market in Greece would primarily be for new rather than retrofit combustors, and the overall prospect for new combustors was deemed fairly good.

following countries present trade possibilities for U.S. ACT: Belgium, Canada, France, Greece, Italy, the Netherlands, Portugal, Spain, and Turkey.

3.1.4 Environmental Issues

Demand for ACT will be highest in those countries having stringent air pollution control requirements that cannot be met by uncontrolled, conventional coal-combustion technology. Those countries in which such environmental pressure exists (indicated by high or medium-high ratings for Factor 8) include Canada, Finland, France, the FRG, Greece, Italy, Japan, the Netherlands, Spain, Sweden, and the UK.

3.2 COUNTRY PROFILES

Based on the ratings described in Sec. 3.1, the countries were classified into three groups:

1. *Countries with good potential as markets for U.S. advanced small-combustor technology:* Spain, Italy, Turkey, Greece, and Canada.
2. *Countries with good potential as markets, but which have some serious impediments:* Australia, France, the FRG, Japan, Portugal, and the UK.
3. *Countries with low potential as markets because of many impediments:* Belgium, Finland, the Netherlands, and Sweden.

3.2.1 Countries with Good Potential Markets

The countries in the first group are those that look promising in each of the four broad areas. (Turkey is included even though it is rated low-medium for Factor 8, environmental pressure for ACT. Since it is generally rated high in the other three categories, the fact that environmental awareness has only recently emerged in Turkey is not seen as an overriding constraint on the use of ACT there.)

3.2.1.1 Spain

Spain is highly dependent on imported energy; in 1985, more than 50% of Spain's TPER was met by imported oil, and a large portion of this came from OPEC countries. Hence, Spain was rated high for dependence on oil/gas imports (Factor 2). The national energy plan of Spain calls strongly for reduced dependence on energy imports. A special effort is being made to substitute coal for oil products in industry and in urban areas through initiatives such as the creation of regional coal stockpiles and investment subsidies (although the response to this plan has been fairly modest, given the current low oil and gas prices). Spain has domestic coal resources and a moderate but increasing level of coal production. Because of difficult mining conditions and resultant high

production costs, however, Spain's average domestic coal prices are generally higher than prices of imported coal. This situation, combined with the poor quality of some of Spain's domestic fuels, has led to increasing coal imports, a large portion of which are from South Africa. These conditions led to a rating of high for energy plan and situation (Factor 1). Spain is rated medium-high for experience with coal (Factor 3), since its use of coal in power production is moderately high and increasing, its use of nuclear power is decreasing, its port capacity is fairly high, and its coal-transport (railway) network is adequate. Overall, the general energy situation in Spain as measured by Factors 1, 2, and 3 appears to strongly favor increased coal use.

Spain was rated medium-high for both Factors 4 and 5. Although current energy demand in the residential/commercial sector (Factor 4) is moderate at 16 Mt (ce), demand grew at 3.6% per year between 1973 and 1985 and is projected to continue to grow at a steady 1% per year between 1985 and 2000. Coal's share of energy demand in the residential/commercial sector is currently a modest 3%, but it has increased since 1973 and is projected to grow to 8% by 2000. The growth in energy demand in the industrial sector (Factor 5) is projected to be quite high between 1985 and 2000 [an increase of 16 Mt (ce) in that period], and the coal share is projected to increase from 6% in 1985 to 12% in 2000. In the residential/commercial as well as the industrial sector, oil use is much higher than natural gas use; therefore, the incentive to increase coal use in order to reduce oil imports is quite strong.

The trade relationship with the United States (Factor 6) is rated low-medium. In 1984, the United States was the leading supplier of goods to Spain, but since Spain's accession to the European Economic Community (EEC) in 1986, its imports have been coming increasingly from European trading partners. The FRG is currently the major investor in Spain. In addition, Spain has a trade deficit with the United States and an overall trade deficit. On the other hand, Spain imports some U.S. coal, is a NATO ally, and receives assistance from the U.S. Agency for International Development (AID). The Spanish government is committed to developing high technology and is promoting the application of new technologies in existing industries. Both the government and private investors are funding some ACT R&D in Spain, and some coal-technology equipment is being manufactured; however, the level of R&D spending relative to the gross domestic product (GDP) is quite low when compared with that in other OECD countries. Spain is rated medium-high for lack of competition (Factor 7), so despite a low-medium rating for Factor 6, conditions for the export of U.S. ACT to Spain are considered favorable.

Factor 8, environmental pressure for ACT, is also rated medium-high. Spain's domestic coals have a very high sulfur content, 4-7%. Under the terms of the EEC Large Combustion Plants Directive, Spain will be required to apply SO₂ removal technology to new power plants. However, Spain has obtained a special derogation through 1999 that allows higher emissions (800 milligrams per cubic meter) from plants that burn imported coal and requires only 60% sulfur removal for domestic solid fuel combustion. The Spanish government is exploring the use of low-cost SO₂ control technologies to meet this requirement.

Overall, there do not seem to be impediments to coal use or constraints on U.S. export initiatives in Spain. On the contrary, most conditions seem to favor Spain as a market for U.S.-developed ACT for small combustors.

3.2.1.2 Italy

Italy is highly dependent on oil imports (Factor 2), significant amounts of which are from OPEC countries and the centrally planned economies, and it relies on the USSR for 22% of its natural gas requirements. Until recently, nuclear power production was seen as a primary way to reduce this dependence; since the Chernobyl accident, however, the nuclear program has been reconsidered, and a national referendum unfavorable to nuclear power was passed in January 1988. Although an increased use of coal in power stations is seen as another way of improving Italy's energy situation, the government has published plans to increase the use of natural gas in power generation by 30%. Gas now appears to be favored over coal for larger applications, especially since Italy already has independent gas pipelines that link it with Algeria, the Netherlands, and the USSR. Most of the increase in coal consumption called for in Italy's national energy plan is expected to occur in power plants.

Italian coal production is low relative to that in the other OECD countries, but Italy has the second highest level of coal imports. A large portion of this imported coal comes from South Africa, although imports from the United States accounted for about 40% of all steam coal in 1985. South African imports may decline in the future, and imports from sources that are less politically sensitive (such as the United States) may rise. The attitude toward coal expressed in the energy plan and the recent trend in coal imports are the primary factors contributing to Italy's medium-high rating for energy plan and situation (Factor 1).

Italy's experience with coal is fairly recent, leading to a low-medium rating for Factor 3. In 1985, coal supplied only 11% of the country's TPER, up from 6% in 1973. Electricity production by coal-fired power plants increased from about 5 TWh to 30 TWh over the same period. Although the rail networks that can transport coal to Italy's interior appear somewhat inadequate at this time, both the national railway system and the port infrastructure are being upgraded. Considering Factors 1, 2, and 3 together, Italy is thought to be quite favorable for increased coal use, especially at the numerous potential coal-combustion sites along Italy's extensive coastline, where transportation constraints would be minimal.

Both energy demand factors were rated medium-high. Current energy use in the residential/commercial and industrial sectors is fairly high, indicating a substantial retrofit market. Residential/commercial energy use has been increasing at 1% per year since 1973, and this trend is projected to continue through 2000; projected growth in the industrial sector is somewhat lower. Although coal's share of residential/commercial energy was less than 1% in 1985, this share is expected to increase by 2000. Coal supplies a greater proportion of the energy used in the industrial sector than in the residential/commercial sector; it is expected to supply 12% of total industrial energy use by 2000. Although coal's share in the cement and chemical industries declined over the period 1970-1985, it has been growing in other industrial categories. Italian industry uses twice as much oil as gas, and since Italy imports so much of its oil, this factor might encourage conversion to coal. Overall, the prospect for new combustors, in both retrofit situations and new facilities, is quite promising in Italy.

Italy appears to offer good prospects for trade with the United States (Factor 6). In 1986, 6% of total Italian imports came from the United States; the United States was Italy's third largest trading partner in both imports and exports; and coal was one of the principal Italian imports from the United States. Italy is a NATO ally, and the United States is Italy's leading foreign investor. Italy's investment in coal R&D has been increasing, and interest on the part of both the public and private sectors in ACT, especially coal/water fuel technology, has been increasing. Although Italy's domestic R&D efforts may lead to a technology that could successfully compete with that from the United States, Italy has traditionally welcomed United States involvement in R&D and commercial development projects. (Italy has a coal-related bilateral R&D agreement with the U.S. Department of Energy, and Italian firms currently license U.S. conventional coal-fired boiler and gas-turbine technology.) Italian domestic competition (Factor 7) is not seen as an overwhelming impediment.

Environmental pressure for ACTs is also high. Local air pollution is a primary concern. Under the EEC Large Combustion Plants Directive, Italy will be required to reduce emissions from existing plants that are more than 50 MW (thermal) by 27% for SO₂ and 2% for NO_x by 1993, by 39% for SO₂ and 26% for NO_x by 1998, and by 63% for SO₂ by the year 2003 (based on 1980 emission levels). Although FGD systems are being promoted for large coal-fired plants, environmentalists favoring the use of natural gas for energy generation are resisting such construction. A potential role for ACT may exist in smaller units to help achieve the SO₂ goals and ameliorate waste disposal problems. In summary, Italy appears to be a promising export market for U.S.-developed ACT.

3.2.1.3 Turkey

Turkey's energy reserves include large quantities of poor-quality lignite and some hard coal. Although lignite production increased substantially over the last decade [from 3 to 13 Mt (ce) between 1973 and 1986], coal users in Turkey have increasingly turned to imported coal. Coal imports, primarily from the United States, rose from 0.01 Mt (ce) in 1973 to 3 Mt (ce) in 1986. However, almost 40% of the TPER in Turkey is currently supplied by imported oil, and a large portion of that comes from OPEC countries and the USSR. Oil imports have not declined over the last decade. Hence, government energy policy objectives in Turkey include increased domestic energy production. Although the government is also encouraging the use of renewable sources (primarily hydroelectric power), interest in the clean combustion of lignite and an increased use of coal (both domestic and imported) is very high. Furthermore, the country currently uses a large amount of wood and animal dung for fuel in rural areas, and the development of replacements for these fuels might be encouraged for environmental reasons. It should be noted that Turkey, like many other OECD countries, is also showing increased interest in natural gas. A combined-cycle plant is under construction and a second is planned.

The increased use of coal in Turkey will be constrained by its low port capacity and lack of an adequate transportation network; inland transportation of coal is primarily by truck. In addition, coal will soon have to compete with natural gas supplied directly to Ankara by a new pipeline from the Soviet Union. Nevertheless, the general energy

situation in Turkey quite strongly favors increased coal use because of coal's current high share of the TPER (almost 30% in 1985), Turkey's domestic coal and lignite reserves, and the increased level of coal imports in Turkey in recent years.

Turkey is an industrializing country with a rapidly growing population and thus has good prospects for increasing its demand for energy. Between 1973 and 1985, combined residential, commercial, and industrial energy use rose by almost 60%. This increase is projected to continue at an even more rapid rate in the future; between 1985 and 2000, residential/commercial energy use is projected to double and industrial energy use is expected to increase by almost a factor of three. Coal's share of residential/commercial energy use, already quite high at 13%, is projected to double between 1985 and 2000. Annual coal use in industry is projected to increase by almost 5 Mt (ce) over the next 15 years. Although no DH capacity is currently installed, the government is carrying out R&D on these systems. Overall, the energy demand situation (Factors 4 and 5) in Turkey looks encouraging for an increased use of ACT.

The environment for ACT trade with Turkey also appears to be quite good. A fairly substantial portion (11%) of Turkish imports in 1986 were from the United States, with coal being the second largest import. U.S. imports from and exports to Turkey have been increasing steadily since 1984, and U.S. investment is about 12% of the total foreign investment in Turkey. In addition, Turkey is a member of the NATO alliance. Therefore, Turkey was rated medium-high for Factor 6, despite its trade deficit with the United States and its overall trade-account deficit. The levels of ACT R&D and manufacturing are minimal in Turkey, yet a strong demand exists for ACT, leading to a high rating for Factor 7 (lack of competition).

Environmental awareness in Turkey is just emerging. Air pollution regulations were passed in 1986 but do not appear to be very stringent. Turkey is looking for ways to burn lignite more cleanly, especially in fairly polluted areas such as Ankara. The new pipeline that will provide natural gas from the Soviet Union to Ankara is expected to help reduce pollution levels as gas is substituted for lignite. Therefore, despite some concern over pollution levels, the environmental pressure for ACT is relatively low and Turkey was rated low-medium for Factor 8. This lack of stringent air pollution control requirements should not be an overriding constraint on ACT use in Turkey, because in addition to reducing emissions, ACT also generally provides a way to use coal and lignite more efficiently and is therefore more desirable than conventional systems. In conclusion, there appear to be no major constraints to, and several strong incentives for, the export of U.S.-developed ACT to Turkey.

3.2.1.4 Greece

Having few domestic energy resources, Greece is highly dependent on foreign oil and gas. The country has made great strides toward reducing this dependence over the last decade; oil imports supplied 58% of Greece's TPER in 1985, down from 91% in 1973. Government policy favors the use of renewable energy sources, imported coal, and an increased use of domestic lignite to reduce dependence on oil imports. The Greek energy minister recently stated that the government was against the construction of a new coal-fired power plant. Construction of such a plant, however, is now being

considered by a private sector consortium. Coal imports have doubled since 1973, and coal production has tripled over the last decade; coal's share of the TPER increased from 17% in 1973 to 33% in 1985. Thus, Greece was rated high for energy plan and situation (Factor 1). Greece's experience with coal is fairly recent, leading to a low-medium rating for Factor 3. Improvements in the country's infrastructure for receiving and transporting coal are needed if coal use is to continue to increase; accordingly, the railway system is being modernized. The pressure for increased coal use in Greece appears to be quite high, as evidenced by the large increases in coal imports, coal production, and the coal share of energy requirements; therefore, the general energy situation in Greece is viewed as favoring coal use.

Although the market for new coal combustors appears to be fairly limited in the residential/commercial sector, the industrial sector offers somewhat better prospects. Total energy use in both sectors is low but increasing, and this trend is expected to continue through 2000. Although coal's share of residential/commercial energy use is low, its share of industrial energy use is 28%, up from 8% in 1973. Coal's share of energy use has been increasing in three major industry categories: cement (in which the coal share was 70% in 1985), chemicals, and transportation equipment and machinery. Conversion to coal in the industrial and residential/commercial sectors would be advantageous, since the main noncoal energy source in these sectors is now oil. The energy-demand situation in Greece offers good prospects for new combustors.

Greece offers a somewhat mixed picture in terms of trade prospects. Its imports from the United States were 3% of its total imports in 1986, down from 8% in 1985. Greece is a recent member of the EEC, which suggests that it will turn increasingly to European trading partners. These considerations led to a low-medium rating for Factor 6. Yet Greece currently imports more than 50% of its steam coal from the United States, and approximately one-third of all foreign investment is from the United States. Moreover, Greek experience with ACT is limited; government budgets for coal R&D are very low, and little private ACT R&D or manufacturing is being carried out. This situation suggests a good opportunity for American manufacturers of ACT (Factor 7).

Greece has no existing federal environmental regulations. The country will be subject to the emission standards for new plants contained in the EEC Large Combustion Plants Directive but will not be required to reduce emissions from existing plants. In spite of these considerations, Greece received a medium-high rating for Factor 8 because of its strong environmental awareness, which is related to its desire to preserve its ancient monuments. Reducing SO₂ emissions and increasing urban-planning measures are favored. A potentially large role for ACT exists in Greece. Overall, Greece appears to be a fairly good candidate as a market for U.S.-developed ACT.

3.2.1.5 Canada

Canada has abundant reserves of oil, gas, and coal and is a net exporter of all three. Canada also produces a large percentage of its electricity from hydropower, and a significant portion of its industrial energy demand (15% in 1985) is supplied by wood. Because its energy resources are so diverse, only 11% of Canada's TPER was met by coal

in 1985. Although the government energy plan contains no explicit policies encouraging greater coal use, some provincial governments have shown a strong interest in coal technologies. Canada received a medium-high rating for both Factor 1 and Factor 3 for the following reasons: coal is readily available; coal production has increased in recent years; coal is currently being used quite widely in power plants; and the coal-transportation network is adequate and expanding. However, the incentives for increased coal use in Canada are not as strong as they are in Italy, Spain, Turkey, and Greece, which are currently highly dependent on imported oil.

Both the current and the projected energy demand in the residential/commercial and industrial sectors are quite high in Canada, indicating that the potential markets for both retrofit and new combustors are good. An especially large increase in industrial energy demand [34 Mt (ce)] is projected for the period between 1985 and 2000. Coal's share of current energy demand is small, although it is projected to increase slightly in the industrial sector. Canada is fairly urbanized, and its population is expected to grow much larger over the next 15 years.

Canada offers excellent prospects as a trading partner because of its proximity to the United States, its historically good trade relationship with the United States, and the fact that it runs a large trade surplus with the United States. Canada and the United States are each other's largest trading partners. About 70% of Canada's total imports were supplied by the United States in 1986, and 78% of its total exports were destined for the U.S. market. Furthermore, the two countries are currently engaged in bilateral trade negotiations (United States-Canada Free Trade Agreement) with the ultimate objective of reducing or eliminating tariffs and other bilateral trade barriers. Canada is a NATO ally, and the United States accounts for 80% of all foreign investment in Canada. For these reasons, Canada received a high rating for Factor 6. Although the Canadian government appears to be reducing its support of coal-related R&D, some fluidized-bed combustion (FBC) equipment is being manufactured and coal/water fuels are being used commercially and are being tested for small-boiler applications. Therefore, Canada received a rating of low-medium for Factor 7. Nevertheless, Canada is viewed as a good market for U.S. ACT because of its very strong historical trade relationship with the United States and its possible interest in U.S. suppliers of ACT.

Environmental pressure for ACT is also fairly high in Canada. National policy calls for a 50% reduction in SO_2 emissions by 1994, although some of this reduction could be achieved by using more hydroelectric and nuclear power and using low-sulfur coals. Regional pressures, through provincial governments, also tend to push for lower emissions and the use of clean technology. Because of its high projected energy growth, favorable trade conditions, high level of environmental pressure, high availability of coal, and considerable experience with coal, Canada appears to have quite favorable opportunities for export of U.S.-manufactured ACT.

3.2.2 Countries with Good Markets but Some Impediments

3.2.2.1 Australia

The Australian government is committed to using its abundant domestic energy resources, especially coal and natural gas. Over the last decade, the country has reduced its oil imports, which were never very high. In 1985, imported oil supplied less than 1% of Australia's TPER. A major coal producer, Australia currently relies on domestic coal for 40% of its energy requirements and is one of the few OECD countries studied that has no current or planned nuclear power generation. Although Australia received a low rating for Factor 2 (dependence on oil and gas imports), its ratings for Factor 1 and Factor 3 are both high, owing to its high level of coal production, extensive experience with coal, and its government's commitment to increased coal use.

Australia was rated medium-high for Factors 4 and 5. Although energy use in the residential/commercial and industrial sectors is moderately low, indicating a fairly small potential retrofit market, it has been increasing over the last decade, and a healthy increase is forecast between now and 2000. Coal currently supplies a small portion of residential/commercial demand but a fairly substantial (13%) share of the industrial demand. In some respects, the residential/commercial sector in Australia is in a favorable situation for conversion to coal: the country is highly urbanized, simplifying the distribution of fuel supplies, and this sector uses almost four times as much oil as gas, indicating that the incentive to switch to coal might be fairly high.

Approximately one-fourth of Australia's total imports are from the United States, and these imports include boilers. The United States enjoys a 2:1 trade surplus with Australia, and U.S. investment in Australia is substantial. The United States has a military alliance pact with Australia, the Australia/New Zealand/United States (ANZUS) treaty. However, because the Australian government is committing a substantial amount of its resources to coal R&D and because ACT is already being manufactured there, U.S. manufacturers are likely to meet with considerable competition.

The country offers no real prospects for U.S.-developed ACT from an environmental perspective. Australia has no acid rain problems, and existing regulations allow uncontrolled burning of low-sulfur coals. Tall stacks are considered an effective means to eliminate local air pollution problems; only the Northern Territory has SO₂ emission regulations. Solid waste disposal is not a problem. Therefore, although increased coal use is favored in Australia and energy demand growth is projected to be quite high, the competition from domestic manufacturers and the lack of strong environmental pressure are seen as fairly strong impediments to the export of U.S. ACT to Australia.

3.2.2.2 France

France is dependent on imported energy, and it imports large amounts of oil and natural gas from OPEC countries and the centrally planned economies. France has made a strong commitment to nuclear power for its late twentieth-century energy needs; in

1985, it was the largest producer of electricity from nuclear power of the countries studied. Coal production has decreased by 40% over the last decade. Nevertheless, some political pressure exists in France to restore production to the higher levels of the 1950s and 1960s. Moreover, coal imports have increased by 30% over the last decade. Coal's share of the TPER has decreased over the same period, although electricity production from coal is fairly high. Despite the fact that much of the general energy situation in France appears to favor a greater use of coal, the preponderance of nuclear power tends to limit the potential for such increased use.

On the other hand, the high total energy demand and fairly high coal share of total energy demand in France led to medium-high ratings for Factors 4 and 5. Although the use of energy in the residential/commercial sector in 2000 is projected to be about the same as in 1985, coal use is projected to increase in that sector by about 6 Mt (ce). The coal share in industry is also projected to increase, from 8% in 1985 to 12% in 2000. Current energy use in both these sectors is fairly high, indicating a good potential retrofit market. Both sectors use about twice as much oil as gas, strengthening incentives to switch to coal. The domestic coal industry is strongly promoting nonutility coal use to counter its losses to the nuclear industry in the utility power market.

Seven percent of French imports in 1986 were from the United States, which made the United States the third largest supplier of goods to France. France is a NATO ally, and investment by the United States represents about 20% of all foreign investment in the country. French firms license boiler and gas-turbine technologies developed in the United States. France received a medium-high rating for Factor 6. However, coal technology, including small coal-fired combustors, has historically been manufactured in France. In addition, the French have begun R&D on and the manufacturing of ACTs, including coal/water fuels and FBC units. Therefore, French demand for ACT for small boilers is likely to be met by domestic technologies.

Environmental pressure for ACT is high in France, particularly in urban areas and for small installations. The French are aiming for a 65% reduction in SO₂ emissions by 1995 and a reduction of 20-30% in NO_x emissions by 2000. These goals are expected to be achieved through increased use of nuclear power, fuel substitution, and limits on sulfur in fuel; however, ACT could possibly compete with low-sulfur coal and fuel oil in protected urban areas.

Several factors -- environmental pressure, projected increases in energy demand, and possible increases in the coal share in the residential, commercial, and industrial sectors -- indicate that some potential for increased use of ACT exists in France. However, French competition with U.S. technology and France's heavy dependence on nuclear energy may limit that potential.

3.2.2.3 The Federal Republic of Germany

The FRG produces the most coal and the most coal-generated electricity of all the countries considered. The objectives of the government's energy policy include increasing the role of coal in the country's energy mix. Because the government explicitly favors using domestic hard coal in electricity generation and in iron and steel

production, it subsidizes the domestic hard coal industry and encourages long-term agreements between the coal mining industry and the electric utility and steel industries. Coal supplied about 30% of the country's TPER in 1985. However, the proportion of coal-generated electricity fell slightly in 1987, with demand being met by increased electricity imports from France and by the use of natural gas and fuel oil. Most of the FRG's oil imports come from other OECD countries, making the country relatively invulnerable to supply interruptions; these considerations led to a low-medium rating for Factor 2. However, the FRG's historical use of coal, adequate transportation network, and favorable attitude toward coal contribute to generally high ratings for Factors 1 and 3.

Both the residential/commercial sector and the industrial sector in the FRG offer good potential retrofit markets. Although energy use in the residential/commercial sector is projected to decline, it is currently higher in Germany than in any of the other countries considered. Coal's share of this energy use is low, but some coal-fired DH capacity is installed, and the German government is investing in coal-fired combined heat and power systems. Coal supplies about 10% of industrial energy use, but this share is expected to decrease by the year 2000. Multifuel capacity is widely available in industry in the FRG, allowing considerable fuel flexibility. The residential/commercial and industrial sectors use considerably more oil than gas; therefore, conversion to coal may be quite desirable. Because of the high potential retrofit market in these two sectors and the government's promotion of coal-fired DH systems, the FRG is rated medium-high for both of the energy demand factors.

Environmental pressure for advanced coal technology is high in the FRG. Detailed emission regulations for large and small plants, both new and existing, are already in place. Although low-sulfur coal is adequate for small installations, considerable pressure exists to use FBC or other ACTs. Technologies that limit both SO₂ and NO_x are considered desirable. The government is offering tax relief to installers of ACTs.

In spite of its high ratings on the above factors, the FRG does not appear to be a very good prospect for trade with the United States in ACTs. Although many factors favor trade with Germany, including a trade surplus in the FRG's favor and a strong U.S. political alliance (leading to a high rating for Factor 6), the German government and private industry are heavily involved in coal R&D and ACT products are manufactured there. U.S. suppliers of ACT would likely meet strong competition from German suppliers. Indeed, the German ACT industry would be a major competitor of the United States in all European markets. A low rating on Factor 7 (lack of competition) tends to override the other positive factors.

3.2.2.4 Japan

Japan has few domestic energy resources and so must rely heavily on imports. Fifty-seven percent of the country's TPER in 1985 was met by imported oil, mostly from OPEC countries. Japan is seeking a balanced mix of energy sources, including nuclear, coal, hydropower, and renewables, to help reduce this reliance on imports. Japan produces only a moderate amount of coal and this production has been decreasing over

the last decade, yet in 1985, Japan was the largest importer of coal of all the countries considered. Although Japan's industrial coal use is primarily in the iron and steel industry, its coal-generated electricity production is the third highest of the countries we considered (about 100 TWh in 1985) and has shown large increases since 1973. However, the country is moving toward increased nuclear power production, and electricity from nuclear plants has increased at a much faster rate (from less than 10 TWh in 1973 to more than 159 TWh in 1985) than that from coal-fired plants over the period 1973-85. Therefore, although increased coal use should be seen as a possible option in Japan, the country is not committed to coal to the exclusion of other energy sources.

Japan has the highest industrial energy use and the second highest residential/commercial energy use of all the countries considered. Energy use in both of these sectors is expected to increase through 2000. Coal's share of residential/commercial use is less than 1% and has been decreasing, whereas the coal share of industrial energy use is increasing and is expected to be about 16% in 2000. The cement industry already uses coal for 82% of its energy needs. Although this industry may be close to its capacity for coal use, other industries seem to have potential for conversion to coal. Japan is fairly urbanized and projects a moderately high growth in population by 2000; these factors, combined with the high total energy use and the fact that four times more oil than gas is used in the residential/commercial sector, suggest a good potential market for both retrofit and new combustors. Therefore, Japan is rated medium-high for Factor 4 (residential/commercial energy demand) and high for Factor 5 (industrial energy demand).

Environmental pressure for ACT is high in Japan. A strong SO₂ and NO_x control program is in place at both the federal and local levels. Flue-gas desulfurization (FGD) and NO_x-reduction technologies are used on large plants, mostly with waste minimization techniques. Heavy industrialization, large population centers, and limited land for waste disposal have made Japan a leader in the development of efficient emission control systems. As a result, Japan looks less promising from a competition perspective. The country has a high level of both U.S. investment (about 50% of total foreign investment) and U.S. imports (about one-quarter of the total imports to Japan, including some coal). Japan has a large trade surplus and also has defense and energy-related R&D agreements with the United States. These factors led to a high rating for Japan on trade relations (Factor 6). However, Japan is a leader in domestic coal R&D and manufacturing activity. The Japanese government's budget for coal R&D is the highest of all the countries considered, a high level of private coal R&D is being carried out, and ACTs are widely manufactured in the country. The stiff competition U.S. manufacturers would meet from domestic suppliers is considered a very strong impediment to the export of U.S.-developed ACT to Japan.

3.2.2.5 Portugal

Portugal has a history of heavy dependence on energy imports; in 1985, 67% of the country's TPER was met by oil imports, and this level of imports has changed little since 1973. Portugal's situation as an oil importer, however, is fairly secure; most of the imports are from OECD countries (lowering an otherwise high rating for Factor 2 to a medium-high).

The primary objectives of the national energy plan of Portugal include development of domestic resources and diversification of energy supplies. The Portuguese government has stressed the importance of coal as a primary energy source and has established a program of grants to cover 15-30% of the cost of projects for energy conservation, oil substitution, and stimulation of domestic energy production and use. Coal production is currently low, as are imports, but imports have increased rapidly since 1973. Most coal imports come from the United States. Hence, Portugal's rating for Factor 1 (energy plan and situation) is high.

Portugal has very little experience with coal. Coal's share of the TPER was only 6% in 1985 and, as of 1983, no coal transportation infrastructure was in place, so Portugal received a rating of low for Factor 3. Therefore, although several important factors favoring increased coal use in Portugal are present, some fairly important constraints tend to make prospects there appear less promising.

In 1985, Portugal had the lowest residential/commercial energy use of all the countries considered. Although this energy use has been increasing and should continue to do so through 2000, it is expected to remain low relative to the other countries considered. No coal is used in this sector, and there are no plans for coal use. Industrial energy use is also fairly low but is expected to almost double by 2000, at which time coal's share is projected to be 12%. A potentially large coal conversion market exists in the cement industry, where the coal share is currently only 18%. Only oil is used in industry now, so coal conversion would be fairly desirable in view of the country's goal to reduce oil imports. However, due to the relatively low absolute levels of energy use in Portugal, the ratings are low for the residential/commercial sector (Factor 4) and low-medium for the industrial sector (Factor 5).

Although the United States and Portugal trade -- 8% of Portugal's imports were from the United States in 1986 and coal is its second largest import from the United States -- Portugal has recently joined the EEC and is likely to turn increasingly to other EEC trading partners. U.S. exports to Portugal have been declining steadily since 1984, and U.S. investment remains low. Portugal is therefore rated low-medium for trade relations (Factor 6). However, little coal R&D or ACT manufacturing is being carried out in the country. Assuming Portuguese interest in ACT, U.S. suppliers would probably meet with little competition from Portuguese domestic suppliers. Therefore, both positive and negative trade influences affect the export of ACT from the United States to Portugal.

Environmental pressure for ACT in Portugal is rated low-medium. Portugal is subject to the new plant emission standards in the EEC Large Combustion Plants Directive, but it will not have to reduce emissions from existing plants. At present, environmental awareness is not strong and few incentives for ACT appear to exist.

Impediments to the export of U.S.-developed ACT for small combustor applications in Portugal include a lack of coal-transportation infrastructure, low energy demand, competition from EEC countries for trade, and a lack of environmental regulations to encourage use of ACT. On the positive side, Portugal is very anxious to increase its coal use as a means to reduce oil imports, and domestic competition for ACT is minimal.

3.2.2.6 The United Kingdom

The government of the UK relies primarily on market forces in implementing its energy policy, the main objective of which is to ensure adequate and secure energy supplies at the lowest long-term cost. Over the last decade, coal has consistently supplied more than 30% of the UK's TPER. Most of the coal used is mined domestically; however, imported coal, primarily from Australia, has begun to supply some power plants. Anticipated privatization of the electricity-generating industry is expected to open up the market to additional imports, but such imports will have to compete with natural gas. Following the decision to privatize the electricity industry, plans for natural-gas-fired power plants have been submitted, and a 1,000-MW gas-fired plant in Scotland has been approved. The UK is therefore rated medium-high for energy plan and situation (Factor 1). Although there has been a substantial increase in nuclear generating capacity in the UK over the last decade, only about 10% of the generating capacity was nuclear in 1985 and most of the remainder was coal-fired. Inland transportation networks, primarily rail, appear to be adequate in the country. Therefore, the rating for the UK for experience with coal (Factor 3) is high.

The UK is a net exporter of petroleum (leading to a low rating for Factor 2) and also produces natural gas. These fuels compete with coal in the residential, commercial, and industrial sectors. Therefore, although the country's prior experience with coal and the availability of coal from domestic sources generally favor increased coal use in the UK, competition from domestic oil and gas may negatively influence prospects for increased coal use. This issue is closely linked to the long-term stability of supplies from North Sea fields.

The UK is mainly a retrofit market for new combustors. Energy demand in the residential/commercial sector in 2000 is projected to be virtually the same as it was in 1985, and growth in the industrial sector is projected to be low. Although the coal share in the residential/commercial sector is now high, at 13%, it has been decreasing (from 25% in 1973), and is projected to continue to decrease (to 9% in 2000). Domestically produced natural gas is the primary fuel used in the residential/commercial sector, and prospects for its replacement with coal in retrofit situations are probably not good unless gas prices increase dramatically. The UK was therefore rated low-medium for Factor 4 (residential/commercial energy demand). However, some research into coal-fired DH has been undertaken, and success in that area of research may provide some impetus for reversing the trend in residential/commercial coal use.

In the industrial sector, the coal share of energy use declined in every industry between 1970 and 1985. However, the coal share of total industrial energy use is projected to increase from 9% to 15% between 1985 and 2000, implying that some industries may reconvert some of their capacity to coal. The UK, therefore, received a medium-high rating for Factor 5.

In general, the UK has a strong trading relationship with the United States. About 11% of UK imports came from the United States in 1986, and the UK is the fifth largest purchaser of U.S. goods. It ran a trade surplus with the United States of about \$3 billion in 1986. Hence, the UK was given a medium-high rating for Factor 6 (trade relations). However, because it has a strong domestic coal-technology industry (which

includes manufacturing of small fluidized-bed combustors) and a considerable level of private ACT R&D, it was rated low for Factor 7 (lack of competition).

The environmental pressure for ACT in the UK was rated medium-high. Proposals for new pollution regulations that would require a 30-90% reduction of SO₂ from industrial boilers are still under discussion. Such proposals will have to take into account the new emissions standards under the EEC Large Combustion Plants Directive. This directive requires the UK to reduce SO₂ and NO_x emissions from existing large plants by 20% and 15%, respectively, by 1993 and to achieve reductions of 40% and 30%, respectively, by 1998 (based on 1980 levels). Therefore, a role exists in industry for highly efficient ACTs. Pretreated "smokeless" coals and coal by-products are considered desirable options for avoiding local air quality problems.

In summary, although the UK was rated fairly high on many of the important factors considered in this analysis, two impediments to increased use of U.S.-developed ACT exist: domestic production of oil and gas that competes with coal and a domestic coal-technology industry.

3.2.3 Countries with Limited Markets

3.2.3.1 Belgium

Belgium is highly dependent on imported oil, but most of its oil imports come from OECD countries, giving a medium-high rating for Factor 2. The country is moving to lessen its oil dependence through measures to encourage rational use of energy and diversification of supply. Nuclear power capacity has been increasingly brought on line to meet electricity demands. Electricity capacity is now in oversupply, and this condition is expected to continue in the near-to-medium term.

Conversion to coal is being encouraged in all economic sectors in the Belgian energy plan. Coal-generated electricity and imports of coal have increased over the last decade. Since Belgian coal is very expensive to exploit, the government subsidizes the difference between the production cost per ton and the world market price for imported coal; in addition, coal is taxed at a lower rate than other fuels. Although these factors indicate some positive pressure from the government of Belgium to promote increased coal use, Belgium is rated low-medium for Factor 1 (energy plan and situation), because the large increase in nuclear power production and the oversupply of electric generating capacity will force coal to compete very strongly with electricity in the residential/commercial and light-industrial sectors.

Domestic coal production is fairly limited but was much higher during the 1950s and 1960s. Coal supplies over 20% of the TPER in Belgium, and the transportation infrastructure is good. Therefore, Belgium is rated medium-high for Factor 3 (experience with coal).

Although the residential/commercial sector uses a moderate level of energy, this use has been decreasing since 1978 and is not expected to grow over the next 15 years;

similarly, coal's share of this energy has been decreasing and this trend is expected to continue. The lack of growth in this energy sector is reflected in the country's low projected population growth over the next 15 years. Belgium does have some installed DH capacity, including combined heat and power systems which are entirely coal-fired. Because the residential/commercial sector uses more than twice as much oil as gas, increased use of DH in the buildings sector could offer opportunities for coal. Belgium was rated low-medium for Factor 4.

Although a modest increase in coal's share of energy use in the industrial sector is expected by 2000, total industrial energy use is low and little growth is expected over the next 15 years. Coal plays only a small role in most of the industry groups that were examined, but it is used extensively in Belgium's cement industry. Overall, because of its low current energy use and low growth projections in the industrial sector, Belgium received a low rating for Factor 5.

Belgium appears to offer some potential as a partner with the United States in ACT trade. U.S. investment in Belgium is very high, and Belgium is a NATO ally. Only 5% of the country's 1985 imports were from the United States, but those imports included both boilers and coal. The United States holds about 20% of the market for pollution control equipment and Belgian firms license U.S. boiler technology. Therefore, Belgium was rated medium-high on Factor 6 (trade relations). ACT manufacturing in Belgium is very limited. However, Belgium is carrying out collaborative research on ACT with both Germany and the Netherlands, and any future Belgian demand for ACT is likely to be filled by imports from those countries or by development of a Belgian domestic industry.

Environmental pressure for ACT is fairly minimal (rated low-medium). Emission limits proposed for existing plants can be met through the use of low-sulfur coal. For new plants, the standards in the EEC Large Combustion Plants Directive have already been incorporated into Belgian law. Belgium will have to reduce SO₂ emissions from existing plants by 40% in 1993, 60% in 1998, and 70% in 2003, and NO_x emissions by 20% in 1993 and 40% in 1998 (based on 1980 levels).

Although a small market for U.S.-developed ACT may exist in Belgium, the overall prospects are limited by the present overabundance of electric power generating capacity, the small increase in projected energy demand, the lack of environmental incentives, and the competition from neighboring ACT technology developers.

3.2.3.2 Finland

Although Finland has extensive peat resources and makes use of waste fuels (such as spent liquors from the pulp and paper industry), it has virtually no domestic oil, gas, or coal and relies on imports to meet much of its demand. About 40% of the TPER in Finland is met by imported oil; most of this oil, however, comes from the USSR, a fairly secure supply for Finland. Therefore, Finland was rated low-medium for Factor 2. Nuclear power supplies 20% of Finland's electricity, but the current government has stated that no new nuclear power plants will be built during its administration. Consumption of spent liquors is currently greater, on an Mt (ce) basis, than coal

consumption. However, coal is playing an increasing role in the energy picture. Coal's share of the country's TPER was about 30% in 1987/88, a significant increase over the 1973 level; moreover, coal imports increased by 66% over the period 1973-1987, and the projected use of coal in 2000 is double the 1985 level. Therefore, Finland's energy situation appears to favor coal in some respects, but its current and projected dependence on nuclear energy suggest that coal will have to compete strongly with electricity in the residential, commercial, and industrial sectors.

Present and projected energy use in the residential/commercial and industrial sectors is low. An increase of 5 Mt (ce) over the period 1985-2000 is expected in industry, which now uses eight times as much oil as gas. Coal supplies almost 8% of industrial energy use, and this share is expected to remain relatively constant through 2000. A considerable switch in the industrial sector from heat to electric power is expected over the next few years, due mainly to process changes in the pulp and paper industry. A number of small gas-fired combined heat and power plants have recently been ordered. The domestic gas grid, however, is limited to major population centers. Residential/commercial energy use is expected to decline. Though the coal share of residential/commercial energy is expected to increase substantially by 2000, overall energy requirements are so small that this increase does not translate to a large market for coal combustors. Moreover, the country's urban population is small and population growth is projected to be fairly low. There may be some opportunities for coal in district heating applications, especially since the government is promoting such systems, and coal use is expected to continue in industrial plants. However, the very small energy demand in the residential/commercial and industrial sectors led to generally low ratings for Factors 4 and 5.

Finland appears to offer limited trade prospects for U.S. ACT. Historically, it has had a strong trading relationship with the Soviet Union, mainly attributed to geographic proximity. This relationship is expected to diminish in importance, however, as Finland looks to its West European neighbors for increased trade. Approximately 5% of Finland's total imports are from the United States, while the same percentage is exported to the United States from Finland. U.S. investment remains at a modest level, and the United States has no military alliance with Finland. These factors led to a low-medium rating for Finland for Factor 6 (trade relations). Finland has a strong domestic industry in a variety of ACTs, and there are several Finnish manufacturers of small fluidized-bed units. Hence, Finland was rated low for Factor 7 (lack of competition).

Environmental pressure for ACT is rated medium-high. Existing regulations will require a 70-80% reduction in SO₂ emissions for larger coal plants, and a limit on coal sulfur content of 1.2% applies until 1994; thereafter, a 1% limit will apply. Finland is interested in flexible-fuel equipment such as fluidized-bed combustors, which can burn a variety of domestic supplies (peat, wood waste, coal, etc.) in an environmentally acceptable manner.

Although Finland was rated high on its energy plan and environmental pressure, the increased use of nuclear power, low current and projected energy demand in the residential, commercial, and industrial sectors, and competition from domestic manufacturers tend to limit its potential for importing U.S.-developed ACTs.

3.2.3.3 The Netherlands

Although the Netherlands has only a very small domestic oil supply and relies on oil imports for a large portion of its energy requirements, the country has a high level of domestic natural gas production, enabling it to use gas for more than 30% of its TPER. The Netherlands is thus rated low-medium for Factor 2, dependence on oil and gas imports.

Nuclear energy supplies only 3% of generating capacity and, since the Chernobyl accident, the government has postponed consideration of new nuclear plants. In the meantime, the Netherlands is considering the use of gas- and coal-fired plants to meet projected electricity demand. The construction of a gas-fired power plant in the north, possibly using relatively inexpensive imported gas from Norway, has been proposed. Increased electricity imports from France and the FRG are also envisaged. Current use of coal for electricity production is fairly low, and coal supplied only 11% of the TPER in 1985. Little coal is produced in the Netherlands, though production was considerable in the past. The coal transportation system is good, although it is used at close to its capacity. Therefore, the country was rated medium-high for Factor 3 (experience with coal). The Netherlands currently relies on coal imports, which have increased by 146% since 1973. The interest in coal appears to be focused primarily on power generation. Renewable energy sources and DH are being promoted in the demand sectors. Furthermore, domestically-produced natural gas will provide strong competition to coal in the residential, commercial and industrial sectors; therefore, the Netherlands was rated low-medium for energy plan and situation (Factor 1).

Current and projected energy demand in the Netherlands, as reflected in its ratings for Factors 4 and 5, is low. Current residential/commercial demand is moderate, but is projected to decrease by 2000; industrial use is fairly low, with low projected growth. Coal's share of energy use is low in both sectors; gas is the predominant energy source. The Netherlands does have some installed DH capacity, and the government provides subsidies for DH projects. Although this implies a potential opportunity, coal is not currently used for such projects.

The Netherlands has one of the most open trading environments of all the countries considered, imposing few tariff or nontariff barriers to U.S. exports. Fourteen percent of the country's 1985 imports were from the United States, and these imports included coal. Thirty-five percent of total coal imports to the Netherlands in 1986 came from U.S. sources (54% in 1982). The Netherlands is a NATO ally, and the United States is the largest foreign investor there. U.S. boiler technology is manufactured under license in the Netherlands. Trade relations (Factor 6) were therefore rated medium-high. However, the government has committed substantial resources to coal R&D and private industry is conducting coal R&D on its own; moreover, some ACT manufacturing is being carried out. These competition factors tend to offset the Netherlands' otherwise favorable rating on trade.

Environmental pressure for ACT is fairly high. A strong control program similar to that of the FRG is in place; limits for smaller plants can be met with low-sulfur coal. Because of the land shortage in the Netherlands, waste disposal is a major issue. Atmospheric fluidized-bed combustion and integrated gasification/combined cycle (IGCC) units are already under development.

The major constraints on the export of U.S.-developed ACT to the Netherlands are a domestic natural gas supply, low current and projected energy demand, and competition from domestic ACT suppliers.

3.2.3.4 Sweden

The Swedish government's energy policy emphasizes the replacement of oil and nuclear energy and the introduction of new energy technologies based on renewable and domestic energy sources. Measures to improve the efficiency of electricity use are also promoted in the Swedish energy plan. Although some coal has been imported by Sweden in recent years, the tax on coal has been increased recently, and other energy resources (in particular, domestic fuel wood and peat) are being encouraged much more strongly than coal. Despite the Swedish government's reservations, there are plans for three coal-fired power plants totaling 1,245 MW (electric) to come on stream between 1988 and 1995. However, there are also plans to import natural gas, either from the North Sea via Denmark or from the USSR via Finland, to compensate for the future loss of nuclear capacity. Energy policy is still a subject of considerable controversy. Sweden was therefore rated low-medium for Factor 1 (energy plan and situation).

Although over 30% of the TPER in 1985 was met by imported oil, most of that came from OECD countries and the centrally-planned economies, so Sweden was rated low-medium for Factor 2. Sweden has very little experience with coal, leading to a low rating for Factor 3. Only 5% or less of its annual TPER was met with coal during the 1973-1985 period. Therefore, the general energy conditions in Sweden do not strongly favor coal use.

Sweden is also rated generally low on the energy demand factors. Residential/commercial energy use is currently moderately low, at 20 Mt (ce), has been decreasing since 1978, and is expected to continue to decrease through 2000. The coal share of residential/commercial energy demand is also low and is projected to remain so. However, Sweden does have a small amount of coal-fired DH capacity, and the government is encouraging expansion of that capacity; this changed Sweden's otherwise low rating for Factor 4 to low-medium. Factor 5 was rated low due to a low current industrial energy demand, a low coal share across most industrial categories, a decrease in industrial energy demand since 1973, and a low projected increase in energy demand.

The United States exports a small amount of coal to Sweden, and imports of U.S. goods comprised about 7% of total Swedish imports in 1986. Sweden has a trade surplus with the United States. Behind Norway and Finland, the United States is the third largest foreign investor in Sweden. Swedish firms manufacture both conventional and fluidized-bed boilers under license to U.S. firms. Therefore, Sweden was rated medium-high on Factor 6 (trade relations). However, Sweden has played a strong leadership role in the development of ACT (particularly FBC units) and pollution-control technology. Application of ACT at small installations has been emphasized in Swedish R&D projects. For this reason, Sweden was rated low for Factor 7 (lack of competition).

Environmental pressure is high in Sweden. There is a strong domestic air pollution control program and high environmental awareness. Control of NO_x is an

important issue, and demand could be high for U.S.-developed technologies that combine SO_2 and NO_x control. Sweden also is strongly interested in fluidized-bed and sorbent-injection systems for small units.

Despite this very positive environmental pressure, increased use of U.S.-developed ACT in Sweden will be constrained by the low energy demand, the commitment of the government to renewable energy sources, the lack of coal experience, and the presence of domestic competition for ACT development in Sweden.

3.3 CONCLUSIONS AND RECOMMENDATIONS

One of the purposes of this analysis was to choose the three OECD countries that appear to have the highest potential as export markets for U.S.-developed ACT in small-combustor applications. Eight of the 24 OECD countries were not examined in depth because of their very low current and projected energy demand. The evaluation of the remaining 15 countries (the United States excluded) led to the grouping of the countries according to their market potential. Group 1 (countries with good potential markets) includes Spain, Italy, Turkey, Greece, and Canada.

We found no strong impediments to the export of U.S. ACT to Spain. Spain was rated high or medium-high on all of the factors except trade relations. The low-medium rating on that factor is due to Spain's recent accession to the EEC, the Spanish trade deficit, and the high level of German investment in Spain. Although such conditions serve as indicators that certain extra incentives to trade with the United States may not be present in Spain, they do not constitute barriers precluding entry of U.S. ACT exports. All other factors characterize Spain as a very promising market.

Italy was rated high or medium-high on all factors except lack of competition, for which it received a low-medium rating. Although the Italian government and industry are carrying out extensive R&D on certain ACTs, the Italians are generally receptive to the idea of working cooperatively with the United States. Domestic competition, which exists primarily in the area of coal/water fuel development, is not viewed as an overriding constraint in this case.

In Turkey, transportation problems could hamper a rapid and extensive increase in coal use. Furthermore, although some environmental pressure exists in Turkey, ACT is not necessarily viewed as the primary way to reduce air pollution there. However, the very favorable attitude toward coal and the high levels of energy growth projected for Turkey appear to be so overwhelming that Turkey is viewed as a very good potential market for U.S. ACT.

Greece and Canada, although promising in many respects, do not appear to be as favorably disposed to increased use of ACT as Spain, Italy and Turkey. Canada has a broad spectrum of energy options -- coal, oil, gas, nuclear, and hydropower -- from which to choose, so coal is not being very heavily promoted. The energy situation and factors driving conversion to coal in Greece are very similar to those in Turkey, but current and projected energy demand in Greece is much lower than in Turkey. Therefore, we recommend that the next phase of study be directed toward Spain, Italy, and Turkey.

APPENDIX A:

FACTOR 1, ENERGY PLAN AND SITUATION

RATINGS AND REASONS, BY COUNTRY

Australia

Factor 1 rating: High

- Government wants to use domestic resources, especially coal and natural gas.
- High coal production in 1985 [117 Mt (ce), about half metallurgical coal]; coal production more than doubled from 1973 to 1985.
- Fairly high nonmetallurgical coal consumption [37 Mt (ce) in 1985].
- No imported coal; abundant domestic coal reserves.
- No existing or projected nuclear power.

Belgium

Factor 1 rating: Low-medium

- Nuclear energy supplies 38% of electricity generating capacity and its share is projected to increase; excess generating capacity exists.
- Coal conversion is encouraged in all economic sectors; "rational energy use" objectives include coal.
- Some domestic coal production [7 Mt (ce)] in 1985, but production declined by 28% from 1973 to 1985.
- Domestic coal industry is subsidized; coal taxes are lower than those on other fuels and electricity.
- Some coal imports in 1985 [9 Mt (ce)]; an 11% increase in imports over the last decade; in 1985, about 70% of steam coal was imported.
- South Africa is a major source of coal imports.

Canada

Factor 1 rating: Medium-high

- Moderately high 1985 coal production [48 Mt (ce)]; production more than doubled over the last decade; about half of 1985 coal production was metallurgical coal; about 5 Mt (ce) of steam coal was exported.
- Some steam coal imports from the United States.
- Fairly high level of steam coal use [30 Mt (ce)].
- Varied energy sources: hydropower provides a large portion of electricity; some nuclear power (12% of electricity generating capacity); wood provides a significant amount of industrial energy.
- Energy plan does not specifically promote coal.

Finland

Factor 1 rating: Medium-high

- Projected use of coal in 2000 is twice the 1985 level.
- 66% increase in coal imports from 1973 to 1985.
- No additional nuclear capacity planned.
- Considerable emphasis on use of unconventional domestic resources (peat, wood chips, etc.).
- Recent agreement with the USSR for import of electricity.
- Energy plan not available (Finland is not a member of the International Energy Agency [IEA]).

France

Factor 1 rating: Low-medium

- High existing and projected nuclear capacity in the utility sector; existing oversupply of generating capacity.
- High increase in electricity use projected for the residential/commercial and industrial sectors.
- Projected total use of coal in 2000 is about the same as use in 1985, but projected use in the residential/commercial and industrial sectors is 62% higher.
- Moderate level of coal production [15 Mt (ce) in 1985]; 40% decrease in production over the last decade; some political pressure to restore coal production to previous levels.
- Moderate level of coal imports [17 Mt (ce)]; 30% increase in imports over the last decade; no longer accepts South African imports.
- Energy plan not available (France is not a member of the IEA).

FRG

Factor 1 rating: Medium-high

- Increasing the use of coal is a policy objective, though the proportion of electricity generated from coal fell in 1987.
- Produces the most coal of all countries considered; second-highest steam-coal producer; slight decrease in production over the last decade.
- Moderate level of coal imports; increased imports over the last decade.
- Domestic hard coal industry is subsidized.
- Nuclear plants supplied about 17% of electricity generating capacity in 1985; nuclear energy production is expected to increase.
- Multifuel capacity is widely available in industry, giving fuel flexibility.

Greece

Factor 1 rating: High

- Policy has favored the use of imported coal and domestic lignite to reduce dependence on oil imports, but some shift in this policy toward natural gas may be indicated.
- Use of imported syngas or natural gas is planned, but currently there is no access to gas pipelines.
- Some domestic coal production [7 Mt (ce) in 1985]; production tripled over the last decade.
- Low level of coal imports [2 Mt (ce) in 1985], but imports doubled since 1973 (primarily for the cement industry).
- Oil products are taxed more heavily than other fuels.
- No current or planned nuclear generating capacity.

Italy

Factor 1 rating: Medium-high

- Increase in coal consumption called for in the national energy plan, to come mostly from steam coal for power generation.
- Planned use of natural gas for power generation; gas is favored over coal for large applications.
- Low coal production [< 1 Mt (ce) in 1985], but 60% increase in production over the last decade.
- Second highest importer of coal in 1985 of countries considered [20 Mt (ce)]; 85% increase in imports since 1973.
- South Africa is its largest source of coal imports.
- Nuclear energy supplied only 2% of generating capacity in 1985; referendum to halt nuclear power plant construction was upheld by the government.

Japan

Factor 1 rating: Low-medium

- A balanced energy mix, including coal, is a major objective; hydropower and renewables are encouraged.
- Moderate level of coal production [14 Mt (ce) in 1985]; decrease in production over the last decade.
- Largest importer of coal in 1985 of countries considered, primarily for the iron and steel industry; some increase in imports over the last decade.
- Nuclear is the largest source of domestic energy (hydropower is second); moving toward increased nuclear power production; renewables are encouraged.

Netherlands Factor 1 rating: Low-medium

- Major natural gas producer.
- Coal conversion promoted in electricity generating sector only; priority on renewables and cogeneration.
- Low coal production, but moderate coal imports [12 Mt (ce) in 1985]; increase in imports of 146% since 1973.
- Nuclear power supplies only 3% of generating capacity; nuclear share is unlikely to increase in the near future.

Portugal Factor 1 rating: High

- Government stresses the importance of coal as a primary energy source.
- Low coal production [< 1 Mt (ce) in 1985]; 26% decrease in production from 1973 to 1986.
- Low imports in 1985 [1.5 Mt (ce)]; large percentage increase (360%) in imports between 1973 and 1986, mostly from the United States.
- Fuel oil is subsidized.

Spain Factor 1 rating: High

- Government is making an effort to substitute coal for oil in industry and in urban areas.
- Moderately high 1985 coal production [20 Mt (ce)]; large increase in production (111%) from 1973 to 1985.
- Moderate level of coal imports [8 Mt (ce)]; large increase in imports (152%) from 1973 to 1985.
- Large amounts of coal are imported from South Africa.
- New, coastal electric power plants are designed for imported coal.

Sweden Factor 1 rating: Low-medium

- No policies to encourage coal in energy plan; use of domestic fuel wood and peat is encouraged.
- Almost no coal production.
- Moderate level of coal imports [5 Mt (ce) in 1985]; 97% increase in imports from 1973 to 1985.
- Coal tax was recently increased.
- All nuclear plants are being phased out.

Turkey

Factor 1 rating: Medium-high

- "Optimal" energy production from lignite is included in goals, along with diversification of energy sources; renewables encouraged.
- Moderate coal (mostly lignite) production [13 Mt (ce)]; high increase (78%) in production between 1973 and 1985.
- Moderately low coal imports, but imports have increased from 0.01 Mt (ce) in 1973 to an estimated 3.1 Mt (ce) in 1986, primarily from the United States.
- Coal will have to compete with natural gas when the gas pipeline from the USSR is complete.

UK

Factor 1 rating: Medium-high

- High 1985 coal production [77 Mt (ce), almost all steam coal]; 29% decrease in production between 1973 and 1985.
- Moderate coal imports [11 Mt (ce)], with large percentage increase in imports from 1973 to 1985 (706%); most imports are metallurgical coal, primarily from Australia.
- Free-market policy for energy.
- Privatization of electric power industry may open the market for imported coal and for power generation from natural gas.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 1 (see Sec. 2.1.1).

TABLE A.1 Energy Plans and Coal Use (Question 1)

| Country | Does the energy plan of the country state that increased coal use is a primary goal? |
|-------------|---|
| Australia | The government is concerned with making the best use of the country's domestic resources, particularly coal and natural gas. |
| Belgium | Energy policy objectives include "rational use of energy," which includes coal; government will provide subsidies of up to 100% for "rational use" development projects. Coal conversion is generally encouraged in all economic sectors. |
| Canada | Energy policy stresses self-sufficiency, energy security, and increased energy efficiency. It does not contain specific provisions encouraging coal. |
| Finland | Information not available from IEA. |
| France | Information not available from IEA. |
| FRG | One objective is to reduce the share of oil in the energy supply and increase the role of all other energy sources, especially domestic coal. |
| Greece | The main goal is to reduce dependence on imported oil; one avenue for this is through the use of imported coal. |
| Italy | The energy plan calls for an increase in coal consumption, mostly steam coal for power generation. |
| Japan | A balanced energy mix, including coal, is a major objective. |
| Netherlands | The government is promoting coal conversion in the electricity generating sector. |
| Portugal | The government stresses the importance of coal as a primary energy source. |
| Spain | A special effort is being undertaken to substitute coal for oil in industry and in urban areas. |
| Sweden | Laws for replacement of oil and nuclear energy have been enacted. Phase-out strategy is based on renewables and domestic energy resources. |
| Turkey | "Optimal" energy production from lignite is included in goals, as is diversification of energy sources. Turkey signed an agreement with the USSR in 1984 to buy natural gas, and a new pipeline to Ankara is under construction. |
| UK | The UK has no centralized energy plan, but general policy is to ensure adequate and secure energy supplies at the lowest long-term cost. |

Source: Ref. 2.

**TABLE A.2 Renewables and Other Energy Sources
(Question 2)**

| Country | Does the country rely on any domestic renewable or unconventional forms of energy? Are any of these sources being heavily promoted in the energy plan? |
|-------------|--|
| Australia | Hydropower provides 12% of electricity. The role of other renewables is small and not heavily promoted. |
| Belgium | Does not rely heavily on renewable energy. However, 18.1% of government energy R&D spending in 1985 was for "other" energy sources (solar photovoltaic, wind, microhydro, and biomass), as opposed to 9.3% for coal. |
| Canada | Biomass (mostly wood) accounted for 14.5% of total industrial energy demand in 1985. Hydropower accounts for almost all electricity generation in Quebec and British Columbia and 66.2% of electricity country-wide. Other renewable sources are not heavily promoted. |
| Finland | Has extensive peat resources and makes use of waste fuels such as spent liquors from the pulp and paper industry. Consumption of spent liquors is currently greater on an Mt (ce) basis than coal consumption. |
| France | Information not available from IEA. |
| FRG | Does not now rely on renewable sources, which accounted for 11.6% of the 1986 energy budget. |
| Greece | Does not now rely on renewable sources. Policy emphasizes switch away from imported oil for electricity generation through increased use of domestic lignite, renewables, and hydropower; 63.2% of the 1986 energy R&D budget was for renewables. |
| Italy | Does not now rely on renewable energy. Hydropower provides 24% of electricity. Geothermal energy is expected to play a larger role in electricity generation. Government is not heavily promoting renewables. |
| Japan | Hydroelectric power follows nuclear as the largest source of domestic energy (33 GW of capacity in 1986); hydropower is promoted by government. Renewable sources such as solar and wind are encouraged, but they claim a small share of the energy R&D budget (4.3% in 1986.) |
| Netherlands | Does not now rely on renewable energy. The government places priority on development of renewables, particularly wind. |
| Portugal | Does not now rely on renewable energy, although it is a priority area for government energy R&D funding. |
| Spain | Does not now rely on renewable energy, which received 27.6% of the 1986 energy R&D budget. |
| Sweden | Domestic fuel wood and peat contributed 5.3 Mt (oe) in 1985. Efforts to develop these resources further are being carried out. Renewables received 21.8% of energy R&D budget in 1986. |
| Turkey | Fuel wood and animal dung are used extensively in rural areas. A major hydroelectric development program is underway. Budget allocation for solar, geothermal, and biomass more than doubled from 1983 to 1986. |
| UK | Does not now rely on renewable sources and they are not heavily promoted. |

Source: Ref. 2.

TABLE A.3 Fuel Taxes or Subsidies (Question 3)

| Country | Does the government alter the market price of any fuel in any way? |
|-------------|---|
| Australia | Government enforces import parity pricing of crude oil. Fossil fuel production is taxed by states. Natural gas prices are partially controlled by states. |
| Belgium | Imported coal is priced at the world market level; higher-cost Belgian coal is subsidized. The value-added tax rate applied to other fuels and electricity is 17%, versus 6% for coal. |
| Canada | Coal prices are market-determined. Crude oil and natural gas prices were deregulated in June 1985. |
| Finland | Information not available from IEA. |
| France | Information not available from IEA. |
| FRG | Energy pricing is generally free of government intervention. Coal levy applies to imports of metallurgical coal. The domestic hard coal industry is subsidized and has an assured market share. |
| Greece | Energy product prices are set by the federal government; there are heavier taxes on oil products. |
| Italy | Coal prices are unregulated. Electricity and natural gas for the residential/commercial sector are regulated. Petroleum product prices are regulated in some cases. |
| Japan | Domestic coal prices are fixed by the government, and domestic coal is assured of markets. Imported coal prices are market-determined. Electricity and town gas tariffs need government approval. |
| Netherlands | Coal prices reflect the world market. Oil product prices are freely determined; gas and electricity are regulated. |
| Portugal | Coal prices are unregulated; petroleum product prices and electricity rates are controlled by the government; fuel oil is subsidized. |
| Spain | Most prices are controlled by government and specific energy taxes are used for policy reasons. Coal prices are unregulated for residential/commercial and nonmetallurgical industrial uses. |
| Sweden | Imported coal is at world market prices. Domestic prices reflect production and distribution costs. The coal tax was recently increased. |
| Turkey | Metallurgical coal is imported at world market price. Residential lignite is priced below average production cost, industrial lignite priced above. Petroleum (except liquified petroleum gas) is at the world market price. Electricity prices are controlled by the government. |
| UK | Oil and coal industries are responsible for setting the prices of their products, but prices are significantly influenced by financial discipline imposed by the government on public corporations and utilities. |

Source: Ref. 2.

TABLE A.4 Domestic Coal Production (Question 4)

| Country | Coal Production [Mt (ce)] | | | Change, 1973-1985 (%) |
|-------------|---------------------------|--------|--------|-----------------------------|
| | 1973 | 1978 | 1985 | |
| Australia | 57.50 | 70.04 | 117.20 | +103.8 |
| Belgium | 9.17 | 6.77 | 6.61 | -27.9 |
| Canada | 16.71 | 24.46 | 48.20 | +188.5 |
| Finland | 0 | 0 | 0 | -- |
| France | 25.77 | 20.11 | 15.37 | -40.4 |
| FRG | 131.91 | 121.23 | 117.77 | -10.7 |
| Greece | 2.41 | 3.97 | 6.91 | +186.7 |
| Italy | 0.43 | 0.43 | 0.69 | +60.5 |
| Japan | 25.57 | 15.97 | 13.74 | -46.3 |
| Netherlands | 1.80 | 0 | 0.1 | -94.4 |
| Portugal | 0.19 | 0.10 | 0.14 | -26.3 |
| Spain | 9.26 | 11.10 | 19.56 | +111.2 |
| Sweden | 0 | 0 | 0 | -- |
| Turkey | 7.44 | 10.04 | 13.23 | +77.8 |
| UK | 108.41 | 98.94 | 76.71 | -29.2 |

Source: Ref. 1.

TABLE A.5 Domestic Nonmetallurgical Coal, 1985 (Question 5)

| Country | Use ^a [Mt (ce)] | Production [Mt (ce)] | Exports (Mt (ce)) | Coal from Domestic Sources (% of use) ^b |
|-------------|-------------------------------|-------------------------|----------------------|---|
| Australia | 37.2 | 63.39 | 29.15 | 92.0 |
| Belgium | 7.4 | 3.13 | 0.84 | 30.9 |
| Canada | 30.6 | 25.05 | 4.64 | 66.7 |
| Finland | 1.5 | 0 | 0.01 | 0 |
| France | 23.7 | 11.98 | 0.81 | 47.1 |
| FRG | 94.3 | 67.15 | 3.47 | 67.5 |
| Greece | 8.7 | 6.91 | 0.21 | 77.0 |
| Italy | 12.6 | 0.69 | 0 | 5.5 |
| Japan | 41.4 | 9.64 | 0 | 23.3 |
| Netherlands | 6.1 | 0 | 1.23 | 0 |
| Portugal | 0.8 | 0.14 | 0 | 17.5 |
| Spain | 22.6 | 18.61 | 0 | 82.3 |
| Sweden | 2.5 | 0 | 0 | 0 |
| Turkey | 11.0 | 11.40 | 0 | >100 ^c |
| UK | 76.4 | 74.19 | 2.17 | 94.3 |

^aConsumption in the industrial, residential/commercial, and transportation sectors plus consumption by electric utilities minus consumption by the iron and steel industry.

^b $[(\text{Production} - \text{exports}) \div \text{use}] \times 100$.

^cProduction exceeded use.

Source: Ref. 1.

**TABLE A.6 Domestic Metallurgical (Coking) Coal, 1985
(Question 6)**

| Country | Use ^a [Mt (ce)] | Production [Mt (ce)] | Exports [Mt (ce)] | Coal from Domestic Sources (% of use) ^b |
|-------------|-------------------------------|-------------------------|----------------------|---|
| Australia | 4.1 | 53.83 | 48.59 | >100 ^c |
| Belgium | 4.9 | 3.49 | 0.20 | 67.1 |
| Canada | 5.7 | 23.14 | 21.36 | 31.2 |
| Finland | 0.5 | 0 | 0 | 0 |
| France | 8.5 | 3.39 | 0 | 39.9 |
| FRG | 17.3 | 50.63 | 5.61 | >100 ^c |
| Greece | 0.0 | 0 | 0 | 0 |
| Italy | 5.9 | 0 | 0 | 0 |
| Japan | 39.7 | 4.10 | 0 | 10.3 |
| Netherlands | 2.4 | 4.10 | 0.10 | >100 ^c |
| Portugal | 0.2 | 0 | 0 | 0 |
| Spain | 4.0 | 0.94 | 0 | 23.5 |
| Sweden | 1.2 | 0 | 0 | 0 |
| Turkey | 2.3 | 1.81 | 0 | 78.7 |
| UK | 6.5 | 2.53 | 0.06 | 38.0 |

^aCoal use by the iron and steel industry.

^b $[(\text{Production} - \text{exports}) \div \text{use}] \times 100$.

^cProduction minus exports exceeded use.

Source: Ref. 1.

TABLE A.7 Coal Imports, 1973-1986 (Question 7)

| Country | Coal Imports [Mt (ce)] | | | | | | Change, 1973-1985 (%) | Average Annual Change, 1983-1895 (%) |
|-------------|------------------------|-------|-------|-------|-------|-------------------|-----------------------------|---|
| | 1973 | 1979 | 1983 | 1984 | 1985 | 1986 ^a | | |
| Australia | 0 | 0.01 | 0 | 0 | 0 | 0 | -- | -- |
| Belgium | 7.60 | 6.87 | 7.19 | 9.43 | 9.30 | 8.43 | +10.9 | +14.9 |
| Canada | 14.96 | 14.19 | 15.10 | 18.24 | 14.49 | 13.76 | -3.1 | -2.0 |
| Finland | 3.49 | 5.23 | 5.06 | 4.43 | 5.80 | 6.00 | +66.2 | + 9.2 |
| France | 15.43 | 23.54 | 18.87 | 22.21 | 20.01 | 17.26 | +29.7 | + 3.9 |
| FRG | 9.71 | 8.43 | 12.09 | 12.06 | 12.70 | 12.84 | +30.8 | + 2.6 |
| Greece | 0.67 | 0.40 | 1.26 | 1.69 | 1.97 | 1.73 | +194.0 | +25.4 |
| Italy | 11.67 | 12.91 | 16.96 | 19.91 | 21.63 | 20.13 | +85.3 | +13.0 |
| Japan | 59.00 | 52.67 | 75.36 | 87.23 | 92.73 | 89.11 | +57.0 | +11.1 |
| Netherlands | 4.66 | 5.57 | 7.79 | 11.13 | 11.47 | 12.10 | +146.1 | +23.5 |
| Portugal | 0.40 | 0.51 | 0.53 | 0.53 | 1.51 | 1.84 | +277.5 | +92.5 |
| Spain | 3.09 | 3.70 | 5.76 | 6.66 | 7.77 | 7.63 | +151.5 | +16.2 |
| Sweden | 2.41 | 1.87 | 3.06 | 3.86 | 4.74 | 4.36 | +96.7 | +24.5 |
| Turkey | 0.01 | 0.46 | 1.53 | 1.99 | 2.67 | 3.06 | +266.0 | +32.2 |
| UK | 1.60 | 2.19 | 5.13 | 10.89 | 12.89 | 10.64 | +705.6 | +65.4 |

^aEstimated.

Source: Ref. 1.

TABLE A.8 Principal Sources of Steam Coal Imports, 1985 (Question 7)

| Country | Source | Quantity (kt) | Country | Source | Quantity (kt) |
|-----------|----------------|---------------|--------------|---------------|---------------|
| Australia | -- | 0 | Japan | Australia | 14,137 |
| Belgium | Australia | 205 | | Canada | 780 |
| | China | 112 | | China | 2,426 |
| | FRG | 1,067 | | South Africa | 4,091 |
| | South Africa | 2,078 | | USSR | 1,020 |
| | United States | 671 | | United States | 960 |
| Canada | United States | 8,391 | Nether-lands | Australia | 1,755 |
| Finland | Australia | 404 | | Canada | 130 |
| | Colombia | 347 | | Colombia | 150 |
| | Poland | 2,407 | | FRG | 143 |
| | USSR | 852 | | Poland | 878 |
| | United States | 1,018 | | South Africa | 812 |
| France | Australia | 850 | Portugal | United States | 2,872 |
| | Canada | 410 | | South Africa | 104 |
| | Czechoslovakia | 883 | | UK | 111 |
| | FRG | 1,134 | | United States | 669 |
| | South Africa | 6,444 | Spain | Australia | 407 |
| | UK | 204 | | Canada | 173 |
| | United States | 678 | | Colombia | 134 |
| FRG | Australia | 720 | | Poland | 379 |
| | Canada | 235 | | South Africa | 2,243 |
| | Czechoslovakia | 346 | | United States | 855 |
| | Poland | 2,709 | Sweden | Australia | 603 |
| | South Africa | 3,196 | | Colombia | 183 |
| | USSR | 166 | | Poland | 1,271 |
| | UK | 180 | | USSR | 407 |
| | United States | 1,072 | | United States | 343 |
| Greece | Australia | 588 | Turkey | United States | 275 |
| | South Africa | 207 | UK | Australia | 2,469 |
| | United States | 1,136 | | FRG | 746 |
| Italy | Australia | 250 | | Poland | 258 |
| | Colombia | 180 | | South Africa | 724 |
| | Czechoslovakia | 1,150 | | United States | 498 |
| | South Africa | 6,641 | | | |
| | USSR | 150 | | | |
| | United States | 3,518 | | | |

Source: Ref. 1.

**TABLE A.9 Electricity Generation Capacity, 1985
(Question 8)**

| Country | Nuclear Capacity ^a (MW) | Total Capacity ^a (MW) | Nuclear Share (%) |
|-------------|--|--|-------------------------|
| Australia | 0 | 32,695 | 0 |
| Belgium | 5,425 | 14,112 | 38.4 |
| Canada | 11,159 | 97,356 | 11.5 |
| Finland | 2,300 | 11,313 | 20.3 |
| France | 37,487 | 86,562 | 43.3 |
| FRG | 16,095 | 92,701 | 17.4 |
| Greece | 0 | 7,116 | 0 |
| Italy | 1,273 | 55,626 | 2.3 |
| Japan | 24,686 | 169,358 | 14.6 |
| Netherlands | 508 | 16,991 | 3.0 |
| Portugal | 0 | 6,010 | 0 |
| Spain | 5,815 | 39,205 | 14.8 |
| Sweden | 9,455 | 33,168 | 28.5 |
| Turkey | 0 | 9,118 | 0 |
| UK | 7,064 | 67,607 | 10.4 |

^aNet maximum capacity as of
December 31, 1985.

Source: Ref. 3.

TABLE A.10 Existing and Projected Nuclear Generating Capacity (Question 8)

| Country | 1985 (GW) | 2000 (GW) | Change (%) |
|----------------------|-----------|-----------|------------|
| Australia | 0 | 0 | -- |
| Belgium | 5.4 | 6.8 | + 25.9 |
| Canada | 11.2 | 17.6 | + 57.1 |
| Finland ^a | 2.3 | 3.6 | + 56.5 |
| France | 37.5 | 78.0 | +108.0 |
| FRG | 16.1 | 25.6 | + 59.0 |
| Greece | 0 | 0 | -- |
| Italy | 1.3 | 9.1 | +600.0 |
| Japan | 24.7 | 62.0 | +151.0 |
| Netherlands | 0.5 | 3.0 | +500.0 |
| Portugal | 0 | 0.9 | -- |
| Spain | 5.5 | 10.4 | + 89.1 |
| Sweden | 9.5 | 8.5 | - 10.5 |
| Turkey | 0 | 0.6 | -- |
| UK | 7.1 | 18.0 | +153.5 |

^aThe current government has stated that no new nuclear plants will be built during its administration. The projections shown here do not reflect that policy.

Source: Ref. 1.

TABLE A.11 Electricity Use in Countries with High Levels of Nuclear Generation^a (%)

| Country | Electricity Share of Total Energy Use ^b | |
|-------------|--|-------------------|
| | 1985 | 2000 |
| Belgium | 16.9 | 21.0 |
| Finland | 25.4 | 31.0 ^c |
| France | 21.6 | 35.6 |
| FRG | 19.9 | 22.7 ^c |
| Italy | 18.5 | 29.4 ^c |
| Japan | 27.7 | 29.9 ^c |
| Netherlands | 12.7 | 14.7 |
| UK | 20.7 | 24.1 |

^aCountries that had a high percentage of nuclear-generated electricity in 1985 or projected high growth in nuclear-generated electricity between 1985 and 2000. Sweden is excluded because all nuclear power plants are scheduled to be phased out by 2000.

^bIncluding residential, commercial, and industrial energy; excluding energy used in the iron and steel industry.

^cProjected industry-specific electricity use not available; may include use in the iron and steel industry.

Source: Ref. 1.

APPENDIX B:**FACTOR 2, DEPENDENCE ON OIL AND GAS IMPORTS****RATINGS AND REASONS, BY COUNTRY****Australia** Factor 2 rating: Low

- Less than 1% of the TPER was met by oil imports in 1985, down from 15% in 1979.
- Moderate levels of domestic oil and gas.

Belgium Factor 2 rating: Medium-high

- 45% of the 1985 TPER was met by oil imports.
- Moderately high imports from the USSR, low imports from OPEC.
- No domestic oil and minimal quantities of gas.

Canada Factor 2 rating: Low

- Net exporter of petroleum.

Finland Factor 2 rating: Low-medium

- 40% of the 1985 TPER was met by oil imports.
- The USSR is the primary source of oil imports; very little oil is imported from OPEC.
- No domestic oil or gas.

France Factor 2 rating: Medium-high

- 41% of the 1985 TPER was met by oil imports.
- Significant oil imports from OPEC and centrally planned economies.
- 24% of the natural gas used in 1985 was imported from the USSR.
- Some domestic oil and gas.

FRG Factor 2 rating: Low-medium

- 40% of the 1985 TPER was met by oil imports, but most imports come from OECD countries.
- 29% of the natural gas used in 1985 was imported from the USSR.
- Moderate level of domestic gas.

Greece Factor 2 rating: High

- 58% of the 1985 TPER was met by oil imports, down from 91% in 1973.
- Much of the imported oil comes from centrally planned economies.
- Minimal domestic oil and gas.

Italy Factor 2 rating: High

- 59% of the 1985 TPER was met by oil imports, down from 79% in 1973.
- Significant oil imports from OPEC and centrally planned economies.
- 22% of the natural gas used in 1985 came from the USSR.
- Moderate level of domestic gas.

Japan Factor 2 rating: High

- 57% of the 1985 TPER was met by oil imports, down from 82% in 1973.
- A large portion of the imported oil is from OPEC.
- Minimal amount of domestic oil and gas.

Netherlands Factor 2 rating: Low-medium

- 40% of the 1985 TPER was met by oil imports, down from 65% in 1973.
- Significant oil imports from OPEC and centrally planned economies, as well as OECD countries.
- High level of domestic gas production.

Portugal Factor 2 rating: Medium-high

- 67% of the 1985 TPER was met by oil imports, and the level of imports has not changed much since 1973.
- Most oil imports are from OECD countries.
- No domestic oil or gas.

Spain Factor 2 rating: High

- 53% of the 1985 TPER was met by oil imports, down from 72% in 1973.
- Minimal domestic crude oil and gas production.
- Crude oil imports come primarily from OPEC.

Sweden **Factor 2 rating: Low-medium**

- 31% of the 1985 TPER was met by oil imports, down from 61% in 1973.
- Practically no domestic gas or oil production in 1985.
- Most oil imports come from OECD countries and centrally planned economies.

Turkey **Factor 2 rating: Medium-high**

- 38% of the 1985 TPER was met by oil imports.
- Oil imports have increased slightly between 1973 and 1985.
- A substantial portion of diesel oil imports come from OPEC and the USSR.
- Minimal amount of domestic oil production and no natural gas.

UK **Factor 2 rating: Low**

- Net petroleum exporter in 1985.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 2 (see Sec. 2.1.2).

TABLE B.1 Oil Imports and the Total Primary Energy Requirement (Question 1)

| Country | TPER [Mt (oe)] | | | Net Oil Imports [Mt (oe)] | | | Oil Imports Share of TPER (%) | | |
|-------------|----------------|-------|-------|------------------------------|-------|-------|----------------------------------|------|------|
| | 1973 | 1979 | 1985 | 1973 | 1979 | 1985 | 1973 | 1979 | 1985 |
| Australia | 59.5 | 71.4 | 77.9 | 9.2 | 10.9 | 0.6 | 15.5 | 15.3 | 0.8 |
| Belgium | 46.2 | 47.9 | 42.8 | 30.9 | 29.0 | 19.2 | 66.9 | 60.5 | 44.9 |
| Canada | 178.8 | 220.3 | 233.2 | -14.0 | 7.7 | -17.5 | 0 | 3.5 | 0 |
| Finland | 22.8 | 25.3 | 27.0 | 13.9 | 14.9 | 10.8 | 61.0 | 58.9 | 40.0 |
| France | 179.7 | 194.2 | 197.2 | 129.7 | 122.0 | 81.5 | 72.2 | 62.8 | 41.3 |
| FRG | 266.2 | 286.5 | 268.5 | 146.8 | 147.1 | 108.1 | 55.1 | 51.3 | 40.3 |
| Greece | 12.5 | 16.3 | 18.4 | 11.4 | 13.1 | 10.6 | 91.2 | 80.4 | 57.6 |
| Italy | 132.3 | 144.7 | 140.2 | 104.5 | 100.4 | 82.4 | 79.0 | 69.4 | 58.8 |
| Japan | 338.9 | 372.2 | 375.6 | 277.5 | 281.8 | 214.4 | 81.9 | 75.7 | 57.1 |
| Netherlands | 63.2 | 69.9 | 62.1 | 41.3 | 41.6 | 24.9 | 65.3 | 59.5 | 40.1 |
| Portugal | 8.2 | 11.4 | 12.8 | 6.2 | 9.1 | 8.6 | 75.6 | 79.8 | 67.2 |
| Spain | 55.5 | 72.4 | 74.3 | 40.2 | 49.1 | 39.3 | 72.4 | 67.8 | 52.9 |
| Sweden | 47.3 | 51.3 | 55.0 | 28.8 | 29.2 | 17.2 | 60.9 | 56.9 | 31.3 |
| Turkey | 24.5 | 32.1 | 39.7 | 8.7 | 11.6 | 15.1 | 35.5 | 36.1 | 38.0 |
| UK | 220.8 | 220.0 | 202.8 | 115.7 | 19.2 | -50.5 | 52.4 | 8.7 | 0 |

Sources: Refs. 2 and 4.

TABLE B.2 Principal Sources of Crude Oil for the Largest OECD Importers, 1985 (kt) (Question 2)

| Country | Total Crude Oil Imports | Main Sources and Quantities Imported | |
|-------------|-------------------------|--------------------------------------|---------|
| France | 67,043 | UK | 14,897 |
| | | Total OECD | 19,737 |
| | | OPEC | 35,166 |
| | | USSR | 2,970 |
| | | Total CPE ^a | 3,070 |
| | | Non-OPEC Africa | 5,773 |
| FRG | 64,193 | UK | 17,218 |
| | | Total OECD | 20,884 |
| | | OPEC | 35,016 |
| | | USSR | 3,886 |
| Italy | 63,551 | UK | 3,289 |
| | | Total OECD | 3,406 |
| | | OPEC | 37,310 |
| | | CPE | 5,844 |
| | | Non-OPEC Africa | 7,640 |
| | | Asia | 7,575 |
| Japan | 164,798 | Australia | 1,746 |
| | | OPEC | 119,522 |
| | | Total CPE | 11,084 |
| | | China | 10,953 |
| | | Asia | 23,306 |
| | | | |
| Netherlands | 37,394 | UK | 10,409 |
| | | Total OECD | 13,137 |
| | | OPEC | 18,123 |
| | | USSR | 2,179 |
| Spain | 43,467 | UK | 1,462 |
| | | Total OECD | 1,793 |
| | | OPEC | 25,461 |
| | | CPE | 1,230 |
| | | Non-OPEC Africa | 4,964 |
| UK | 26,596 | Norway | 10,959 |
| | | Total OECD | 11,971 |
| | | OPEC | 10,872 |

^aCPE = centrally planned economies.

Source: Ref. 25.

**TABLE B.3 Primary Sources of Petroleum Product Imports, 1986 (kt)
(Question 2)**

| Country | Gasoline/Diesel Oil | | Residual Fuel Oil | |
|-----------|------------------------|----------|-------------------|----------|
| | Source | Quantity | Source | Quantity |
| Australia | OPEC | 166 | OPEC | 448 |
| | Singapore | 499 | Singapore | 416 |
| | United States | 80 | United States | 80 |
| | Total CPE ^a | 20 | | |
| Belgium | Netherlands | 3,566 | Netherlands | 1,065 |
| | UK | 192 | Total OECD | 3,496 |
| | OPEC | 84 | OPEC | 176 |
| | USSR | 979 | USSR | 1,016 |
| Canada | UK | 751 | OPEC | 749 |
| | OPEC | 232 | United States | 119 |
| Finland | USSR | 1,419 | USSR | 2,083 |
| France | Italy | 1,456 | Italy | 206 |
| | UK | 1,093 | Total OECD | 655 |
| | Total OECD | 4,827 | OPEC | 153 |
| | OPEC | 2,463 | USSR | 67 |
| | USSR | 1,455 | | |
| | Total CPE | 2,382 | | |
| FRG | Netherlands | 12,339 | Belgium | 1,060 |
| | UK | 1,729 | Netherlands | 2,290 |
| | Total OECD | 18,286 | Total OECD | 5,152 |
| | OPEC | 1,941 | OPEC | 656 |
| | USSR | 3,080 | USSR | 1,492 |
| | Total CPE | 5,567 | Total CPE | 3,446 |
| Greece | Italy | 65 | OECD | 123 |
| | OPEC | 127 | OPEC | 298 |
| | USSR | 170 | USSR | 52 |
| | Total CPE | 893 | | |
| Italy | OECD | 468 | OECD | 1,413 |
| | OPEC | 2,096 | OPEC | 4,781 |
| | USSR | 559 | USSR | 70 |
| | Total CPE | 2,369 | Total CPE | 364 |
| Japan | UK | 573 | UK | 1,679 |
| | OPEC | 530 | OPEC | 2,927 |
| | USSR | 467 | USSR | 214 |
| | China | 292 | Total CPE | 446 |

TABLE B.3 (Cont'd)

| Country | Gasoline/Diesel Oil | | Residual Fuel Oil | |
|-------------|---------------------|----------|-------------------|----------|
| | Source | Quantity | Source | Quantity |
| Netherlands | UK | 1,030 | Belgium | 1,413 |
| | Total OECD | 3,537 | Total OECD | 3,114 |
| | OPEC | 2,912 | OPEC | 1,495 |
| | USSR | 4,629 | USSR | 2,424 |
| | Total CPE | 4,965 | Total CPE | 2,592 |
| Portugal | OECD | 48 | OECD | 1,121 |
| Spain | OECD | 334 | OECD | 316 |
| | USSR | 144 | USSR | 275 |
| | Total CPE | 292 | | |
| Sweden | OECD | 1,375 | UK | 690 |
| | USSR | 635 | Total OECD | 1,809 |
| | Total CPE | 1,128 | USSR | 444 |
| Turkey | OPEC | 230 | Total CPE | 778 |
| | USSR | 209 | Non-OPEC | |
| | | | Middle East | 121 |
| UK | Netherlands | 420 | Spain | 1,005 |
| | Total OECD | 676 | Total OECD | 3,721 |
| | USSR | 704 | | |

^aCPE = centrally planned economies.

Source: Ref. 7.

TABLE B.4 Imports of Natural Gas from the USSR, 1985 (Question 3)

| Country | TPER [Mt (ce)] | Consumption [Mt (ce)] | Natural Gas Imports from USSR | | |
|---------|-------------------|--------------------------|-------------------------------|-------------------------|----------------------------|
| | | | Mt (ce) | As Share of TPER (%) | As Share of Gas Use (%) |
| France | 281.7 | 35.8 | 8.7 | 3.1 | 24.3 |
| FRG | 383.6 | 59.2 | 17.1 | 4.5 | 28.8 |
| Italy | 200.3 | 39.6 | 8.5 | 4.2 | 21.5 |

Source: Ref. 15.

TABLE B.5 Domestic Oil and Gas Production, 1985 (Question 4)

| Country | Crude Oil (kt) | Natural Gas (10 ³ Tcal) |
|-------------|-------------------|---------------------------------------|
| Australia | 25.0 | 125.0 |
| Belgium | 0 | 0.4 |
| Canada | 65.1 | 765.5 |
| Finland | 0 | 0 |
| France | 2.6 | 50.0 |
| FRG | 4.1 | 134.3 |
| Greece | 1.3 | 0.8 |
| Italy | 2.4 | 128.2 |
| Japan | 0.5 | 21.8 |
| Netherlands | 3.7 | 678.0 |
| Portugal | 0 | 0 |
| Spain | 2.2 | 2.6 |
| Sweden | 0 | 0 |
| Turkey | 2.1 | 0.5 |
| UK | 122.4 | 396.9 |

Source: Ref. 3.

APPENDIX C:

FACTOR 3, EXPERIENCE WITH COAL

RATINGS AND REASONS, BY COUNTRY

Australia Factor 3 rating: High

- Coal supplied 40% of the TPER in 1985, 38% in 1973.
- Fairly high electricity production from coal in 1985, moderately high in 1973; no nuclear power.
- Adequate transportation infrastructure, with expansion continuing.

Belgium Factor 3 rating: Medium-high

- Coal supplied 21-24% of the TPER between 1973 and 1985.
- Low but increasing use of coal for electricity production since 1973.
- High level of coal production in the 1950s and 1960s.
- Good transportation infrastructure.

Canada Factor 3 rating: Medium-high

- Coal supplied 11% of the TPER in 1985, 9% in 1973.
- Substantial coal-fired electricity generating capacity.
- Good transportation infrastructure.

Finland Factor 3 rating: Low-medium

- Coal supplied 11-18% of the TPER between 1973 and 1985.
- Low level of electricity production from coal; increasing use of nuclear power.
- Moderately low port capacity; no data on transportation networks.

France Factor 3 rating: Medium-high

- Decrease in coal's share of the TPER between 1973 and 1985 (to 12.6% in 1985).
- Moderately high level of electricity from coal (highest in 1978); very large increase in nuclear power over the 1973-85 period.
- Moderately high port capacity, with planned additions; no data on transportation networks.
- Higher levels of coal production in the past.

FRG

Factor 3 rating: High

- Coal supplied 28-32% of the TPER between 1973 and 1985.
- Very high and increasing use of coal for electricity production (highest of all countries considered).
- Moderately low port capacity, but expansion is planned; adequate transportation networks.

Greece

Factor 3 rating: Low-medium

- Coal supplied 17% of the TPER in 1973, 33% in 1985.
- Low use of coal for electricity production in 1973 and 1978, moderately low in 1985; no nuclear power.
- Low port capacity; inadequate transportation networks as of 1983; railway system now being modernized.

Italy

Factor 3 rating: Low-medium

- Coal supplied 6% of the TPER in 1973, 11% in 1985.
- Coal use for electricity production was low in 1973 and moderately low relative to other countries in 1985 (but greatly increased over the 1973 level).
- Moderately high port capacity; national railway system being upgraded.

Japan

Factor 1 rating: Medium-high

- Coal supplied 17-20% of the TPER between 1973 and 1985.
- Moderately high electricity production from coal between 1973 and 1985; large increase in coal-generated electricity since 1973.
- Very high port capacity with planned expansion; adequate inland transport networks.
- Extensive experience handling metallurgical coal shipments.

Netherlands

Factor 1 rating: Medium-high

- Coal supplied 5% of the TPER in 1973, 11% in 1985.
- Low use of coal for electricity production in 1973 and 1978, moderately low in 1985.
- Considerably higher coal production in the 1950s and 1960s.
- High port capacity; excellent inland transportation infrastructure, but it is being used at close to capacity.

Portugal **Factor 3 rating: Low**

- Coal supplied 6% or less of the TPER between 1973 and 1985.
- Very low electricity production from coal.
- Coal transportation infrastructure was not in place as of 1983.

Spain **Factor 3 rating: Medium-high**

- Coal supplied 16% of the TPER in 1973, 26% in 1985.
- Moderately high and increasing use of coal for electricity production.
- Moderately high port capacity with planned expansion; existing railways are sufficient for domestic coal production as of 1983.

Sweden **Factor 3 rating: Low**

- Coal supplied 5% or less of the TPER between 1973 and 1985.
- Very low electricity production from coal.
- Moderately low port capacity; adequate transportation networks.

Turkey **Factor 3 rating: Low-medium**

- Low port capacity; inland transportation is mostly by truck.
- Coal supplied 21% of the TPER in 1973, 27% in 1985.
- Low electricity production from coal in 1973 and 1978, moderately low in 1985; no nuclear power.

UK **Factor 3 rating: High**

- Coal supplied 31-35% of the TPER between 1973 and 1985; coal's share has been decreasing since 1973.
- Very high electricity production from coal; increasing use of nuclear power.
- Moderately low port capacity; adequate inland transportation network.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 3 (see Sec. 2.1.3).

TABLE C.1 Total Energy and Electricity Production from Coal (Questions 1 and 2)

| Country | Electricity Production (TWh) | | | | | | | | | | | | | |
|-------------|------------------------------------|------|------|-------|-------|---------|-------|-------|------|---------|-------|-------|-----|---------|
| | Share of TPER Supplied by Coal (%) | | | | | | 1978 | | | | | | | |
| | 1973 | 1978 | 1985 | Coal | Oil | Nuclear | 1973 | Coal | Oil | Nuclear | 1978 | Coal | Oil | Nuclear |
| Australia | 38.0 | 34.7 | 40.4 | 48.2 | 1.7 | 0 | 60.7 | 5.3 | 0 | 88.9 | 4.7 | 0 | | |
| Belgium | 24.1 | 20.8 | 22.8 | 8.9 | 21.8 | 0.1 | 13.7 | 17.2 | 12.5 | 15.0 | 3.7 | 34.6 | | |
| Canada | 8.5 | 8.5 | 10.9 | 34.9 | 9.1 | 15.3 | 50.0 | 15.4 | 31.2 | 79.5 | 6.8 | 60.5 | | |
| Finland | 11.3 | 17.5 | 15.5 | 4.9 | 8.3 | 0 | 12.1 | 5.0 | 3.3 | 8.9 | 1.1 | 19.1 | | |
| France | 16.3 | 16.1 | 12.6 | 35.3 | 73.3 | 14.7 | 63.9 | 55.5 | 30.5 | 44.9 | 7.1 | 224.1 | | |
| FRG | 31.5 | 27.4 | 30.1 | 190.4 | 42.8 | 11.8 | 199.7 | 31.1 | 35.9 | 226.5 | 9.4 | 125.9 | | |
| Greece | 16.9 | 19.7 | 33.1 | 5.3 | 7.3 | 0 | 10.2 | 7.9 | 0 | 17.8 | 7.2 | 0 | | |
| Italy | 6.1 | 6.6 | 11.0 | 5.2 | 89.7 | 3.1 | 10.3 | 98.1 | 4.4 | 30.0 | 76.2 | 7.0 | | |
| Japan | 17.1 | 13.1 | 19.5 | 37.3 | 340.8 | 9.7 | 41.1 | 332.5 | 59.3 | 99.9 | 195.1 | 159.6 | | |
| Netherlands | 5.1 | 5.1 | 10.7 | 3.2 | 6.5 | 1.1 | 7.0 | 10.4 | 4.1 | 17.1 | 3.3 | 3.9 | | |
| Portugal | 6.2 | 4.2 | 6.0 | 0.4 | 1.9 | 0 | 0.2 | 3.3 | 0 | 1.0 | 6.6 | 0 | | |
| Spain | 16.2 | 13.5 | 26.1 | 14.3 | 25.1 | 6.5 | 20.9 | 28.8 | 7.6 | 55.5 | 8.1 | 2.0 | | |
| Sweden | 3.3 | 3.0 | 5.1 | 0.5 | 15.2 | 2.1 | 0.1 | 10.9 | 23.8 | 2.1 | 4.0 | 58.6 | | |
| Turkey | 21.0 | 20.2 | 27.0 | 4.2 | 5.5 | 0 | 5.6 | 6.7 | 0 | 15.0 | 7.1 | 0 | | |
| UK | 34.6 | 32.2 | 30.5 | 174.6 | 72.2 | 28.0 | 189.2 | 52.9 | 37.2 | 178.3 | 48.3 | 61.1 | | |

Source: Ref. 1.

TABLE C.2 Capacity of Coal-Importing Ports (Mt/yr) (Question 3)

| Country | Throughput ^a | Current Effective Capacity ^a | Planned Additions to Capacity by 1990 ^b | Long-Term Proposed/Planned Capacity Additions ^c |
|-------------|-------------------------|---|--|--|
| Australia | 0 | 0 | 0 | 0 |
| Belgium | 29.3 | 57.9 ^d | 0 | 0 |
| Canada | 17.0 | 28.1 | 0 | 0 |
| Finland | 4.5 | 23.1 | 0 | 0 |
| France | 23.5 | 62.4 ^d | 0 | 2.5 |
| FRG | 8.8 | 19.3 | 0 | 10.7 |
| Greece | 1.4 | 4.0 ^d | 0 | 0 |
| Italy | 24.1 | 40.7 ^d | 0 | 0 |
| Japan | 109.4 | 154.0 ^d | 6.6 | 50.3 |
| Netherlands | 36.0 | 35.1 | 0 | 32.3 |
| Portugal | 0.9 | na ^e | 5.0 | 0 |
| Spain | 10.8 | 32.3 ^d | 0 | 7.4 |
| Sweden | 3.5 | 10.1 | 0 | 8.5 |
| Turkey | 2.0 | 2.9 ^d | 0 | 0 |
| UK | 0.8 | 20.5 | 0 | 0 |

^aActual (as of 1985, 1986, or 1987).

^bZero values indicate that OECD has no record of reported additions.

^cNonzero values are shown for projects which are uncertain or which will be completed after 1990; zeros indicate that OECD has no record of long-term expansion plans.

^dEffective capacity may be larger than value shown because data are not available for all ports.

^eInformation not available.

Source: Ref. 1.

TABLE C.3 Coal Transportation Infrastructure (Question 4)

| Country | Does a transportation infrastructure exist to transport coal to major residential/commercial and industrial demand centers? |
|-------------|---|
| Australia | Yes, adequate rail; expansion and upgrading continuing. Coal industry considers state-determined freight rates high. |
| Belgium | Yes, adequate; additional handling facilities may be required for substantial expansion of coal use. |
| Canada | Yes; rail capacity being expanded. |
| Finland | No information available from IEA. |
| France | No information available from IEA. |
| FRG | Yes; adequate rail, inland waterways, and roads. |
| Greece | Inadequate in both capacity and network spread as of 1983; rail system now being modernized. |
| Italy | Adequate for coastal shipments. Energy plan calls for expansion of port infrastructure to accommodate increased imports. Railway system being upgraded. |
| Japan | Adequate. |
| Netherlands | Yes; excellent inland transportation infrastructure (inland waterways and rail). Lack of space for new transportation developments could become a constraint in the future. |
| Portugal | Transportation infrastructure not yet in place. |
| Spain | Existing railways are sufficient to handle domestic production; a few small lines might be added in the future. |
| Sweden | Yes; adequate for the near future. |
| Turkey | Mostly by truck (expensive and inadequate for future development). |
| UK | Yes; adequate rail. |

Sources: Refs. 1 and 5.

APPENDIX D:

FACTOR 4, RESIDENTIAL/COMMERCIAL ENERGY DEMAND

RATINGS AND REASONS, BY COUNTRY

Australia Factor 4 rating: Medium-high

- Moderately low energy use [15 Mt (ce)] in the residential/commercial sector, implying a moderately small retrofit market; moderate increase in residential/commercial energy use since 1978 and a healthy increase (2%/yr) projected by 2000.
- Coal provides a very small share of residential/commercial energy; share has decreased since 1978; negligible projected increase by 2000.
- A high percentage of the urban population is in large cities; high percentage of urban dwellers in total population; second highest population growth between 1985 and 2000 of all countries considered.
- Residential/commercial sector uses almost four times as much oil as gas.

Belgium Factor 4 rating: Low-medium

- Moderately low level of energy use in the residential/commercial sector [18 Mt (ce)]; level has decreased since 1978; no change projected by 2000.
- Coal's share of residential/commercial energy is 8%, third highest of all countries considered; large decrease in coal share since 1973, decreasing trend to continue through 2000.
- High percentage of population in cities/towns of < 500,000 persons; very low population growth projected for 1980-2000.
- Some installed DH capacity, with combined heat and power capacity entirely coal-fired; government energy programs could favor DH in the buildings sector.
- Residential/commercial sector uses more than twice as much oil as gas.

Canada Factor 4 rating: Medium-high

- Moderately high energy use in the residential/commercial sector [70 Mt (ce)]; increasing by 1%/yr since 1973; increasing trend projected to continue through 2000. Total increase in energy use between 1985 and 2000 projected to be 16 Mt (ce) (potentially high retrofit and new combustor market).

- Coal's share of current residential/commercial energy is very low; coal share has decreased since 1973; decrease is projected to continue through 2000.
- A high percentage of the population is in large cities; third highest projected population growth of countries considered for 1980-2000.
- More gas than oil is used in the residential/commercial sector.

Finland

Factor 4 rating: Low-medium

- Low energy use in the residential/commercial sector [10 Mt (ce)]; roughly constant since 1973; slight decrease projected by 2000.
- More oil than gas is used in this sector.
- 1985 coal share of total residential/commercial energy was 5%, up from 1% in 1978. Share is projected to increase to over 21% in 2000, but due to fairly low energy requirements, the projected increase in coal use between 1985 and 2000 is only 1.5 Mt (ce).
- The population resides primarily in small cities and nonurban settings; only one city of more than 500,000; moderately low population growth projected for 1980-2000.
- Installed DH capacity, some coal-fired; government policy promotes increased use of DH and combined heat and power systems.

France

Factor 4 rating: Medium-high

- Moderately high energy use in the residential/commercial sector [70 Mt (ce)], implying a large retrofit market; 7% decrease since 1973; 2.5% decrease projected between 1985 and 2000.
- Coal's share of residential/commercial energy was 5% in 1985, down from 11% in 1973, but it is expected to increase to 13.5% in 2000.
- Low percentage of urban population in large cities; high percentage of urban dwellers in total population; moderately high population growth is projected for 1980-2000.
- Twice as much oil as gas is used in this sector.

FRG

Factor 4 rating: Medium-high

- Highest residential/commercial energy use of all countries considered, hence, a large retrofit market; slight increase since 1973 but decreasing since 1978; decreasing trend projected to continue through 2000.
- Coal's share of residential/commercial energy use is low and has decreased since 1973; decreases are projected to continue.

- A high percentage of the population is in small-medium cities; 11 cities of more than 500,000 persons; negative population growth projected for 1980-2000.
- Installed DH capacity; 52% of combined heat and power capacity is coal-fired; government is investing in development of coal-fired combined heat and power systems.
- Twice as much oil as gas is used in this sector.

Greece

Factor 4 rating: Low-medium

- Second lowest 1985 residential/commercial energy use of all countries considered [8.5 Mt (ce)], but increasing at 2%/yr since 1973; increases projected to continue at 2.9%/yr through 2000.
- Coal has a very low share of residential/commercial energy and this share has been decreasing; decreases are projected to continue.
- No gas is used in the residential/commercial sector.
- A high percentage of the population is in large cities; moderately low population growth is projected for 1980-2000.

Italy

Factor 4 rating: Medium-high

- Moderately high residential/commercial energy use [52 Mt (ce)], increasing at 1%/yr since 1973; increases are projected to continue at 1%/yr through 2000.
- Coal's share of residential/commercial energy is very low (0.3%) but has been stable since 1978; projected to increase by 2000.
- Moderately high percentage of the population is in large cities; low population growth is projected for 1980-2000.
- About 40% more oil than gas is used in this sector.

Japan

Factor 4 rating: Medium-high

- Second highest residential/commercial energy use of all countries considered [93 Mt (ce)], increasing at 2%/yr since 1973; increases are projected to continue at 2%/yr through 2000.
- Coal's share of residential/commercial energy is very low (<1%) and has been decreasing since 1973; slight decrease projected by 2000.
- Moderate-size population in large cities; moderately high population growth is projected for 1980-2000.
- Four times more oil than gas is used in this sector.

Netherlands Factor 4 rating: Low

- Moderate level of residential/commercial energy use [30 Mt (ce)]; that level has been roughly stable since 1973 but is projected to decrease by 2000.
- Coal has a very low share of residential/commercial energy (0.3%), but the share has been constant since 1978; a slight increase is projected by 2000.
- A high percentage of the population is in small-medium cities; moderately low population growth projected for 1980-2000.
- Installed DH capacity; government subsidizes DH systems; no coal is used in these systems.
- Domestic gas supplies most of the residential/commercial energy.

Portugal Factor 4 rating: Low

- Lowest 1985 residential/commercial energy use of countries considered [3 Mt (ce)], but this has been increasing since 1973; the increasing trend is projected to continue, but energy use will still be low [4 Mt (ce)] in 2000.
- No historical or projected coal use in this sector (1973-2000).
- High ratio of oil use to gas use in this sector.
- Fairly low percentage of urban dwellers in total population; only one city of more than 500,000; moderately high population growth projected for 1980-2000.

Spain Factor 4 rating: Medium-high

- Moderately low residential/commercial energy use [16 Mt (ce)], but increasing at 3.6%/yr since 1973; increases are projected to continue at 1%/yr through 2000.
- Coal has a low share of residential/commercial energy (3%), but the share has been increasing since 1978; increases are projected to continue through 2000, when 8% of residential/commercial energy is to be supplied by coal.
- High oil/gas use ratio in the residential/commercial sector.
- A high percentage of urban dwellers in the total population, about evenly split between large and small-medium cities; moderately high population growth is projected for 1980-2000.

Sweden Factor 4 rating: Low-medium

- Moderately low residential/commercial energy use [20 Mt (ce)], decreasing since 1978; decreases are projected to continue through 2000.

- Coal's share of residential/commercial energy is very low (2%); no coal was used in 1978; a small increase in coal use is projected by 2000.
- Very high oil/gas use ratio (i.e., practically no gas is used) in this sector.
- A high percentage of urban dwellers in the total population, more in small-medium cities than in large ones; no population growth projected.
- Installed DH capacity; a small amount of DH capacity is coal-fired; government encourages expansion of coal-based DH systems.

Turkey

Factor 4 rating: High

- Moderately low residential/commercial energy use [22 Mt (ce)], increasing since 1973; projected almost to double by 2000.
- High 1985 coal share of residential/commercial energy use (13%), increasing since 1978; projected to double by 2000 [an increase in coal use of 9 Mt (ce) between 1985 and 2000].
- Very high oil/gas ratio (almost no gas used) in this sector.
- Only about half the population is urban; cities are primarily small-medium; projected population growth is the highest of all countries considered (about 2%/yr for 1980-2000).
- No installed DH capacity; R&D is being carried out.

UK

Factor 4 rating: Low-medium

- High residential/commercial energy use [83 Mt (ce)]; increasing since 1973; projected to remain roughly stable through 2000.
- High competition from domestic natural gas.
- Coal's share of residential/commercial energy was high (13%) in 1985, but decreasing since 1973; decreases are projected to continue through 2000.
- Highly urbanized; about half of the cities are large (17 cities of more than 500,000 persons); low population growth projected for 1980-2000.
- Installed DH capacity (no information on fuels used); no government policy on DH.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 4 (see Sec. 2.2.1).

TABLE D.1 Historical and Projected Residential/Commercial Energy Use (Questions 1-3)

| Country | Total Residential/Commercial Energy Use [Mt (ce)] | | | | Average Annual Change (%) | | Absolute Change [Mt (ce)] | | 1985 Ratio of Oil to Gas Used |
|-------------|---|-------|-------|-------------------|---------------------------|------------------------|---------------------------|--------|-------------------------------|
| | 1973 | 1978 | 1985 | 2000 ^a | 1973-1985 | 1985-2000 ^a | 1985-2000 ^a | | |
| Australia | 13.1 | 13.1 | 14.9 | 20.1 | +1.1 | +2.0 | +5.2 | 3.6 | |
| Belgium | 18.4 | 19.7 | 17.6 | 17.6 | -0.4 | 0 | 0 | 2.3 | |
| Canada | 62.0 | 69.4 | 70.3 | 86.7 | +1.1 | +1.4 | +16.4 | 0.5 | |
| Finland | 10.2 | 11.0 | 10.1 | 9.4 | -0.1 | -0.5 | -0.7 | 42.0 | |
| France | 77.2 | 77.3 | 71.8 | 70.0 | -0.6 | -0.1 | -0.9 | 1.8 | |
| FRG | 112.4 | 119.4 | 115.7 | 103.3 | +0.2 | -0.8 | -12.4 | 2.1 | |
| Greece | 4.3 | 4.8 | 5.5 | 8.5 | +2.0 | +2.9 | +3.0 | Note b | |
| Italy | 45.7 | 49.4 | 51.8 | 59.3 | +1.1 | +0.9 | +7.5 | 1.4 | |
| Japan | 73.9 | 86.0 | 93.3 | 121.3 | +2.0 | +1.8 | +28.0 | 4.3 | |
| Netherlands | 29.1 | 31.2 | 29.7 | 23.9 | +0.2 | -1.4 | -5.8 | 0.1 | |
| Portugal | 2.1 | 2.5 | 3.0 | 4.1 | +3.1 | +2.2 | +1.1 | 15.0 | |
| Spain | 10.4 | 12.8 | 15.9 | 18.6 | +3.6 | +1.1 | +5.8 | 11.5 | |
| Sweden | 20.4 | 20.7 | 19.8 | 17.3 | -0.3 | 0.9 | -2.5 | 72.0 | |
| Turkey | 16.0 | 18.5 | 21.8 | 42.0 | +2.6 | +4.5 | +20.2 | 53.0 | |
| UK | 73.5 | 77.3 | 82.7 | 82.9 | +1.0 | 0 | +0.2 | 0.3 | |

^aProjected.^bNo gas used.

Source: Ref. 1.

TABLE D.2 Coal Share of Total Residential/Commercial Energy Use (Questions 4 and 5)

| Country | Coal Share of Total Energy Use (%) | | | | Projected Average Annual Change in Coal Use, 1985-2000 | |
|-------------|------------------------------------|------|------|-------------------|--|--------|
| | 1973 | 1978 | 1985 | 2000 ^a | Mt (ce) | % |
| Australia | 3.1 | 3.1 | 1.3 | 1.4 | +0.1 | +1.33 |
| Belgium | 16.8 | 7.6 | 8.0 | 4.0 | -0.7 | -4.33 |
| Canada | 1.0 | 0.3 | 0.3 | 0.1 | -0.1 | -0.45 |
| Finland | 2.0 | 0.9 | 5.0 | 21.3 | +1.5 | +9.75 |
| France | 11.0 | 7.4 | 5.4 | 13.5 | +5.7 | +6.21 |
| FRG | 13.2 | 6.3 | 5.7 | 3.5 | -3.0 | -4.03 |
| Greece | 2.3 | 0 | 1.8 | 1.1 | <0.1 | +3.80 |
| Italy | 1.5 | 0.6 | 0.6 | 2.3 | +1.1 | +11.14 |
| Japan | 3.3 | 0.9 | 0.6 | 0.5 | <0.1 | -0.15 |
| Netherlands | 1.7 | 0.3 | 0.3 | 0.8 | +0.1 | +2.19 |
| Portugal | 0 | 0 | 0 | 0 | <0.1 | +17.09 |
| Spain | 3.8 | 2.3 | 3.1 | 8.0 | +1.0 | +7.04 |
| Sweden | 0.4 | 0 | 2.0 | 2.8 | +0.1 | +2.19 |
| Turkey | 11.9 | 11.4 | 13.3 | 27.0 | +8.5 | +9.62 |
| UK | 25.4 | 16.6 | 13.1 | 8.6 | -0.7 | -2.73 |

^aProjected.

Source: Ref. 1.

TABLE D.3 Population and Urbanization Statistics (Questions 6 and 7)

| Country | Average Annual Population Growth, 1980-2000 (%) | 1984 | | 1980 Share | | 1980 Share | |
|-------------|--|---|---|---|---|---|-----------------------------------|
| | | Urban Share of Total Population ^a (%) | Urban Share of Urban Population in Largest City (%) | Urban Share of Urban Population in Largest City (%) | Urban Share of Urban Population in Cities of > 500,000 (%) | Urban Share of Urban Population in Cities of > 500,000 (%) | Cities of > 500,000 in 1980 |
| Australia | 1.1 | 86 | 24 | 68 | 5 | | |
| Belgium | 0.1 | 89 | 14 | 24 | 2 | | |
| Canada | 0.9 | 75 | 18 | 62 | 9 | | |
| Finland | 0.3 | 60 | 27 | 27 | 1 | | |
| France | 0.5 | 81 | 23 | 34 | 6 | | |
| FRG | -0.1 | 86 | 18 | 45 | 11 | | |
| Greece | 0.4 | 65 | 57 | 70 | 2 | | |
| Italy | 0.2 | 71 | 17 | 52 | 9 | | |
| Japan | 0.5 | 76 | 22 | 42 | 9 | | |
| Netherlands | 0.4 | 76 | 9 | 24 | 3 | | |
| Portugal | 0.6 | 31 | 44 | 44 | 1 | | |
| Spain | 0.7 | 77 | 17 | 44 | 6 | | |
| Sweden | 0.0 | 86 | 15 | 35 | 3 | | |
| Turkey | 2.0 | 46 | 24 | 42 | 4 | | |
| UK | 0.1 | 92 | 20 | 55 | 17 | | |

^aEstimates are based on different national definitions of "urban," so comparisons between countries should be made with caution.

Source: Ref. 13.

TABLE D.4 Residential/Commercial District Heating Systems^a
(Question 8)

| Country | Installed Capacity (1981) | | | |
|----------------------|---------------------------|-------------------|-------------------------|-------------------|
| | Heating Only | | Combined Heat and Power | |
| | MW (thermal) | Coal Share (%) | MW (thermal) | Coal Share (%) |
| Belgium | 741 | na ^b | 193 | 100 |
| Finland ^c | 5,163 | na | 3,964 | 38 |
| FRG | 9,950 | 15 | 21,050 | 52 |
| Netherlands | 991 | 0 | 556 | 0 |
| Sweden | 12,800 | 4 ^d | 4,000 | na |
| Turkey | None | -- | None | -- |
| UK | 5,707 | na | 93 | na |

^aOnly countries for which information is available are shown. The other OECD countries are assumed to have little DH capacity.

^bData not available.

^cContracts have recently been let for a number of small, gas-fired combined heat and power plants. However, the domestic gas grid is limited to major population centers.

^dIncludes wood.

Sources: Refs. 6 and 12.

TABLE D.5 Institutional Factors Affecting District Heating Programs (Question 9)

| Country | Comment |
|-------------|---|
| Belgium | There is a program to look into rational use of energy in the domestic (buildings) sector that could favor DH. |
| Finland | Government gives priority to combined electricity and heat supply in industrial and municipal back-pressure power plants when electric capacity is increased. A policy objective is to increase DH capacity by 600-700 MW/yr during the 1980s. DH schemes are supported in areas where economically justified, and combined heat and power projects are promoted by long-term loans. |
| FRG | Government places heavy emphasis on development of DH-based systems, particularly coal-fired combined heat and power and waste heat recovery systems. The government has invested U.S. \$3.0 billion over 1981-85 and U.S. \$2.5 billion over 1986-1990 for, among other things, the construction of new or the extension of existing coal-fired combined heat and power systems, conversion of oil or gas-fired combined heat and power systems to coal, and conversion of existing coal combustion plants to combined production. |
| Netherlands | Government subsidizes DH projects (based on the total energy saved over the life of the project) with risk-bearing loans of up to 15-20% of total capital expenditure. However, social housing policy is a constraint: government financing does not allow for use of capital-intensive systems like DH. Also, there is a trend toward more insulation and less energy use. |
| Sweden | Government has introduced measures to encourage development of DH systems and believes that the expansion of DH in the next decade should be based primarily on coal. |
| Turkey | R&D is being carried out on DH. |
| UK | Government has not formulated a policy on DH, but it has commissioned some studies. The National Coal Board operates a number of coal-fired, heating-only DH schemes. There is some concern about eventually switching to combined production because of the relatively high price of British coal. |

Source: Ref. 6.

APPENDIX E:

FACTOR 5, INDUSTRIAL ENERGY DEMAND

RATINGS AND REASONS, BY COUNTRY

Australia Factor 5 rating: Medium-high

- Moderate level of industrial energy use [27 Mt (ce)], increasing since 1973; moderately high projected growth between 1985 and 2000 [13 Mt (ce)].
- Coal has a moderate share of industrial energy use (13%); coal's share was lower in 1985 than in 1973, but higher in 1985 than in 1978; slight decrease in coal share is projected by 2000.
- Large decrease in coal's share in cement and food/tobacco industries since 1970 (reconversion is possible).
- Equal amounts of oil and gas are used in industry.

Belgium Factor 5 rating: Low

- Low industrial energy use [15 Mt (ce)], decreasing since 1973; low projected growth [1.4 Mt (ce) increase] between 1985 and 2000.
- Coal has a moderate share of industrial energy use (7%), stable since 1973; small projected increase in coal share (to 10% by 2000), but the absolute amount of additional coal used will be small.
- Coal supplies a moderately low share of energy for most industry categories; high (42%) 1985 coal share of total energy used in the cement industry, which could be close to the maximum the industry could use.
- Somewhat more oil than gas is used in industry.

Canada Factor 5 rating: Medium-high

- High industrial energy use [84 Mt (ce)], increasing since 1973; high projected growth [34 Mt (ce) to be added between 1985 and 2000].
- Coal has a low share of industrial energy use (3%), decreasing from 5% in 1973; a small increase is projected in coal share, to 6% in 2000.

- In 1985, coal's share of energy in most industry categories was moderately low; its share of energy used in the cement industry was moderately high (32%), up from 17% in 1970; coal was eliminated in the transportation equipment and food/tobacco industries between 1970 and 1985 (reconversion is possible).
- Equal amounts of oil and gas are used in industry.
- Several small steel mills; coal's share in the iron and steel industry dropped between 1973 and 1985.

Finland

Factor 5 rating: Low

- Low industrial energy use [13 Mt (ce)], increasing since 1978; moderate projected growth [an increase of 5 Mt (ce) between 1985 and 2000].
- Coal's share of industrial energy use is moderate (8%) and roughly stable since 1973; projected increase in coal share is insignificant, but coal use is expected to continue in industrial plants.
- Coal's share of energy across industry categories is low.
- Eight times more oil than gas is used in the industrial sector.
- Some small steel mills.

France

Factor 5 rating: Medium-high

- Industrial energy use is moderately high [61 Mt (ce)] but decreasing since 1973; no projected growth, but a large potential retrofit market.
- Moderate coal share of industrial energy (8%), increasing since 1973; coal's share is projected to increase to 12% by 2000.
- Moderate coal share of energy used in most industry categories; somewhat higher coal share in "other industry" category. Coal's share in cement and chemical industries declined between 1970 and 1985 but grew in other industries.
- Twice as much oil as gas is used by industry.
- Many small steel mills; growth is projected in energy use in the steel industry.

FRG

Factor 5 rating: Medium-high

- High industrial energy use [96 Mt (ce)], decreasing slightly since 1973; no projected growth, but large potential retrofit market.
- Coal's share of industrial energy use is moderate (10%), increasing since 1973 but projected to decrease by 2000.
- Coal's share of energy in all selected industries except cement decreased between 1970 and 1985.

- About twice as much oil as gas is used in industry.
- Many small steel mills.

Greece

Factor 5 rating: Medium-high

- Low industrial energy use [6 Mt (ce)], increasing since 1973; moderate projected increase by 2000 [3 Mt (ce)].
- High coal share of industrial energy, increasing from 8% in 1973 to 28% in 1985; projected to remain stable.
- Increasing coal share in cement industry (from 20% in 1970 to 70% in 1985), as well as in the chemical and transportation equipment industry.
- Noncoal energy source is primarily oil.

Italy

Factor 5 rating: Medium-high

- Moderately high industrial energy use [53 Mt (ce)], decreasing since 1973; moderately low [7 Mt (ce)] increase projected by 2000.
- Coal's share of industrial energy is about 5%, up from 1.5% in 1973; projected to remain stable.
- Coal's share of energy in most industry categories declined somewhat between 1970 and 1985. The coal share was moderately high in 1985 in the cement industry (21%), an increase from 3% in 1970, and the potential could exist to increase even further.
- Almost twice as much oil as gas is used in industry.
- Many moderately small steel mills; possibility of increased coal use in the iron and steel industry (the coal share is lower than in some other countries).

Japan

Factor 5 rating: High

- Highest industrial energy use of all countries considered [143 Mt (ce)], but decreasing since 1973; high projected growth [59 Mt (ce)] between 1985 and 2000.
- Coal's share of industrial energy is moderate (8%), increasing from 1.5% in 1973 and projected to increase to 16% by 2000.
- Coal's share in the chemical industry is low, but it was high (62%) in cement industry for 1985.
- Much greater use of oil than gas.
- Several small and moderate-sized steel mills.

Netherlands Factor 5 rating: Low

- Moderate industrial energy use [28 Mt (ce)], decreasing slightly since 1973; very low projected growth.
- Coal's share of industrial energy is low (1%); stable since 1973 and projected to remain stable.
- Low coal share across industry categories.
- More gas than oil is used in industry.

Portugal Factor 5 rating: Low-medium

- Fairly low industrial energy use [6 Mt (ce)], increasing from 4 Mt (ce) in 1973; projected to almost double by 2000 [5 Mt (ce) increase between 1985 and 2000].
- Moderately low coal share of industrial energy (6%), increasing from 3% in 1978; projected to increase to 12% by 2000, but the absolute quantity of coal consumed will remain fairly small.
- Low coal share (19%) in the cement industry, indicating a potentially large coal-conversion market there.
- Only oil (no gas) is used in industry.

Spain Factor 5 rating: Medium-high

- Moderate industrial energy use [28 Mt (ce)]; small decrease since 1978; moderately high projected growth [16 Mt (ce) increase between 1985 and 2000].
- Moderately low coal share of industrial energy (6%), up from 2% in 1978; increase to 12% projected by 2000.
- Coal's share declined in the chemical industry, from 16% in 1970 to 3% in 1985 (potential reconversion); large increase in coal's share in "other industry" category between 1970 and 1985.
- Ten times more oil than gas is used in industry.

Sweden Factor 5 rating: Low

- Fairly moderate industrial energy use [18 Mt (ce)], decreasing since 1973; low projected growth.
- Low coal share of industrial energy use (4%), increasing slightly since 1973; projected to increase slightly by 2000 (to 5%).
- Low coal share across most industry categories; high 1985 coal share (41%) of energy used in the cement industry (may have reached maximum).
- Industry uses mostly oil.

Turkey Factor 5 rating: High

- Low industrial energy use [11 Mt (ce)], increasing since 1973; projected to grow by 27 Mt (ce) from 1985 to 2000.
- Moderately high coal share of industrial energy (18%), decreasing slightly since 1973; projected to decrease slightly by 2000 (but still remaining high relative to other countries considered).
- Coal supplies a large share of the energy used in three industry categories: transportation equipment and machinery, food and tobacco, and "other." Decreasing coal share between 1970 and 1985 in the chemical industry (possible reconversion).
- Only oil (no gas) is used in industry.
- Steel industry is projected to grow rapidly.

UK Factor 5 rating: Medium-high

- Moderately high industrial energy use [57 Mt (ce)], decreasing since 1973; moderate projected growth by 2000 [8 Mt (ce) increase]; thus moderately high retrofit and moderate new-combustor markets.
- Moderate coal share of industrial energy use, increasing since 1978; projected to increase to 15% by 2000.
- Coal share of energy use was much higher in the past (coal share decreased between 1970 and 1985 in all industry categories), indicating a potential for reconversion.
- About equal amounts of oil and gas are used in industry.
- Many small steel mills, but the iron and steel industry is not projected to grow.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 5 (See Sec. 2.2.2).

TABLE E.1 Industrial Sector Energy Use, 1973-2000 (Questions 1-4)

| Country | Total ^a [Mt (ce)] | | | | Change, 1985-2000 ^b [Mt (ce)] | Coal Share of Total (%) | | | | 1985 Oil/Gas Ratio |
|-------------|------------------------------|-------|-------|--------------------|--|-------------------------|------|------|-------------------|--------------------------|
| | 1973 | 1978 | 1985 | 2000 ^b | | 1973 | 1978 | 1985 | 2000 ^b | |
| Australia | 21.7 | 24.8 | 27.1 | 40.5 ^c | +13.4 | 16.1 | 10.0 | 12.9 | 10.6 | 1.0 |
| Belgium | 20.8 | 19.4 | 14.8 | 16.2 | + 1.4 | 7.2 | 8.2 | 7.4 | 9.8 | 1.5 |
| Canada | 64.1 | 77.0 | 83.6 | 117.6 ^d | +34.0 | 4.8 | 2.6 | 2.6 | 5.9 | 0.9 |
| Finland | 12.6 | 11.5 | 13.1 | 18.5 ^d | + 5.4 | 7.9 | 5.2 | 7.6 | 8.1 | 7.6 |
| France | 73.4 | 70.8 | 61.3 | 60.6 | - 0.7 | 5.5 | 3.3 | 7.9 | 12.0 | 1.8 |
| FRG | 101.1 | 96.9 | 95.9 | 95.7 ^d | - 0.2 | 5.6 | 6.5 | 9.9 | 6.5 | 1.7 |
| Greece | 4.8 | 5.7 | 6.1 | 9.0 ^d | + 2.9 | 8.3 | 7.0 | 27.8 | 27.7 | 29.0 |
| Italy | 66.8 | 61.0 | 53.2 | 60.2 ^d | + 7.0 | 1.5 | 1.8 | 4.8 | 4.9 | 1.7 |
| Japan | 177.7 | 162.0 | 142.7 | 202.0 ^d | +59.3 | 1.5 | 1.8 | 7.7 | 16.1 | 17.0 |
| Netherlands | 29.8 | 31.7 | 27.8 | 29.1 | + 1.3 | 1.3 | 0.9 | 1.4 | 1.3 | 0.8 |
| Portugal | 3.8 | 4.9 | 6.4 | 11.5 | + 5.1 | 2.6 | 2.0 | 6.2 | 12.1 | Note e |
| Spain | 26.5 | 30.7 | 28.1 | 44.3 ^d | +16.2 | 7.9 | 2.2 | 8.5 | 16.2 | 9.9 |
| Sweden | 21.5 | 19.2 | 17.7 | 21.4 | + 3.7 | 2.3 | 2.6 | 3.9 | 5.1 | 57.0 |
| Turkey | 5.7 | 9.8 | 11.3 | 38.0 | +26.7 | 21.0 | 17.3 | 7 | 16.8 | Note e |
| UK | 89.1 | 75.9 | 57.8 | 66.2 | + 8.4 | 11.3 | 7.1 | 9.1 | 14.6 | 1.2 |

^aExcluding coal use in the iron and steel industry.

^bProjected.

^cBased on last year of available data for iron and steel consumption (1995).

^dBased on last year of available data for iron and steel consumption (1985).

^eNo gas used.

Source: Ref. 1.

TABLE E.2 Energy Use in Selected Industries (Question 5)

| Country | Cement | | | | | | Chemical | | | | | |
|-------------|--------------------|-------------------------|--------------------|-------------------------|--------------------|-------------------------|--------------------|-------------------------|--------------------|-------------------------|--------------------|-------------------------|
| | 1970 | | 1985 | | 1970 | | 1985 | | 1970 | | 1985 | |
| | Total [Mt (oe)] | Coal Mt (oe) % total | Total [Mt (oe)] | Coal Mt (oe) % total | Total [Mt (oe)] | Coal Mt (oe) % total | Total [Mt (oe)] | Coal Mt (oe) % total | Total [Mt (oe)] | Coal Mt (oe) % total | Total [Mt (oe)] | Coal Mt (oe) % total |
| Australia | 0.81 | 0.68 84.0 | 2.05 | 0.58 28.3 | 1.84 | 0.0 0.0 | 3.26 | 0.18 5.5 | 3.26 | 0.0 0.0 | 3.26 | 0.18 5.5 |
| Belgium | 0.42 | 0.0 0.0 | 1.20 | 0.50 41.7 | 3.93 | 0.13 3.3 | 4.42 | 0.06 1.4 | 4.42 | 0.13 3.3 | 4.42 | 0.06 1.4 |
| Canada | 1.45 | 0.25 17.2 | 1.58 | 0.50 31.6 | 3.96 | 0.0 0.0 | 13.39 | 0.17 1.3 | 13.39 | 0.0 0.0 | 13.39 | 0.17 1.3 |
| Finland | 0.22 | 0.0 0.0 | 0.80 | 0.50 62.5 | 0.78 | 0.01 1.3 | 1.63 | 0.05 3.1 | 1.63 | 0.01 1.3 | 1.63 | 0.05 3.1 |
| France | 2.16 | 0.73 33.8 | 3.78 | 1.22 32.3 | 10.18 | 1.35 13.3 | 16.38 | 0.84 5.1 | 16.38 | 1.35 13.3 | 16.38 | 0.84 5.1 |
| FRG | 7.72 | 1.46 18.9 | 5.98 | 2.00 33.4 | 16.07 | 2.57 16.0 | 24.58 | 2.85 11.6 | 24.58 | 2.57 16.0 | 24.58 | 2.85 11.6 |
| Greece | 0.05 | 0.01 20.0 | 1.28 | 0.89 69.5 | 0.45 | 0.08 17.8 | 0.46 | 0.16 34.8 | 0.46 | 0.08 17.8 | 0.46 | 0.16 34.8 |
| Italy | 8.32 | 0.28 3.4 | 7.40 | 1.55 20.9 | 15.24 | 0.38 2.5 | 12.50 | 1.1 1.1 | 12.50 | 0.38 2.5 | 12.50 | 1.1 1.1 |
| Japan | 7.89 | 0.0 0.0 | 7.85 | 4.86 61.9 | 35.60 | 0.0 0.0 | 30.72 | 2.7 2.7 | 30.72 | 0.0 0.0 | 30.72 | 2.7 2.7 |
| Netherlands | 0.87 | 0.01 1.1 | 0.84 | 0.10 11.9 | 6.73 | 0.23 3.4 | 12.56 | 0.33 2.6 | 12.56 | 0.23 3.4 | 12.56 | 0.33 2.6 |
| Portugal | 0.42 | 0.0 0.0 | 1.07 | 0.19 17.8 | 0.41 | 0.0 0.0 | 1.23 | 0.02 1.6 | 1.23 | 0.0 0.0 | 1.23 | 0.02 1.6 |
| Spain | 0.28 | 0.0 0.0 | 3.51 | 1.29 36.8 | 2.42 | 0.38 15.7 | 6.52 | 0.20 3.1 | 6.52 | 0.38 15.7 | 6.52 | 0.20 3.1 |
| Sweden | 1.01 | 0.0 0.0 | 0.59 | 0.24 40.7 | 1.73 | 0.04 2.3 | 1.45 | 0.06 4.1 | 1.45 | 0.04 2.3 | 1.45 | 0.06 4.1 |
| Turkey | 0.0 | 0.0 0.0 | 0.29 | 0.0 0.0 | 0.49 | 0.21 42.9 | 0.90 | 0.11 12.2 | 0.90 | 0.21 42.9 | 0.90 | 0.11 12.2 |
| UK | 6.85 | 3.46 50.5 | 3.65 | 1.20 32.9 | 14.22 | 2.43 17.1 | 12.84 | 0.38 3.0 | 12.84 | 2.43 17.1 | 12.84 | 0.38 3.0 |

TABLE E.2 (Cont'd)

| Country | Transportation Equipment | | | | | | Food/Tobacco | | | | | |
|-------------|--------------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|
| | 1970 | | 1985 | | 1985 | | 1970 | | 1985 | | 1985 | |
| | Total [Mt (oe)] | Coal Mt (oe) | Total [Mt (oe)] | Coal Mt (oe) | Total [Mt (oe)] | Coal Mt (oe) | Total [Mt (oe)] | Coal Mt (oe) | Total [Mt (oe)] | Coal Mt (oe) | Total [Mt (oe)] | Coal Mt (oe) |
| Australia | 0.0 | 0.0 | 0.59 | 0.01 | 1.7 | 0.14 | 0.14 | 100.0 | 2.83 | 0.25 | 8.8 | 0.25 |
| Belgium | 0.06 | 0.0 | 0.52 | 0.01 | 1.9 | 0.0 | 0.0 | 0.0 | 0.88 | 0.12 | 13.6 | 0.12 |
| Canada | 0.33 | 0.10 | 0.66 | 0.0 | 0.0 | 0.06 | 0.06 | 18.2 | 0.88 | 0.0 | 0.0 | 0.0 |
| Finland | 0.16 | 0.0 | 0.34 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.59 | 0.03 | 5.1 | 0.03 |
| France | 1.12 | 0.0 | 3.59 | 0.14 | 3.9 | 0.0 | 0.0 | 0.0 | 3.50 | 0.26 | 7.4 | 0.26 |
| FRG | 4.60 | 1.00 | 5.83 | 0.42 | 7.2 | 0.67 | 0.67 | 18.4 | 3.65 | 0.30 | 8.2 | 0.30 |
| Greece | 0.0 | 0.0 | 0.05 | 0.01 | 20.0 | 0.0 | 0.0 | 0.0 | 0.29 | 0.01 | 3.4 | 0.01 |
| Italy | 3.26 | 0.25 | 3.21 | 0.05 | 1.6 | 0.04 | 0.04 | 2.0 | 1.87 | 0.02 | 1.1 | 0.02 |
| Japan | 0.0 | 0.0 | 3.27 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.06 | 0.0 | 0.0 | 0.0 |
| Netherlands | 0.0 | 0.0 | 0.79 | 0.01 | 1.3 | 0.0 | 0.0 | 0.0 | 1.55 | 0.03 | 1.9 | 0.03 |
| Portugal | 0.0 | 0.0 | 0.08 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.43 | 0.0 | 0.0 | 0.0 |
| Spain | 0.01 | 0.0 | 0.98 | 0.06 | 6.1 | 0.0 | 0.0 | 0.0 | 1.54 | 0.02 | 1.3 | 0.02 |
| Sweden | 0.65 | 0.0 | 0.91 | 0.02 | 2.2 | 0.0 | 0.0 | 0.0 | 0.53 | 0.03 | 5.7 | 0.03 |
| Turkey | 0.0 | 0.0 | 0.07 | 0.02 | 28.6 | 0.0 | 0.0 | — | 0.42 | 0.22 | 52.4 | 0.22 |
| UK | 5.27 | 0.36 | 5.09 | 0.23 | 4.5 | 1.32 | 1.32 | 30.6 | 3.35 | 0.23 | 6.9 | 0.23 |

TABLE E.2 (Cont'd)

| Country | Other Industries ^a | | | | | | | |
|-------------|-------------------------------|------|------|--------------------|------|------|--------------------|---------|
| | 1970 | | | | 1985 | | | |
| | Total [Mt (oe)] | Coal | | Total [Mt (oe)] | Coal | | Total [Mt (oe)] | % total |
| Australia | 10.32 | 1.74 | 16.9 | 8.12 | 1.46 | 18.0 | | |
| Belgium | 4.75 | 0.70 | 14.7 | 36.16 | 0.08 | 0.2 | | |
| Canada | 24.70 | 2.49 | 10.1 | 35.08 | 0.91 | 2.6 | | |
| Finland | 5.14 | 0.74 | 14.4 | 4.86 | 0.08 | 1.6 | | |
| France | 26.82 | 1.93 | 7.2 | 9.47 | 0.96 | 10.1 | | |
| FRG | 13.31 | 1.36 | 10.2 | 10.86 | 1.07 | 9.9 | | |
| Greece | 1.43 | 0.08 | 5.6 | 2.09 | 0.14 | 6.7 | | |
| Italy | 5.90 | 0.04 | 0.7 | 5.52 | 0.05 | 0.9 | | |
| Japan | 33.57 | 3.15 | 9.4 | 38.17 | 2.03 | 5.3 | | |
| Netherlands | 3.03 | 0.21 | 6.9 | 2.14 | 0.0 | 0.0 | | |
| Portugal | 1.43 | 0.18 | 12.6 | 1.26 | 0.09 | 7.1 | | |
| Spain | 9.10 | 1.20 | 13.2 | 3.65 | 1.39 | 35.6 | | |
| Sweden | 7.66 | 0.38 | 5.0 | 7.27 | 0.17 | 2.3 | | |
| Turkey | 4.72 | 0.23 | 4.9 | 4.83 | 1.01 | 20.9 | | |
| UK | 16.75 | 3.93 | 23.5 | 9.75 | 1.68 | 17.2 | | |

^aExcluding iron and steel industry.

Source: Ref. 4.

TABLE E.3 Chief Industries in OECD Countries (Question 6)

| Country | Major Industries |
|-------------|--|
| Australia | Mining, manufacturing, transportation |
| Belgium | Machinery, iron and steel, coal, textiles, chemicals, glass |
| Canada | Motor vehicles and parts, fish products, forest products, petroleum and natural gas, telecommunications, processed and unprocessed minerals |
| Finland | Metal and steel, forest products, foodstuffs, textiles, clothing |
| France | Steel, machinery, textiles and clothing, chemicals, food processing, aircraft, electronics |
| FGR | Iron and steel, coal, chemicals, electrical products, ships, vehicles |
| Greece | Processed food, textiles, metals, chemicals, electrical equipment, cement, glass, transportation equipment, petroleum products, construction, electrical power |
| Italy | Automobiles, machinery, chemicals, textiles, shoes |
| Japan | Machinery and equipment, metals and metal products, textiles, automobiles, chemicals, electrical and electronic equipment |
| Netherlands | Petroleum refining, steel, metal products, electronics, bulk chemicals, natural gas |
| Portugal | Textiles, footwear, wood and pulp, paper, cork, metal-working, ore processing, chemicals, fish canning, wine |
| Spain | Processed foods, textiles, footwear, petrochemicals, steel, automobiles, consumer goods, ships |
| Sweden | Machinery |
| Turkey | Textiles, processed foods, iron and steel, cement, leather goods |
| UK | Steel, motor vehicles and aircraft, construction, electronics, chemicals |

Source: Ref. 14.

TABLE E.4 Energy Use in the Iron and Steel Industry (Question 7)

| Country | 1970 | | | 1985 | | | 2000 ^a | | |
|-------------|-----------|---------|---------|-----------|---------|---------|-------------------|---------|---------|
| | Total | | Coal | Total | | Coal | Total | | Coal |
| | [Mt (ce)] | Mt (ce) | % total | [Mt (ce)] | Mt (ce) | % total | [Mt (ce)] | Mt (ce) | % total |
| Australia | 7.2 | 5.7 | 79.2 | 5.2 | 4.1 | 78.8 | na ^b | na | — |
| Belgium | 10.5 | 7.5 | 71.4 | 6.6 | 4.9 | 74.2 | 4.7 | 3.3 | 70.2 |
| Canada | 7.1 | 5.6 | 78.9 | 9.0 | 5.7 | 63.3 | na | na | — |
| Finland | 0.7 | 0.3 | 42.9 | 1.3 | 0.5 | 38.5 | na | na | — |
| France | 19.8 | 13.1 | 66.2 | 11.8 | 8.5 | 72.0 | 12.3 | 10.0 | 81.3 |
| FRG | 33.0 | 19.7 | 59.7 | 24.2 | 17.3 | 71.5 | na | na | — |
| Greece | 0.8 | 0.3 | 37.5 | 0.3 | 0.0 | 0.0 | na | na | — |
| Italy | 10.3 | 4.9 | 47.6 | 11.0 | 5.9 | 53.6 | na | na | — |
| Japan | 73.5 | 48.4 | 65.9 | 51.6 | 39.7 | 76.9 | na | na | — |
| Netherlands | 3.9 | 2.2 | 56.4 | 3.2 | 2.4 | 75.0 | 4.7 | 3.4 | 72.3 |
| Portugal | 0.3 | 0.2 | 66.7 | 0.3 | 0.2 | 66.7 | 0.7 | 0.5 | 71.4 |
| Spain | 8.5 | 5.5 | 64.7 | 6.6 | 4.0 | 60.6 | na | na | — |
| Sweden | 3.3 | 1.3 | 39.4 | 2.4 | 1.2 | 50.0 | 2.6 | 1.4 | 53.8 |
| Turkey | 1.1 | 0.9 | 81.8 | 3.1 | 2.3 | 74.2 | 16.5 | 14.3 | 86.7 |
| UK | 21.7 | 12.2 | 56.2 | 10.1 | 6.5 | 64.4 | 8.6 | 5.7 | 66.3 |

^aProjected.

^bData not available.

Source: Ref. 1.

TABLE E.5 Number of Small Steel Mills in OECD Countries (Question 8)

| Country | Capacity Between 5×10^5 and 10^6 t/yr | Capacity Between 10^5 and 5×10^5 t/yr | Capacity less than 10^5 t/yr | Unknown Capacity ^a | Total |
|-------------|---|---|--------------------------------------|----------------------------------|-------|
| Australia | 2 | 1 | 4 | 2 | 9 |
| Belgium | 0 | 1 | 3 | -- | 4 |
| Canada | 1 | 7 | 8 | 7 | 23 |
| Finland | 0 | 1 | 2 | --- | 3 |
| France | 1 | 13 | 16 | -- | 30 |
| FRG | 1 | 5 | 17 | -- | 23 |
| Greece | 0 | 0 | 0 | -- | 0 |
| Italy | 2 | 21 | 9 | -- | 31 |
| Japan | 3 | 13 | 8 | -- | 24 |
| Netherlands | 0 | 0 | 0 | -- | 0 |
| Portugal | 1 | 1 | 0 | -- | 2 |
| Spain | 1 | 8 | 5 | -- | 14 |
| Sweden | 0 | 10 | 6 | -- | 16 |
| Turkey | 2 | 8 | 5 | 1 | 16 |
| UK | 1 | 10 | 23 | --- | 34 |

^aMills for which plant capacity data are not available that have fewer than 500 employees.

Sources: Refs. 21 and 22.

APPENDIX F:

FACTOR 6, TRADE RELATIONSHIP WITH THE UNITED STATES*

RATINGS AND REASONS, BY COUNTRY

Australia Factor 6 rating: Medium-high

- About one-fourth of total imports have been from the United States since 1984.
- Boilers are imported from the United States.
- High level of U.S. investment in Australia.
- Conventional U.S. boilers are manufactured under license.
- Trade deficit with the United States.
- Overall trade deficit; current account deficit.
- Member of the ANZUS alliance.

Belgium Factor 6 rating: Medium-high

- Boilers are imported from and exported to the United States.
- The United States holds about 20% of the Belgian market for pollution control equipment; a great increase in this market is expected.
- Conventional U.S. boilers are manufactured under license.
- Strong U.S. security/defense partner; significant U.S. presence in Belgium.
- Trade balance with the United States is roughly in equilibrium.
- 5% of imports are from the United States; ranks below the top ten countries in imports from and exports to the United States.
- Small overall trade deficit, but current account surplus.

Canada Factor 6 rating: High

- Large trade surplus with the United States.
- Overall trade surplus, but current account deficit.
- 70% of imports are from the United States; the United States and Canada are each other's largest trading partner.
- Energy R&D agreements with the United States.
- The United States and Canada are engaged in trade negotiations, seeking to reduce or eliminate various tariff and nontariff barriers to trade.

*Trade statistics presented are for 1986 unless otherwise noted.

- 80% of all foreign investment comes from the United States.
- NATO ally.

Finland

Factor 6 rating: Low-medium

- Small trade surplus with the United States.
- Overall trade surplus, but current account deficit.
- 5% of imports are from the United States since 1984.
- The USSR has been a major trading partner, but its importance has been decreasing as Finland looks more to Western European partners.
- U.S. exports to Finland have been declining.
- No U.S. military alliance with Finland.
- Modest level of U.S. investment in Finland.

France

Factor 6 rating: Medium-high

- Trade surplus with the United States.
- Overall trade deficit; current account surplus.
- 7% of total imports are from the United States; the United States is France's third largest supplier of goods.
- The United States is France's most important investor.
- U.S. boilers and turbines are manufactured under license.
- NATO ally.

FRG

Factor 6 rating: High

- Large trade surplus with the United States.
- Overall trade surplus; current account surplus.
- 6% of imports are from the United States.
- High level of U.S. investment in the FRG.
- U.S. boilers and turbines are manufactured under license.
- Strong U.S. security/defense partner; large U.S. presence in the FRG (NATO ally).

Greece

Factor 6 rating: Low-medium

- Small trade surplus with the United States.
- Overall trade deficit, current account deficit.
- 7% of imports are from the United States; U.S. exports to and imports from Greece have been decreasing since 1984.
- Recent member of EEC; Greece is expected to look more toward European trading partners.

- 51% of steam coal imports came from the United States in 1986, 94% in 1982.
- High level of U.S. investment in Greece.

Italy

Factor 6 rating: Medium-high

- Trade surplus with the United States.
- Overall trade deficit, but current account surplus.
- 11% of total imports are from the United States; the United States is Italy's third largest trading partner for both exports and imports.
- 41% of Italy's steam coal imports came from the United States in 1985.
- U.S. pollution control equipment was in second place among Italian imports of such products in 1986.
- U.S. boilers and turbines are manufactured under license.
- Memorandum of understanding with the United States exists for cooperation in coal-related R&D.

Japan

Factor 6 rating: High

- Trade surplus with the United States.
- Overall trade and current account surpluses.
- 23% of imports were from the United States; the United States is Japan's largest export market and, next to Canada, Japan is the largest supplier of goods to the United States.
- A small amount of coal is imported from the United States.
- U.S. conventional and fluidized-bed boilers and gas turbines are manufactured under license.
- The United States accounts for more than 50% of all foreign investment in Japan.
- Bilateral and multilateral agreements with the U.S. Department of Energy.
- Strong U.S. security/defense partner.

Netherlands

Factor 6 rating: Medium-high

- The United States is the largest foreign investor in the Netherlands.
- Trade deficit with the United States.
- Overall trade and current account surpluses.
- 8% of imports are from the United States.
- Coal is imported from the United States (30% of steam coal imports in 1985, 54% in 1982).
- U.S. conventional boilers are manufactured under license.
- Open trading environment.

Portugal Factor 6 rating: Low-medium

- Trade with the United States is roughly in equilibrium.
- 7% of imports are from the United States; the United States is the fifth largest export market for Portugal.
- Coal is the second largest Portuguese import from the United States (63% of steam coal imports in 1986).
- Turning increasingly to European trading partners since accession to EEC.
- Receives U.S. AID assistance.
- NATO ally.
- Low level of U.S. investment in Portugal.

Spain Factor 6 rating: Low-medium

- Trade deficit with the United States.
- Overall trade deficit; current account surplus.
- 9% of imports are from the United States.
- Some coal imported from the United States, but Australia and South Africa have taken over the Spanish coal market.
- Fairly high levels of U.S. investment, but the FRG is by far the largest investor in Spain.
- NATO ally.

Sweden Factor 6 rating: Medium-high

- Trade surplus with the United States.
- Overall trade and current account surpluses.
- High level of U.S. investment in Sweden.
- 8% of total imports are from the United States; imports have been declining in recent years.
- NATO ally.
- Coal and coke are imported from the United States, but U.S. steam coal has been virtually replaced by imports from Australia, Poland, and the USSR.
- U.S. conventional and fluidized-bed boilers are manufactured under license.

Turkey Factor 6 rating: Medium-high

- 11% of imports are from the United States; U.S. imports from and exports to Turkey have been increasing steadily since 1984.
- Coal is the second largest import from the United States; the United States was the sole steam coal supplier in 1986.

- Import regime was recently liberalized; the government encourages importation of foreign technology.
- Receives U.S. AID assistance.
- Trade deficit with the United States.
- Overall trade and current account deficits, which are typical of a newly industrializing nation.

UK

Factor 6 rating: Medium-high

- Trade surplus with the United States.
- Overall trade and current account deficits.
- 11% of total imports are from the United States; the UK is the fifth largest purchaser of U.S. goods (including power-generating equipment).
- 26% of coal imports were from the United States in 1986.
- The United States is a major foreign investor in the UK.
- U.S. conventional boilers and gas turbines are manufactured under license.
- Coal research agreements exist with the United States.
- Major U.S. security/defense partner (NATO ally).

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 6 (see Sec. 2.3.1).

TABLE F.1 Indicators of Trade Relations (Questions 1-3)^a

| Country | Trade Account Balance ^b | Current Account Balance ^c | Main U.S. Exports to | Main U.S. Imports from | U.S. Exports to (\$) | U.S. Imports from (\$) | Trade Balance with the U.S. ^d | U.S. Share of Country's Total Exports (%) | U.S. Share of Country's Total Imports (%) | Comments |
|---------------------|------------------------------------|--------------------------------------|---|--|----------------------|------------------------|--|---|---|---|
| Australia | -2,317 | -9,846 | Aircraft parts Boilers | Beef and mutton Aluminum | 5,661 ^e | 2,873 | -2,678 | 13 | 23 | The United States has had a trade surplus with Australia since 1984. The U.S. share of imports has remained about 25% since 1984. Australia is a member of the ANZUS military alliance. |
| Belgium | -220 | 3,000 | Grain Boilers and mechanical equipment | Film Diamonds Boilers and mechanical equipment | 3,670 | 3,672 | -2 | 5.3 | 5.4 | The United States and Belgium have had a bilateral trade balance roughly in equilibrium since 1984; no real increase in imports or exports for either country recently. Belgium ranks below the top 10 countries in imports from and exports to the United States. The United States holds about 20% of the market for pollution control equipment; increase expected in this market. Belgium is a NATO ally. |
| Canada | 7,485 | -6,693 | Autos and parts Industrial machinery | Autos and parts Lumber | 77,144 | 94,068 | +16,924 | 78 | 70 | The U.S. trade deficit with Canada has grown steadily since 1984. The United States and Canada are negotiating a bilateral free-trade agreement to reduce or eliminate tariff and non-tariff barriers to trade. The United States and Canada are each other's largest trading partners. Canada is a NATO ally. |
| Finland | 980 | -886 | Office machinery Chemicals | Forest products Skins, furs Cheese Alcoholic beverages | 734 | 781 | +47 | 4.8 | 4.8 | The U.S. share of Finland's exports and U.S. exports to Finland have been declining since 1985. The USSR has been a major trading partner, but Finland is looking more to West European partners for trade. |
| France ^f | -2,254 | 3,000 | Analytical scientific instrumentation 32% of total computer market | Food products Chemicals Aerospace and rail technology Autos | 7,159 | 9,551 | +2,392 | 7.4 | 7.5 | U.S. exports to France are increasing, but the United States still recorded a trade deficit with France in 1986. The United States is France's third largest supplier of goods. French exports to the United States are decreasing due to stronger dollar. France is a NATO ally. |

TABLE F.1 (Cont'd)

| Country | Trade Account Balance ^a | Current Account Balance ^c | Main U.S. Exports to | Main U.S. Imports from | U.S. Exports to (\$) | U.S. Imports from (\$) | Trade Balance with the U.S. ^d | U.S. Share of Country's Total Exports (%) | U.S. Share of Country's Total Imports (%) | Comments |
|---------|------------------------------------|--------------------------------------|---|---|----------------------|------------------------|--|---|---|--|
| FRG | 51,879 | 35,220 | Machinery Chemicals Electronics | Autos Machinery Chemicals | 12,375 | 25,435 | +13,060 | 10.5 | 6.5 | Since 1984, the FRG has dramatically increased exports to the United States while U.S. exports to the FRG have remained level. The FRG has maintained surpluses in both overall trade and current account balances. The FRG is a strong NATO ally. |
| Greece | -5,587 | -1,704 | Raw materials Machinery and transportation equipment Coal and coke | Manufactured goods Petroleum products Beverages and tobacco | 340 | 400 | +60 | 7.1 | 3.2 | The gap between the U.S. exports to and U.S. imports from Greece has been closing since 1984, while U.S. imports from Greece have remained steady. Greece recently joined the EEC and will look more to European partners. Greece is a NATO ally. |
| Italy | -2,496 | 4,762 | Mechanical products Chemicals Energy products Coal | Mechanical equipment Textiles and apparel Metals | 5,683 | 10,465 | +4,782 | 10.7 | 5.7 | The United States trade deficit with Italy has been growing steadily since 1984. Italy recorded a current account deficit in 1985 of \$4.2 billion, and in 1986 turned that around to a \$4.8 billion surplus, while its overall trade balance remained a deficit (although the deficit is decreasing). The United States is Italy's third largest trading partner for both exports and imports. The United States is second largest supplier of pollution-control imports into Italy. Italy is a strong NATO partner. |
| Japan | 92,827 | 85,845 | Foodstuffs Chemicals Coal | Cars Office machinery Power generators | 25,935 | 79,152 | +53,217 | 38.5 | 23.0 | Japan has recorded surpluses in overall trade and current accounts. The United States maintains a large export share to Japan but is not narrowing the trade gap. Strong U.S. security/defense partner (Treaty of Mutual Cooperation between the United States and Japan). |

TABLE F.1 (Cont'd)

| Country | Trade Account Balance ^b | Current Account Balance ^c | Main U.S. Exports to | Main U.S. Imports from | U.S. Exports to (\$) | U.S. Imports from (\$) | Trade Balance with the U.S. ^d | U.S. Share of Country's Total Exports (%) | U.S. Share of Country's Total Imports (%) | Comments |
|-------------|------------------------------------|--------------------------------------|--|---|----------------------|------------------------|--|---|---|--|
| Netherlands | 3,200 | 3,600 | Machinery Animal feed Coal | Petroleum products Beer Chemicals Transportation equipment | 4,400 | 2,800 | -1,600 | 4.7 | 7.9 | The United States has maintained a bilateral trade surplus with the Netherlands since 1984; the U.S. share of total Netherlands imports remains high. The Netherlands is a NATO ally. |
| Portugal | -1,635 | 1,159 | Grain Coal Computer parts | Molds for plastic Footwear Cork Wine | 586 | 505 | -81 | 7.0 | 6.6 | The United States is fifth largest export market for Portugal. The U.S. share of Portugal's total imports has been steadily decreasing, as well as the U.S. share of Portugal's total exports. This may be a result of recent (1986) accession to EEC. Portugal receives U.S. AID assistance and is a NATO ally. |
| Spain | -6,251 | 4,131 | Soybeans Seed corn Coal | Footwear Auto parts Cement Steel Olives | 3,400 ^e | 2,500 | -900 | 9.2 | 9.2 | The U.S. share of total Spanish exports has been decreasing since 1984, and U.S. imports into Spain are decreasing as well. The EEC has supplanted the United States as the primary source of Spanish imports. Spain is a NATO ally. |
| Sweden | 4,346 | 970 | Machinery, appliances Motor vehicles Coal and coke | Cars Trucks Machinery | 2,546 | 4,205 | +1,659 | 11.3 | 7.8 | U.S. imports into Sweden have been decreasing steadily (resulting in a U.S. trade deficit with Sweden), while Swedish exports to the United States have remained steady. Sweden is a NATO ally. |
| Turkey | -3,081 ⁸ | -1,528 | Civil engineering and contracting Coal Aircraft Scrap metal | Tobacco Refined petrol products Fruit and nuts | 1,177 | 549 | -628 | 7.4 | 10.6 | U.S. imports into Turkey have been slowly increasing since 1984, while Turkish exports to the United States have recorded a similar increase, but the United States still has a trade surplus with Turkey. Turkey is a NATO ally. The government strongly encourages import of foreign technology and capital; import regime was recently liberalized. |

TABLE F.1 (Cont'd)

| Country | Trade Account Balance ^b | Current Account Balance ^c | Main U.S. Exports to | Main U.S. Imports from | U.S. Exports to (\$) | U.S. Imports from (\$) | Trade Balance with the U.S. ^d | U.S. Share of Country's Total Exports (%) | U.S. Share of Country's Total Imports (%) | Comments |
|---------|------------------------------------|--------------------------------------|---|---|----------------------|------------------------|--|---|---|--|
| UK | -1,828 | -1,439 | Office machines Electrical equipment Scientific equipment Power-generating machinery | Petroleum and petroleum products Autos and auto parts Jet engines Aircraft and parts | 12,278 ^e | 15,044 | +2,766 | 14.3 | 9.9 | While the United States is recording a trade deficit with the UK, exports to and imports from the UK have remained at a steady pace. The UK is the fifth largest purchaser of U.S. goods. The UK is a major U.S. security/defense partner. |

^aAll data presented are for 1986 in millions of 1986 U.S. dollars; exports free on board (fob); imports cost, insurance, and freight (cif), unless noted.

^bThe difference between the value of total exported goods and the value of total imported goods. Negative numbers indicate that the value of imports is greater than the value of exports (i.e., that the country has a trade-account deficit).

^cThe difference between the value of total exported goods (merchandise) and services (e.g., shipping services, travel expenditures, income on investments, governmental export of military goods to allies, and humanitarian or military aid) and the value of total imported goods and services. Negative numbers indicate that the value of imports is greater than that of exports (i.e., that the country has a current-account deficit).

^dThe difference between the value of U.S. imports from the country and U.S. exports to the country. A positive value indicates a trade imbalance in favor of the foreign nation (i.e., the country has a trade surplus with the United States), while a negative value indicates a trade imbalance in favor of the United States (i.e., the country has a trade deficit with the United States).

^eFree alongside ship (fas).

^fFrance's indicators are from the U.S. Department of Treasury (the information is not included in the Foreign Economic Trends reports).

^gTurkey is the only country that includes gold bullion imports in the trade-balance figure.

Sources: Refs. 16 and 17.

TABLE F.2 U.S. Coal Imported by OECD Countries (Question 4)

| Country | Steam Coal Imports from the United States (kt) | | | | | U.S. Share of Total Steam Coal Imports (%) | | | Comments |
|-------------|--|-------|--------|--------|-------------|--|-------|-------|---|
| | 1978 | 1980 | 1982 | 1984 | 1986 (est.) | 1978 | 1982 | 1986 | |
| Australia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- |
| Belgium | 0 | 1,436 | 1,360 | 612 | 671 | 0 | 22.4 | 15.0 | U.S. imports compete with those of the FRG and South Africa. |
| Canada | 8,796 | 9,245 | 11,141 | 11,762 | 7,672 | 100.0 | 100.0 | 100.0 | United States is the sole source of both coking and steam coal imports. |
| Finland | 0 | 533 | 678 | 1 | 396 | 0 | 14.5 | 7.3 | Imports from the USSR and Poland have been increasing. |
| France | 36 | 3,600 | 4,563 | 666 | 1,403 | 0.2 | 30.7 | 14.9 | Total U.S. coal imports to France declined between 1982 and 1986; a greater share has come from Australia in that period. |
| FRG | 32 | 1,218 | 2,486 | 1,143 | 807 | 0.5 | 23.6 | 8.2 | Imports from Poland and South Africa increased between 1982 and 1986. |
| Greece | 0 | 0 | 474 | 613 | 920 | 0 | 93.9 | 51.1 | Main U.S. competitors are Australia and South Africa. |
| Italy | 0 | 1,327 | 4,970 | 2,070 | 4,446 | 0 | 51.7 | 40.6 | Imports from South Africa increased between 1982 and 1986. |
| Japan | 0 | 385 | 1,642 | 469 | 552 | 0 | 11.4 | 2.3 | U.S. exports to Japan are small compared to those of Australia, Canada, Russia, China, and South Africa. |
| Netherlands | 14 | 1,053 | 259 | 2,132 | 2,749 | 0.6 | 53.7 | 35.3 | Imports from Australia and South Africa increased between 1982 and 1986. |
| Portugal | 0 | 0 | 28 | 0 | 940 | 0 | 62.2 | 62.7 | The rest of the imports to Portugal come primarily from South Africa and the UK. |
| Spain | 0 | 723 | 2,730 | 487 | 342 | 0 | 77.1 | 6.3 | Coal from Australia and South Africa has supplanted U.S. coal in Spain. |
| Sweden | 0 | 54 | 641 | 337 | 197 | 0 | 50.7 | 7.2 | Imports from Australia, Poland, and the USSR increased between 1982 and 1986. |
| Turkey | 0 | 0 | 0 | 0 | 122 | 0 | 0 | 100.0 | -- |
| UK | 1 | 2,167 | 395 | 400 | 1,126 | 0 | 27.8 | 26.2 | Between 1984 and 1986, U.S. and Australian imports have risen, whereas South African and Polish imports have declined. |

Source: Ref. 1.

TABLE F.3 Energy Research Agreements between OECD Countries and the U.S. Department of Energy (Question 5)

| Country | Energy Research Agreements |
|-----------|--|
| Australia | A U.S./Australian bilateral agreement in the area of coal with the U.S. Department of Energy, Office of Fossil Energy (DOE/FE), from June 1973 to June 1983 is now inactive. No funds have been budgeted or spent. There are no products resulting from this agreement; its purpose was the exchange of information concerning magnetohydrodynamics and coal conversion, extraction, processing, and mining. DOE/FE is a participant in three multilateral agreements that include Australia, and an oil shale agreement between the United States and Australia is pending. |
| Belgium | DOE/FE does not have a bilateral agreement with Belgium. |
| Canada | DOE/FE currently has four active bilateral agreements with Canada in the areas of resource characterization of tar sands, steam-flooding with additives in a tar sand deposit, dissemination of information (oil), and monitoring frontal movements in thermal recovery. The United States and Canada also participate in six multilateral agreements. |
| FRG | DOE/FE has just completed a bilateral agreement that involved the design, construction, testing, and evaluation of a plant converting approximately 100 barrels of methanol per day to gasoline/olefins in a fluidized bed reactor. The FRG currently participates in two multilateral agreements. |
| Finland | DOE/FE has a general cooperative bilateral agreement in energy research and development with Finland that has been extended until November 6, 1990, but there are no active annexes at this time. |
| France | DOE/FE does not have any bilateral or multilateral agreements with France. An enhanced oil recovery agreement between the United States and France is pending. |
| Greece | DOE/FE does not have any bilateral agreements with Greece, nor is Greece a participant in any multilateral agreements that include DOE/FE. |

TABLE F.3 (Cont'd)

| Country | Energy Research Agreements |
|-------------|--|
| Italy | DOE/FE has one memorandum of understanding for cooperation in fossil fuels research and development, the activities of which include coal/water mixtures, structure and reactivity of coal, combustion studies, enhanced oil recovery, and 11 other topics. An implementing agreement for a program for direct coal liquefaction was signed on December 5, 1985, for a five-year period. Italy also participates in two multilateral agreements that involve DOE/FE. |
| Japan | DOE/FE currently has one general bilateral agreement with the Japanese Ministry of International Trade and Industry and one memorandum of understanding with the Japanese Agency of Industrial Science and Technology. DOE/FE participates in four multilateral agreements that include Japan. |
| Netherlands | There are no bilateral agreements between the DOE/FE and the Netherlands, but there is participation in three multilateral agreements. |
| Portugal | Portugal and the DOE/FE do not participate in any energy-related agreements. |
| Spain | DOE/FE and Spain have two current bilateral agreements, one to study catalysts for the reduction of NO _x emissions and one for laboratory experiments on in-situ gasification of Spanish coal. DOE/FE and Spain also participate in two multilateral agreements. |
| Sweden | DOE/FE and Sweden do not have any bilateral energy agreements but do participate in three multilateral agreements. |
| Turkey | DOE/FE and Turkey do not participate in any energy-related agreements. |
| UK | The DOE/FE and the UK DOE have one memorandum of understanding for collaboration in energy research signed October 1984. DOE/FE and the NCB (National Coal Board), CEGB (Central Electricity Generating Board) have a memorandum of agreement signed March 1986. The United States and the UK also participate in three multilateral energy-related agreements, one of which is related to the Grimethorpe pressurized fluidized-bed test facility. |

Source: Ref. 23.

TABLE F.4 U.S. Investment in OECD Countries (Question 6)

| Country | 1986 Investment (U.S. \$, millions) | Comments |
|-----------|---|---|
| Australia | 9,120 | There are 750 U.S. companies (composed of, inter alia, subsidiaries, branches, etc.) represented in Australia. Another 500 firms have licensing agreements. The government is encouraging inward investment through liberalization of its investment review procedures. |
| Belgium | 5,229 | Over 900 U.S. companies have operations in Belgium, nearly 400 of which are regional headquarters. |
| Canada | 49,940 | The United States is Canada's principal supplier of foreign capital, accounting for 80% of all direct investment. |
| Finland | 292 | U.S. investment remains at a modest level. Only a few U.S. sales and manufacturing subsidiaries are in operation. |
| France | 8,857 | More than 600 American firms are represented in France; these firms accounted for one-fifth of all foreign investment in France. U.S. investment has been dropping over the last four years. |
| FRG | 20,846 | American direct investment in the FRG has been in all the usual forms: branch offices, subsidiaries, and joint ventures. In most cases, management has remained in German hands. The FRG's central location, liberal attitude toward foreign investment, and predominant position in Europe are highly attractive to investors. |
| Greece | 172 | Eighty-six U.S. regional marketing offices are based in Athens. There are five U.S. bank branches located in Greece. U.S. investment in Greece represents 32% of all foreign investment. Investors have enjoyed the right to full repatriation of profits earned on all investment of foreign capital made after July 25, 1986. |

TABLE F.4 (Cont'd)

| Country | 1986 Investment (U.S. \$, millions) | Comments |
|-------------|---|--|
| Italy | 6,935 | The United States has been the leading foreign investor in Italy for over a decade, with 6,500 U.S. firms represented. Some 40% of U.S. investments are wholly U.S. owned. |
| Japan | 11,332 | Japan is the eighth largest recipient of U.S. investments, accounting for more than one-half of major direct investment in Japan in 1986. The Japanese government appears to take a positive attitude toward foreign investment and its promotion. |
| Netherlands | 11,618 | The United States is the Netherlands' largest source of foreign direct investment; more than 1,000 U.S. firms have offices there. The investment environment is free of major impediments. |
| Portugal | 278 | U.S. investment in 1986 was \$13 million, which was only 8% of total 1986 foreign investment into Portugal. Some incentives for investment established in 1986 are meant to encourage efficient energy use. |
| Spain | 2,612 | New tax investment laws have been passed that are more liberal and simplified. The FRG supplies one-third of all foreign investment in Spain; the United States is a distant second. The Spanish government is actively promoting the creation of new industries and the application of new technologies to existing industries. |
| Sweden | 1,002 | There are about 170 subsidiaries and affiliates of U.S. companies operating in Sweden; over half are sales and distribution firms. Sweden does not offer special tax or other inducements to attract foreign capital. |

TABLE F.4 (Cont'd)

| Country | 1986 Investment (U.S. \$, millions) | Comments |
|---------|---|---|
| Turkey | 242 | Twenty-two American firms maintain operations in Turkey. A number are engaged in the petroleum industry. U.S. investment represents about 12% of total foreign investment in Turkey. In order to stimulate the Turkish economy, the government actively encourages the importation of foreign capital and technology. |
| UK | 35,692 | Eighty percent of approximately 2,000 U.S. branches and subsidiaries are 100% U.S. owned, concentrating mainly in export-oriented industries. The U.K. generally welcomes foreign investment; 40% of all U.S. investment in Europe is in the UK. |

Sources: Refs. 15-17.

TABLE F.5 Licensing Experience of Selected U.S. Firms in OECD Countries^a (Question 7)

| Country | Conventional Coal-Fired Boilers | Fluidized-Bed Boilers | Gas Turbines |
|-------------|---------------------------------------|--------------------------|-----------------|
| Australia | X ^b | -- | -- |
| Belgium | X | -- | -- |
| Finland | X | -- | -- |
| France | X | -- | X |
| FRG | X | -- | X |
| Greece | X | -- | -- |
| Italy | X | -- | X |
| Japan | X | X | X |
| Netherlands | X | -- | -- |
| Portugal | X | -- | -- |
| Spain | X | -- | -- |
| Sweden | X | X | -- |
| Turkey | X | -- | -- |
| UK | X | -- | X |

^aWe interviewed 11 U.S. boiler and gas-turbine manufacturers by telephone. This table is intended solely to illustrate typical licensing experiences of these manufacturers and is by no means comprehensive, since only 11 firms were contacted. Licensing agreements may also exist in other countries. Individual licensing experiences of particular firms are not presented in detail because that information is proprietary. The firms represented here are Babcock & Wilcox, Barberton, Ohio; Combustion Engineering, Windsor, Conn.; Combustion Power Co., Menlo Park, Calif.; Fluidyne Engineering Group, Minneapolis, Minn.; Foster-Wheeler Energy Corp., Livingston, N.J.; Keeler/Dorr-Oliver Boiler Co., Williamsport, Penn.; Riley-Stoker Corp., Worcester, Mass.; Pyropower Corp., San Diego, Calif.; Johnston Boiler Co., Ferrysburg, Mich.; Wormser Engineering, Inc., Woburn, Mass.; and General Electric Corp., Schenectady, N.Y.

^b"X" indicates that at least one U.S. firm licenses this technology in the country.

APPENDIX G:**FACTOR 7, LACK OF COMPETITION****RATINGS AND REASONS, BY COUNTRY****Australia** **Factor 7 rating: Low**

- Moderately high budget for coal R&D in 1983; coal has a large share of the total energy P&D budget and coal budget is increasing.
- Low level of private coal R&D.
- Moderate ACT manufacturing activity, including small AFB units.

Belgium **Factor 7 rating: Low-medium**

- Moderately low budget for coal R&D in 1986; moderately high coal share of the total energy R&D budget; stable coal R&D budget.
- Moderate level of private coal R&D.
- Low level of ACT manufacturing, but collaborative ACT R&D is underway with Germany and the Netherlands (hence, imports are more likely from those countries).

Canada **Factor 7 rating: Low-medium**

- Moderately high coal R&D budget in 1986; moderately low coal share of total energy R&D budget; decreasing coal R&D budget.
- AFB and CWM technologies being demonstrated in small units.
- Moderate level of private coal R&D.
- Some ACT manufacturing.
- Strong ACT demand and interest in U.S. suppliers.

Finland **Factor 7 rating: Low**

- Moderate level of ACT manufacturing.
- Strong domestic industry in ACTs; emphasis on heat combustion.
- Several domestic suppliers of small AFB units.

France **Factor 7 rating: Low-medium**

- Domestically manufactured conventional small boilers available.
- Some R&D on ACT is being conducted.
- Some domestic manufacturing of small FBC units.

FRG

Factor 7 rating: Low

- High budget for coal R&D in 1986; moderately high coal share of the energy R&D budget; stable coal R&D budget.
- High level of private coal R&D.
- High level of ACT manufacturing.
- Major ACT exporting country.

Greece

Factor 7 rating: High

- Low budget for coal R&D in 1986; moderately high coal share of the energy R&D budget; stable coal R&D budget.
- Low level of private coal R&D.
- Low level of ACT manufacturing.

Italy

Factor 7 rating: Low-medium

- CWM technology is produced and marketed on a commercial scale; extensive R&D program on CWM.
- Interest in coal is very recent; ACT demonstrations are planned and industrial projects are underway.
- Low budget for coal R&D; coal has a very low share of the energy R&D budget; stable coal R&D budget.

Japan

Factor 7 rating: Low

- Budget for coal R&D is the highest of all countries considered (U.S. \$202.6 million in 1986); coal's share of the energy R&D budget is fairly low; the coal R&D budget is stable.
- High level of private coal R&D.
- High level of ACT manufacturing.
- Leader in R&D and commercial activity on ACTs.

Netherlands

Factor 7 rating: Low-medium

- Moderately high budget for coal R&D; high coal share of the energy R&D budget; increasing trend in coal R&D budget.
- High level of private coal R&D.
- Domestic ACT manufacturing.
- AFB and pressurized fluidized-bed (PFB) research is ongoing, some directed at small applications.

Portugal Factor 7 rating: High

- Very low budget for coal R&D; very low coal share of the energy R&D budget; the coal R&D budget is stable.
- Low level of ACT manufacturing.

Spain Factor 7 rating: Medium-high

- Moderately low coal R&D budget; moderately high coal share of the energy R&D budget; decreasing trend in coal R&D budget.
- Moderate level of private coal R&D.
- Some domestic ACT manufacturing.
- ACTs for treatment of high-sulfur coal is a research priority.

Sweden Factor 7 rating: Low

- Low coal R&D budget; moderately high coal share of the energy R&D budget; the coal R&D budget is stable.
- High level of private coal R&D.
- High level of ACT manufacturing, including AFB.
- Leader in novel flue-gas desulfurization (FGD), AFB, and NO_x control technologies.

Turkey Factor 7 rating: High

- Low budget for coal R&D; high coal share of the total energy R&D budget; stable coal R&D budget.
- Low level of private coal R&D.
- Low level of ACT manufacturing.
- Needs ACT for clean lignite combustion.

UK Factor 7 rating: Low

- Low government budget for coal R&D; very low coal share of the total energy R&D budget; the coal R&D budget is stable.
- High level of private coal R&D.
- High level of ACT manufacturing.
- AFB is being developed for small applications.
- AFB is being manufactured by several companies.

SUPPORTING INFORMATION

The following table presents information that helped to answer the questions guiding the ratings for Factor 7 (see Sec. 2.3.2).

TABLE G.1 ACT Competition from OECD Countries (Questions 1-3)

| Country | Government Funding for Coal R&D | | | | Share of Energy R&D Budget (%) | 1986 Budget Trend | 1986 Budget (10 ⁶ U.S. \$) | 1986 Budget per million GDP | Private Coal R&D | ACT Manufacturing | Favored Technologies | Notes |
|-----------|---------------------------------|-------------|-----------------|-----------------|--------------------------------|-------------------|---------------------------------------|--|--|--|--|--|
| | 1986 Budget | 1986 Budget | 1986 Budget | 1986 Budget | | | | | | | | |
| Australia | 23.0 ^a | Up | 28 ^a | na ^b | 0.13 | Low | Medium | AFB CWM Gasification Liquefaction | AFB CWM Gasification | AFB CWM Gasification Liquefaction | AFB CWM Gasification Liquefaction | AFB pilot plants for industrial and electric-utility applications have been built. Some small AFB combustors (< 25 x 10 ⁶ Btu/h) have been installed. Babcock Australia Ltd. and other Australian firms offer small AFB units. |
| Belgium | 10.0 | Level | 14 | 0.13 | Medium | Low | Medium | AFB Gasification | AFB Gasification | AFB Gasification | AFB Gasification | Domestic R&D seems adequate to meet limited needs. No large domestic ACT industry, but collaborative R&D is being conducted with Germany and the Netherlands. Commercial fluidized-bed/gas-steam turbine for small utility applications is installed. Feasibility of converting blast furnaces to coal gasifiers is being studied. |
| Canada | 21.0 | Down | 6 | 0.06 | Medium | Medium | Medium | AFB PFB Gasification Sorbent injection Low-NO _x burner AFGC CWM | AFB PFB Gasification Sorbent injection Low-NO _x burner AFGC CWM | AFB PFB Gasification Sorbent injection Low-NO _x burner AFGC CWM | AFB PFB Gasification Sorbent injection Low-NO _x burner AFGC CWM | Declining R&D budget, but quite strong ACT demand. Some interest in U.S. suppliers. Utility and industrial AFB demonstrators are underway. CWM is being used commercially in industrial plants and being tested in small industry/residential applications. Some domestic production of FBC units. |
| Finland | na | na | na | na | na | na | Medium | Spray drying Sorbent injection AFB Gasification | Spray drying Sorbent injection AFB Gasification | Spray drying Sorbent injection AFB Gasification | Spray drying Sorbent injection AFB Gasification | Strong domestic industry in varied ACTs. Utility, industrial/commercial, and pilot-plant stage development of AFB. Several domestic suppliers of small AFB units. |
| France | na | na | na | na | na | na | Medium | CWM Sorbent injection AFB | CWM Sorbent injection AFB | CWM Sorbent injection AFB | CWM Sorbent injection AFB | Domestically-manufactured conventional combustors for residential/commercial and small industrial applications are available. Some R&D on ACT; one French firm is researching an innovative CWM. Some domestic manufacturing of FBC units. |

TABLE G.1 (Cont'd)

| Country | Government Funding for Coal R&D | | | | Share of Energy Budget (%) | 1986 Budget per million GDP | Private Coal R&D | ACT Manufacturing | Favored Technologies | Notes |
|-------------|---------------------------------|--------------|-----------------|-----------------------------|----------------------------|-----------------------------|------------------|--|--|-------|
| | 1986 (10 ⁶ U.S. \$) | Budget Trend | 1986 Budget (%) | 1986 Budget per million GDP | | | | | | |
| FRG | 106.9 | Level | 19 | 1.17 | High | High | High | AFGD SCR ^d AFB PFB Gasification Liquefaction Hot-gas cleanup | Very strong domestic ACT R&D and commercial activity. Germany has the largest FBC unit in operation for power and district heat generation. Application of FBC in industrial and commercial/residential settings is being studied. Gasification for industrial applications is at the commercial-scale demonstration stage. There are several manufacturers of FBC units, including small units. | |
| Greece | 2.6 | Level | 17 | 0.08 | Low | Low | Low | — | No significant experience with ACT. Minimal R&D budget. Good prospects. | |
| Italy | 4.4 | Level | 1 | 0.02 | Low | Low | Medium | CWM AFGD SCR AFB Gasification Liquefaction | CWM is produced and marketed on commercial scale; several tests of CWM in an experimental utility plant as part of extensive R&D program. CWM is also being demonstrated in an industrial application. At least one Italian firm manufactures FBC units. R&D on other ACTs also. | |
| Japan | 202.6 | Level | 9 | 0.16 | High | High | High | AFGD SCR AFB PFB Gasification Liquefaction CWM | Leaders in domestic R&D and commercial activity. AFB, PFB, gasification, advanced combustors, CWM, liquefaction, and advanced hot-gas cleanup are being studied. Several Japanese firms offer AFB units. Very hard for the United States to compete. Small-capacity coal burners for use in oil-fired boilers are being developed. | |
| Netherlands | 43.3 | Up | 27 | 0.35 | High | High | Medium | AFGD AFB PFB Gasification SCR Low-NO _x burner Hot-gas cleanup | Intensive federal R&D program. Waste disposal problems. Significant domestic industry. Ongoing AFB research, directed at design of industrial applications. Commercial AFB unit installed in industry based on design by a domestic firm. R&D ongoing on PFB, gasification, coal-fired gas turbines, and hot-gas cleanup. | |
| Portugal | 0.2 | Level | 3 | na | na | na | Low | None | No significant initiatives in ACT development or commercial use. | |

TABLE G.1 (Cont'd)

| Government Funding for Coal R&D | | | | | | | Notes |
|---------------------------------|-----------------------------------|-----------------|--------------------------------------|-----------------------------------|---------------------|---------------------------|---|
| Country | 1986 (10 ⁶ U.S. \$) | Budget Trend | Share of Energy R&D Budget (%) | 1986 budget per million GDP | Private Coal R&D | ACT Manufac- turing | |
| Spain | 12.2 | Down | 17 | 0.07 | Medium | Medium | ACT for pretreatment of high-sulfur coal is important. FBC is under development. Plans exist to retrofit a power plant with a super-charged PFB combustor with gas turbine in 1990. |
| Sweden | 9.1 | Level | 11 | 0.09 | High | High | Strong leadership, especially in novel FGD, AFB, and NO _x control. AFBs for industrial and district heating have been operational since 1982. PFB research, testing, and demonstration for utilities, but also application to smaller units. Research on industrial applications of gasification ongoing. IGCC with hot-gas cleanup for industrial applications is being patented (joint venture with UK firm). Several CWM conversion projects at small industrial plants and a hospital. AFB units are being manufactured in Sweden. |
| Turkey | 0.5 | Level | 21 | 0.01 | Low | Low | Minimal R&D and experience. Needs ACT for clean lignite combustion. |
| UK | 4.4 | Level | 1 | 0.01 | High | High | Moderate control technology favored (not much FGD, no SCR). Currently, government R&D is low, but manufacturers exist and private R&D is high. Babcock Power/British Coal and others are developing AFB units for industrial applications. Very small AFBs are being made in England by several manufacturers. PFB is also being tested. IGCC with hot-gas cleanup for industrial applications is being patented (joint venture with Swedish firm). |

^a1983 data.

^bna = not available.

^cAdvanced flue-gas desulfurization.

^dSelective catalytic reduction.

^eSelective noncatalytic reduction.

Sources: Refs. 2, 9, 10, 19, 20, and 24.

APPENDIX H:**FACTOR 8, ENVIRONMENTAL PRESSURE FOR ACT****RATINGS AND REASONS, BY COUNTRY****Australia** Factor 8 rating: Low

- No strong environmental pressure for ACT.
- No acid rain or long-range transport problems.
- Existing regulations permit combustion of domestic coals without controls; tall stacks avoid local problems.
- No solid-waste disposal problems.

Belgium Factor 8 rating: Low-medium

- Required emission reductions to be achieved by increased nuclear power, fuel switching, and energy conservation.
- Low-sulfur coal and emissions bubbling preferred for smaller units.
- No FGD systems or new, large coal-fired plants planned.
- EEC Large Combustion Plant Directive will apply.

Canada Factor 8 rating: Medium-high

- Strong environmental concerns over acid rain damage.
- Major reduction in SO₂ emissions planned by 1994, some from smelters.
- Other reductions to be achieved by increased hydropower and nuclear power, increased electricity imports and use of low-sulfur coal, and 15-20 FGD retrofits.
- Interest in ACT at R&D and pilot-plant scale (FBC, slagging combustor, IGCC). Opportunities for commercial ACT to reduce emissions.

Finland Factor 8 rating: Medium-high

- New regulations in 1987 require 70-80% reduction in SO₂ emissions from new plants > 50 MW (thermal); proposals for limits on the sulfur content of fuel for smaller units.
- Limits on sulfur content of fuel are in place.
- Preferred controls for large plants are spray dryers.
- Environmentally benign use of coal (and peat) is a policy objective, since the nuclear option has been halted. In use or planned are

AFB units; low-energy gas from peat, wood waste, and coal; and gas-fired combined heat and power (district heating).

France

Factor 8 rating: Medium-high

- EEC emission standards for new plants will apply.
- The emission reduction target of 65% by 1995 is expected to be met easily at low cost by continued emphasis on nuclear power generation and switching away from high-sulfur fuel oil.
- No federal regulations, but the sulfur content of fuel is regulated in major urban areas (Paris, Marseilles, Lyon, etc.).
- Sulfur emissions from smaller units are expected to increase as the French coal industry seeks to replace the coal consumption lost to nuclear power generation.
- No large-scale air pollution problems, but opportunities for using ACT to burn coal in urban areas could be significant.

FRG

Factor 8 rating: High

- Detailed and stringent emission regulations for new and existing, large and small combustors.
- Strong environmental pressure for emission reductions as a result of forest damage that may be linked with acid rain or related air pollution. Some expansion of nuclear power, but most of the reduction will come from FGD retrofits.
- Low-sulfur coal may be adequate for small units, but there is strong pressure for AFB or other ACTs. NO_x reductions are called for also, which favors certain ACTs.
- Tax relief for new, clean technologies could further spur development and commercial installations.
- Waste disposal regulations effectively force the use of regenerable or saleable-waste control systems.

Greece

Factor 8 rating: Medium-high

- No existing federal regulations, but the EEC emission standards for new plants will apply. Local regulations are strictest in the Athens area (0.7% sulfur in fuel oil).
- Environmental concern over damage to historical structures has led to new urban planning measures in Athens, where most of the industrial and commercial activity resides.
- Potential role for ACT, especially for burning low-quality domestic lignite, but the scope is limited.

Italy

Factor 8 rating: High

- No federal emission regulations below 100 MW (thermal), but coal is limited to 1% sulfur content. Local air pollution is more important than acid rain or long-range transport.
- Emphasis at large plants is on multifuel capability with FGD systems. Two AFB units are planned by 1991.
- ACT for smaller plants would help achieve the 30% reduction goal and ameliorate waste disposal problems.

Japan

Factor 8 rating: High

- Strong SO₂ and NO_x control programs are in place at both federal and local levels.
- FGD and NO_x removal technologies are used on major plants, mostly with waste minimization techniques.
- There is strong domestic R&D into many kinds of ACT, especially coal-derived liquids or gases and FBC units.

Netherlands

Factor 8 rating: High

- Strong control program in place, similar to that in the FRG; limits for smaller plants can be met with low-sulfur coal; high environmental awareness.
- Domestic interest in ACT is to improve energy efficiency while providing additional environmental protection. AFB and IGCC units are already under development in support of an active coal policy.
- Waste disposal is a major issue due to shortage of land.

Portugal

Factor 8 rating: Low-medium

- EEC emission standards for new plants will apply.
- Some sulfur content restrictions for fuel; the average coal sulfur content is about 1.5%.
- No strong environmental awareness.
- No firm plans for FGD at the few existing large coal plants.
- Although sulfur in coal is high and ACT could improve the environment, there seems to be little pressure at present to absorb higher costs of ACT.
- For government projects (such as some district-heating projects), funding could come from an international organization such as the World Bank, in which case environmental issues would have to be addressed. Portugal has received funding from the EEC for small energy projects.

Spain

Factor 8 rating: Medium-high

- EEC emission standards for new plants will apply, but with derogations for certain power plants over 500 MW (thermal).
- Local coal is very high in sulfur (4-7%); government is exploring the use of low-cost SO₂ control technologies.
- Policy is to achieve emission reductions in the longer term by developing and utilizing new technologies that can burn domestic coals cleanly and efficiently.
- Emerging interest in ACT, especially PFB and AFB; potential for U.S. technology to assist in domestic policy goals.

Sweden

Factor 8 rating: High

- Strong air pollution control policy, high environmental awareness.
- FGD systems, particularly spray dryers, are favored for large units.
- Strong interest in AFB and PFB and in sorbent injection systems for smaller units. NO_x control is an important issue; potential for U.S. combined SO₂/NO_x control technologies to fill a niche.

Turkey

Factor 8 rating: Low-medium

- Environmental awareness is just emerging; air pollution regulations passed in 1986 are not thought to be very stringent.
- Looking for ways to burn domestic lignites cleanly, but resources devoted to R&D are small and commercial interest is low.
- A new gas pipeline to Ankara may ameliorate air pollution as lignite is replaced with gas.
- Despite some concern over pollution, the environmental push for cleaner technology must be considered relatively weak.

UK

Factor 8 rating: Medium-high

- EEC emission standards for new plants will apply.
- If proposed regulations are adopted, new industrial coal-fired boilers would require 30-90% SO₂ reduction; a role exists for ACTs having high removal efficiencies.
- Domestic R&D interest in AFB, PFB, and IGCC; low-NO_x burners are preferred for NO_x control.

SUPPORTING INFORMATION

The following tables present information that helped to answer the questions guiding the ratings for Factor 8 (see Sec. 2.3.3).

TABLE H.1 Environmental Pressure for ACT (Questions 1-5)

| Country | Regulations ^a | | Notes |
|-----------|--|--|--|
| | SO ₂ | NO _x | |
| Australia | No federal emission regulations (local impacts of concern); 1.76 lb/10 ⁶ Btu in Northern Territory. | No regulations for units < 150 x 10 ⁶ Btu/h. | No real prospects for ACT from an environmental perspective. No acid rain problems. Low-sulfur coals can be burned uncontrolled under existing regulations. |
| Belgium | 1.76 lb/10 ⁶ Btu (new) and 2.8 lb/10 ⁶ Btu (existing) for 50-100 MW (t) units. Proposed 30% reduction by 1995. | 0.65 lb/10 ⁶ Btu (new) and 0.32 lb/10 ⁶ Btu (new, after 1995) for 50-100 MW (t) units. Best available technology for existing units. | Required reductions to be achieved with increased nuclear and fuel switching. Proposed limits for existing plants achievable with low-sulfur coal. No FGD planned. EEC emission standards for SO ₂ and NO _x apply for new plants. |
| Canada | Federal guideline is 0.6 lb/10 ⁶ Btu; provinces have regulations. 50% reduction by 1994. | Federal guideline is 0.6 lb/10 ⁶ Btu. | Some opportunities from an environmental perspective. Some reduction achievable through increased hydro/nuclear and low-sulfur coals. FGD or ACT is planned at 15-20 units. R&D interest in ACT. |
| Finland | 0.5 lb/10 ⁶ Btu for 50-150 MW (t) new units. 1.2% sulfur coal for all other units until 1994; thereafter a 1% limit will apply. 30% reduction by 1993. | No regulations, but draft emission standards exist. | Existing regulations will require 70-80% SO ₂ reduction on larger coal plants. Proposal for mandatory use of low-sulfur coal on other plants. Installed and planned SO ₂ control is largely sorbent injection, with one spray-dry scrubber. FGD units are being installed. ACT (especially AFB combustors) are expected to be able to compete. EEC emission standards apply. |
| France | No federal emission regulations. Some cities limit sulfur in coal (0.7-1.4%). 65% reduction by 1995. | Target of 20-30% reduction by 2000. No regulations. | Increased nuclear, fuel substitution, and sulfur-in-fuel limits are expected to achieve emissions goals. ACT could perhaps compete with low-sulfur coal in protected urban areas (Paris, Marseilles, Lyon, etc.). |
| FRG | Detailed regulations in place: 1.76 lb/10 ⁶ Btu (new); 1.76 lb/10 ⁶ Btu (existing); 0.32 lb/10 ⁶ Btu (FBC) for 1-50 MW (t) units. | 1-50 MW (t), 0.4 lb/10 ⁶ Btu (new/existing); 1-20 MW (t), 0.4 lb/10 ⁶ Btu (FBC); 20-50 MW (t), 0.24 lb/10 ⁶ Btu (FBC). | Detailed emission regulations for both new and existing plants (large and small). Low-sulfur coal is adequate for small installations, but considerable pressure exists for FGD (or other ACTs). Tax relief for ACT. Existing regulations are stricter than EEC standards. |
| Greece | No existing federal regulations. EEC directive will apply. Strict limits (0.7% sulfur in fuel oil) in Athens area. | No federal regulations. | Absence of federal regulations, need to reduce SO ₂ emissions, strong environmental awareness (re: historical structures), and recent urban planning measures imply a potentially large role for ACT. EEC emissions standards apply. |

TABLE H.1 (Cont'd)

| Country | Regulations ^a | | Notes |
|----------------|---|---|--|
| | SO ₂ | NO _x | |
| Italy | No emission regulations below 100 MW (t). Limit of 1% sulfur in fuel. 39% reduction planned. | No federal regulations below 100 MW (t). | Extensive use of FGD is planned at new, large plants. Two AFB units are planned by 1991. Multifuel plants are in favor. Potential role for ACT on smaller units to help achieve 30% reduction. EEC emission standards apply. |
| Japan | Source-specific regulations. Limits of 0.1-1.2% sulfur in fuel. | All small units are limited to 0.58 lb/10 ⁶ Btu. | Strong control program in place. Strict limits are imposed at federal and local levels. Extensive commercial use of and R&D on ACT. Novel FGD systems are favored for large plants. |
| Netherlands | For 50-300 MW (t) units, 0.57 lb/10 ⁶ Btu (new) and 1.2% sulfur (existing). 50% reduction by 2000. | For < 300 MW (t), 0.65 lb/10 ⁶ Btu (new, pre-83) and 0.40 lb/10 ⁶ Btu (new, post-88). | Limits for smaller, existing plants can be met by low-sulfur coal. Interest in ACT is to improve efficiency while providing additional environmental protection. AFB and IGCC units are under development. Existing regulations are stricter than EEC standards. |
| Portugal | No federal regulations; not a member of 30% club. | No federal regulations. | No emission limits in place that would require controls or ACT. Some sulfur-in-fuel limits. No firm plans for FGD at the few coal plants that exist or are planned. Little incentive for ACT at present. EEC emission standards apply. |
| Spain | Regulations for industrial boilers: 1.94 lb/10 ⁶ Btu (hard coal); 4.8 lb/10 ⁶ Btu (brown coal). | No federal regulations. | Low-cost SO ₂ control approaches (including sorbent injection) are being investigated; no FGD is planned. In the longer term, a major role is possible for ACT that can utilize high-sulfur coal. EEC emission standards apply, but with derogations for certain power plants over 500 MW (t). |
| Sweden | Federal guidelines: 0.46-0.78 lb/10 ⁶ Btu for plants emitting < 400 tons/yr. 65% reduction by 1995. | Proposed guidelines: 0.46-0.92 lb/10 ⁶ Btu for new and existing plants. | Strong control program and environmental awareness. Lime spray-dryers are favored now, with AFB seen as having potential. R&D into sorbent injection for future small units. High potential for ACT. |
| Turkey | New regulations in 1986, but details are not available. | Probably not covered in new regulations. | More information is needed. It is believed that the new regulations are not very stringent. Environmental awareness has only recently begun. |
| United Kingdom | Proposed regulations: 1.1 lb/10 ⁶ Btu and 30-90% reduction for 30-100 MW (t) units (new). | No regulations proposed for new plants over 30 MW (t). | If proposed regulations are adopted, new industrial boilers would require 30-40% SO ₂ reduction. There is a role for ACTs having high removal efficiencies. Domestic interest in AFB, PFB, and IGCC as well as low-NO _x burners for NO _x control. EEC emission standards apply. |

^aIn almost all countries, there are no statutory limits for small industrial combustors [e.g., < 50 MW (t)] or residential/commercial combustors. In such cases, control is exercised through the planning process, which is administered by the appropriate local authority. The requirements imposed may often be case-specific. Information on such requirements can only be obtained by more detailed investigations. Nevertheless, it is believed that examination of the statutory requirements for the smallest class of nonutility combustors (which are included in the table) is a good indicator of likely regulations for smaller combustors.

Sources: Refs. 1 and 9-12.

TABLE H.2 Solid Waste Issues (Questions 6)

| Country | Issues |
|-------------|--|
| Australia | No major concerns; sufficient land is available for disposal. |
| Belgium | Regional responsibility, with emphasis on waste minimization and regenerable control systems. No waste-producing FGD systems are allowed. Ash is largely reused in cement manufacture. Land is limited, but no major concerns at present. |
| Canada | No national solid waste disposal policy; provincial governments issue permits for solid waste disposal. Characterization studies of FGD waste, FBC waste, and disposal options are under way. |
| Finland | FGD waste is currently disposed of as landfill. Strong interest in reusable waste products from spray drying and sorbent injection (sorbent injection limits the reuse of fly ash). Concrete and road bed materials are desired. |
| France | Waste disposal requirements are determined for individual facilities after public hearings. General policy is to limit waste generation and encourage recycling. Disposal is usually on land, sometimes in nearby coal mines. |
| FRG | Demonstration of waste minimization is required as part of licensing; this has forced the choice of either gypsum-producing FGD systems or regenerable systems. Markets exist for sulfur products; ash is often disposed of in worked-out coal mines. |
| Greece | Local requirements only; land availability for disposal is becoming a serious problem. |
| Italy | Disposal of wastes on land is becoming a serious problem, leading to the selection of regenerable FGD systems or technologies with usable waste. |
| Japan | The 1970 Waste Management Law requires isolation of wastes from surface waters and groundwater. Land reclamation from the sea by waste filling is now strictly controlled. Severe shortage of land for disposal has resulted in a waste minimization policy that effectively forces the use of regenerable or similar systems. |
| Netherlands | Strong policy to limit waste generation is in effect. Utilities have set up a company, Fliegasunie, to market coal combustion by-products. Wastes are used for cement, asphalt, roadbed, and concrete production; may be a surplus of usable gypsum from regenerable FGD by 2000. |

TABLE H.2 (Cont'd)

| Country | Issues |
|----------|--|
| Portugal | No national policy or regulations; requirements established on a plant-by-plant basis as part of the licensing process. |
| Spain | No problems yet, because no FGD systems are in place. Regenerable FGD systems are not attractive due to a glut of sulfur products. |
| Sweden | Landfill is currently adequate and low-cost. Coal combustion waste is often dumped with household garbage. Environmental pressure exists for reuse of wastes, but strict regulations control acceptable leaching rates from such applications. |
| Turkey | Awareness of environmental issues such as solid waste disposal is just beginning. One approach is to improve the quality of Turkish lignite prior to combustion. Disposal of wastes does not appear to be a major problem. |
| UK | No national policy for disposal of combustion wastes, but waste minimization is encouraged according to the EEC Directive. Waste disposal was a major factor in the UK decision to install FGD systems with salable products. However, gypsum production may exceed market demand. |

Sources: Refs. 1 and 9-12.

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