1. RESOURCES, POLICIES AND PROGRAMS

Except for a few countries which are mainly the members of the Organization of Petroleum Exporting Countries (OPEC), the nations of the world are importers of crude oil. This oil is the overwhelming source of transportation fuels and to a lesser extent fuels for stationary applications and heating. Like the United States, many other countries around the world are investigating ways to reduce their dependence on imported fuels by developing their indigenous resources.

As a result, fossil energy sources are currently receiving a great deal of attention. Worldwide, exploration efforts for new supplies of crude oil and natural gas have been stepped up, as have efforts to find new coal resources and utilize these resources in an environmentally and economically sound fashion.

Each country is developing its energy objectives and programs in ways that fit its needs. Consequently, the mix of programs is different for every country. However, there are common elements in these programs and so it is possible to use the experience in one country to expedite the development of similar technologies in other countries.

This chapter deals with an overview of the resources, policies and programs of Australia, the Federal Republic of Germany, Japan, New Zealand, South Africa and the United Kingdom. For each, the national situation and policies are described and then related to those liquefaction and gasification programs that are being pursued which would most likely have an impact on coal liquefaction programs that are evolving in the United States.

1.1 Australia

This is a country that is well endowed with mineral resources. Among them are large reserves of coal, natural gas and uranium, as well as some reserves of crude oil (See Table 1.1). Other energy resources include hydropower systems that are in place and the potential for more, solar energy, potential oil shale, and an agricultural industry that can be geared to providing biomass as raw material for renewable energy supplies.

Table 1.1 Australian energy resources, production and consumption[1,2,3,4,UW] (Petajoules)*

	Known reserves			Production	Consumption
	Proven	Probable	Total	1976/77	1976/77
Non-Renewable					
Black Coal	624,000	2,457,000	3,081,000	1920	801
Brown Coal	600,000	1,248,000	1,848,000	320	303
Oil	16,000	16,000	32,000	1000	1240
Gas	13,000	29,000	42,000	260	253
Uranium	67,000	N/A	N/A	230	-
			TOTAL	3710	2597
Renewable					
Biomass				80	80
Hydro**				180	180
			TOTAL	260	260

*1 Petajoule = 10^{15} Joules = 0.9478×10^{12} Btu.

**In terms of equivalent primary fuel at 10 MJ/kWh (9478 Btu/kWh).

At the present time, Australia is a net exporter of energy. Coal and uranium exports lead the way, while crude oil and refined petroleum products are the only energy imports. The area where imports have the biggest impact is in the transportation sector. Although 65-70% of the petroleum products is now supplied from domestic sources, this situation is not expected to last beyond 1995. This is true if moderate quantities of crude oil are found in the next 5 to 10 years. Failing this, the domestic supply will fall off after 1985.[1] The Federal government is cooperating with the state governments to formulate a comprehensive energy program. In 1977 the Federal government identified the following policy objectives to handle the energy situation in Australia:[2]

- Move domestic crude oil prices to world parity over a number of years.

- Restrain the average rate of growth of energy consumption, particularly of liquid fuels.

- Achieve the highest degree of self-sufficiency in liquid fuels consistent with the broad economic use of Australian energy resources.

- Develop new economic oil and gas resources.

- Substantially increase energy research and development, particularly in coal liquefaction and solar power.

- Encourage individual major projects to meet overseas demand for energy materials where these could provide an adequate return to Australia.

Of all its energy resources (See Fig. 1.1), Australia's coal reserves are in prime assets. Black coal, a volatile bituminous type, is found in the states of New South Wales and Queensland while brown coal, a lignite variety, is found predominantly in Victoria. At present, all the brown coal is used domestically in electricity generators. Of the 77 million tonnes (85 million tons) of black coal that is mined annually, 44 million tonnes (48 million tons) is exported (chiefly to Japan) making Australia second, behind the United States, as a coal exporting country. The World Coal Study anticipates Australian coal exports rising to as much as 200 million tonnes (220 million tons) per year by the year 2000. This will require large investments in mines, internal transport systems, and ports.

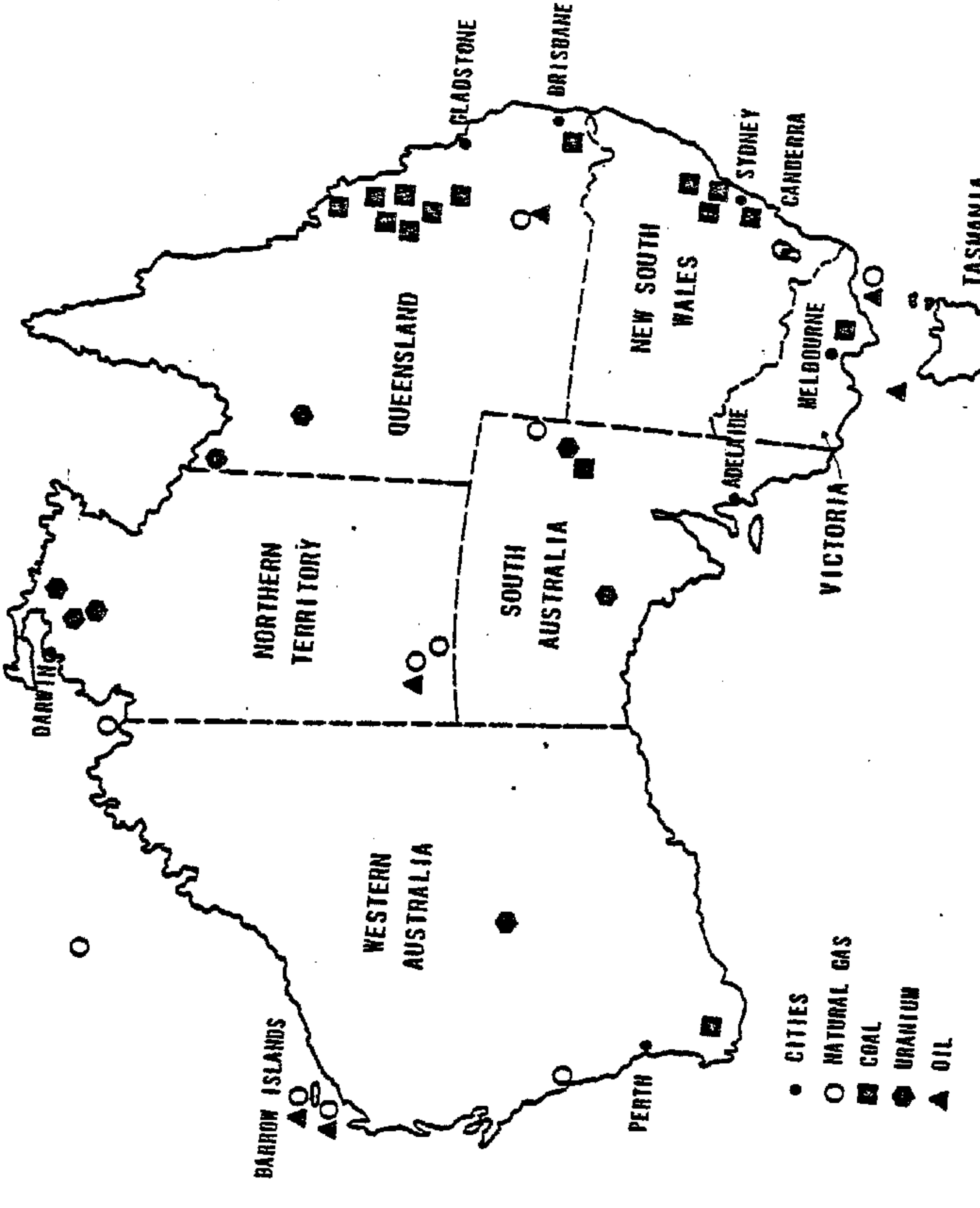

FIGURE .1
AUSTRA

Because of the need for transportation fuels and the expected decline in domestic crude oil production, coal is being looked at as one of the raw materials upon which a synthetic fuels industry can be based. The need for an Australian synfuels industry is being assessed against the rate of new oil finds, the production rate of existing wells, conversion of transport systems to other fuels and energy conservation.

Present crude oil production is from fields in the Bass Straits off the coast of Victoria and near Western Australia's Barrow Island.[3] However, oil exploration activity is on the increase. Some $550 million will be spent in 1980[5] to drill 45 development wells and 61 exploratory wells. Major areas of activity include the states of Queensland, South Australia and Western Australia and the waters off Western Australia and Victoria.

Domestic crude oil would not be suitable for all petroleum product requirements even if sufficient were available. It is too light to supply the complete spectrum of required products.

In order to make better use of the crude and of condensate associated with natural gas finds, incentives are in place to encourage the use of LPG and CNG (compressed natural gas) in automobiles to replace gasoline. These include the removal of the road tax on LPG and the removal of sales tax on conversion equipment.[2]

Another program is attempting to convert stationary users of liquid petroleum fuels to natural gas, a resource that is more abundant (See Table 1.1.) Australia's natural gas supplies come mainly from wells in the Bass Strait and on the North West Shelf off the coast of Western Australia. Some on-shore production comes from the fields in the Cooper Basin of South Australia and the Amadeus Basin in the Northern Territory. Total reserves are estimated at 842,000 million m^3 [30 trillion cubic feet (tcf)] with an annual consumption rate of about 6500 million m^3 (230,000 million cubic feet) in 1977/78.[2,3] The main consumption areas are in and around the cities of Melbourne, Brisbane, Adelaide, Perth and Sydney. The authorization of a 300 mm (12 in) gas pipeline from Young to Wagga Wagga, N.S.W. will increase this area.[2] The Federal government has also approved the export of LNG (liquefied natural gas) from the North West Shelf.

Uranium is an abundant resource and is mined for export. There are no plans to use it for local electricity needs before at least the early 1990's.[2] The regions that have a large demand for electricity are also near coal fields where there are existing fossil fuel power plants while the regions away from the coal demand less electricity than an economically sized nuclear power plant would generate.

Conservation measures that are being stressed are very similar to those that are emphasized in the United States. Already mentioned are the moves toward pricing crude oil products at world price levels and interfuel substitution. As the conservation measures are directed towards lessening liquid fuel demand, the Federal Government has worked out a set of voluntary fuel economy standards to be achieved by the automobile manufacturers. For the rest, advertising campaigns directed at making the public aware of the need to conserve have been implemented.[2] However, per capita energy use by the]4.5 million people in Australia is about 200 GJ/year (190 x 10^6 Btu/yr) which is well below U.S. levels (340-350 GJ/year) but above the New Zealand level of 120 GJ/year (115 x 10^6 Btu/yr).

In order to fill the gap that will occur when the indigenous crude oil production drops, Australia is looking at two different raw materials to supply the fuel and so lessen the dependence on what is seen as a tenuous supply line with the OPEC countries. The synfuel industry can use coal or oil shale or both as raw materials. Most of the oil shale is in Queensland near Gladstone. The Rundle deposits have more than 4000 million tonnes (4400 million tons) of shale with an average yield of 85 litres/tonne[6] (20 gal/ton). The first phase ($350 million) of the possible $12 billion oil shale synfuels project is in the process of obtaining enabling legislation from the Queensland parliament. This phase will take some three years to build and about a year to test the technology.[7]

Other oil shale deposits in Queensland are:

> Yaamba, near Rockhampton with deposits that may rival the size of Rundle.
>
> Julia Creek in northern inland Queensland but smaller than Rundle.

Condor, near Prosperpine and up to three times the size of Rundle.

Stuart, near Mackay.

Bongobone, 200 km (125 mi) west of Mackay.

There is also some prospecting for oil shale in Western Australia.

As far as synfuels from coal are concerned, both black and brown coals are being considered as starting materials. Direct liquefaction, indirect liquefaction, and pyrolysis are all being considered. Table 1.2 gives a list of the approved research projects that have received grants in the National Energy Research, Development, and Demonstration Program.[2] Australia views its situation as sufficiently different from those in other countries so as to require unique solutions.

Table 1.2 Approved coal conversion projects in the Australian National Energy Research, Development and Demonstration Program[2]

Brief description	Recipient	Grant A$*
Coal Liquefaction		
Synthetic oil and chemicals from coal: continuous reactor work	Australian Coal Industry Research Laboratories	800,000
Influence of catalysts, and identification of intermediates in the coal liquefaction process	Minerals Research Laboratory CSIRO (Commonwealth Scientific and Industrial Research Organization)	300,000
CO-Steam process development	Victorian Brown Coal Development Council	300,000
Catalytic coal hydrogenation for automotive fuels	CSR Ltd.	200,000
Flash pyrolysis - experiments on the 20kg/hour (44 lb/hr) rig	Minerals Research Laboratories CSIRO	196,000
Development of the continuous coal hydrogenation unit	Broken Hill Pty Co. Ltd.	184,000
Zeolite catalysts for synthetic liquid fuels	Division of Materials Science CSIRO	168,324
Use of a Nuclear Magnetic Resonance spectrometer for evaluation of coal liquids	Broken Hill Pty Co. Ltd.	155,000
2kg/hour (4 lb/hr) hydrogenation plant for flash pyrolysis tar	Division of Applied Organic Chemistry	66,000
Experiments to generate solvent materials for coal hydrogenation	Broken Hill Pty Co. Ltd.	43,000
An approach to oil formation from coal - use of pyrolysis as an analytical tool	Department of Organic Chemistry, University of Melbourne	43,000
Lubricating oil from low temperature coal tar	Department of Fuel Technology University of New South Wales	34,000
Coal to liquid fuel - the development of new Fischer-Tropsch catalysts	School of Physical Sciences Flinders University of South Australia	30,000

Table 1.2 (cont'd)

Brief Description	Recipient	Grant A$*
Coal Liquefaction		
A continuous flow catalytic converter for the direct hydrogenation of brown coal	Departments of Chemical Engineering and Chemistry Monash University	28,000
Structure of brown coal and its effect on the hydrogenation process	Department of Chemical Engineering, University of Melbourne	20,950
The rheology of brown coal slurries	Department of Chemical Engineering, University of Melbourne	8,750
The regeneration of catalysts for use in continuous flow coal hydrogenation	Department of Chemistry Monash University	7,900
	Sub-total	2,584,924
Methanol		
Development of catalysts to produce methanol from coal via synthesis gas	School of Chemical Technology University of New South Wales	25,822
	Sub-total	25,822
Coal Gasification		
Hydrogen production from coal New catalysts for the water gas shift reaction	Department of Chemistry Monash University	54,316
Gasification of low grade fuels	Broken Hill Pty Co. Ltd.	48,250
Studies on the reactivity of chars derived from various coal processing conditions	Department of Fuel Technology University of New South Wales	24,500
Underground gasification of coal in-situ	Department of Chemical Engineering, University of Newcastle	22,500
Gasification of char in fluidized bed systems	Department of Fuel Technology University of New South Wales	21,500
	Sub-total	171,066
	TOTAL	2,781,812

*AUST $1.00 = US $1.17

The Federal government and the governments of Queensland, New South Wales and Victoria are participating in a joint oil-from-coal feasibility study with the Federal Republic of Germany's Ministry of Research and Technology (BMFT) and a group of German companies led by Imhausen International GmbH. This two-year project,[4,II.1] called the Imhausen study and costing about $4 million, commenced in April 1979, and should be completed by the end of 1981. The major objectives of the project were (a) to study the process characteristics of the conversion of Australian coals to liquid fuels by utilizing combined hydrogenation, gasification, and Fischer-Tropsch synthesis technologies, and (b) to investigate the feasibility of commercializing these technologies at designated sites in Australia. Preliminary results of the Imhausen study are summarized in Appendix A.

Atlantic Richfield Company (U.S.) and Moonie Oil Limited are investigating the feasibility of using the Gelliondale brown coal deposits in southern Victoria for liquid fuel production.[8]

The Latrobe Valley brown coal deposits are being studied by the Kominic Group (Kobe Steel Ltd. of Tokyo, Mitsubishi Chemical Industries, Ltd. of Tokyo and Nissho-Iwai Company of Osaka).[9] This group has leased the Sasol 0.5 t/d direct liquefaction pilot plant in Sasolburg, South Africa, to test the Victorian coal. A one-year run showed that moisture in the lignite can be reduced from 60 to 10%, and that 95% of the material can be converted into coking coal.

Other joint Australian-Japanese projects are discussed in Sect. 1.3.

1.2 Federal Republic of Germany

The country has an energy demand of about 10,500 PJ/year (11,000 x 10^{18} Btu/yr = 11,000 Q/yr) with about 65% of this energy being imported.[10,11] Oil supplies 51% of the energy needs but about 96% of it is imported.

Coal is the next largest source of energy, 28%, and Germany has large reserves of hard coal and lignite (brown coal). Local coal supplies are about equal to the demand for coal. Natural gas supplies 17% of the energy requirements and, like oil, the majority of it (62% in this case) is imported. Other sources of energy are nuclear energy and hydroelectricity.

As a result of the 1973 oil crisis the Federal government developed the Energy Policy Program. This was revised in 1974 and again in 1977 and will probably be revised at regular intervals in the future. It established emergency reserves for oil and coal, stepped up exploration for oil, invested in the coal mining industry, diversified natural gas sources, encouraged the use of nuclear fuel and discouraged the use of oil for electricity generation, developed a non-nuclear research program and helped set up national and international contingency plans for future energy crises.[10] (See Appendix B for a brief summary of the German coal processing program.)[E]

Energy conservation measures are aimed primarily at holding oil imports to about their present level of 127 Mt (140 million tons/yr = 930 million barrels/yr) per year. Germany has committed itself to a goal of a maximum of 141 Mt (155 million tons = 1,035 million barrels) of oil imports in 1985. Keeping oil at this level will decrease its portion of the energy supply to at most 40-45% in the 1990's.

Much emphasis has been placed on increasing the nuclear power generating capacity to supply some of the growth in energy demands. However, there is well organized political and environmental opposition. This has led to a steady scaling down of the estimates of future installed capacity. Estimates for 1985 installed capacity are now about 18 GW (18,000 MW).[11]

Natural gas will supply an increased portion of Germany's energy and efforts have been made to diversify the non-German sources. Some of the additional requirements come from the Norwegian sector of the North Sea, additional imports from the Soviet Union and LNG imports from Algeria.[10]

In the first half of this century Germany led the world in the production of synthetic fuels from coal by both the direct and indirect liquefaction routes. Maximum production was reached during World War II. Interest in these technologies revived again after 1973. Numerous domestic gasification and liquefaction projects are part of the present research, development and demonstration program. However, there is also involvement at Federal government and private industry levels in overseas programsin countries such as the United States, Australia and South Africa. For example, see Appendix A for a brief summary of the Imhausen study, a two-year, $4-million project concerning various schemes for liquefying Australian coals.[UQ]

West Germany has 14 demonstration scale coal liquefaction and gasification plants under consideration at an estimated cost of $7.4 billion. (See Table 1.3 for gasification projects and Table 1.4 for liquefaction development efforts.) Locations of some of the existing gasification and liquefaction pilot plants are shown in Fig. 1.2.

1.2.1 Gasification Programs

From 1920 to 1945 the German coal industry devoted considerable effort to the improvement of gasification technology. In the 1930's Lurgi developed a gasifier able to operate at pressures up to 20 bars (300 psi) with an oxygen-steam blast. The first commercial plant was built in 1935, followed by large multi-unit works in the UK, Germany, South Africa and elsewhere. Development of larger reactors and general improvements to the process and the range of usable coals has continued to the present, when some 65 units have been installed at 13 sites worldwide.

Winkler fluidized bed gasifiers have been used commercially since the 1920's when the process was originally developed by F. Winkler of BASF for making active carbon. The gasifier is most suited for use with lignite and reactive non-coking coals with high ash softening temperatures. The basic process operates at atmospheric pressures on air at relatively low specific throughput, but the use of oxygen is also being developed. Thirty-six commercial units at 15 sites have been built.[UI]

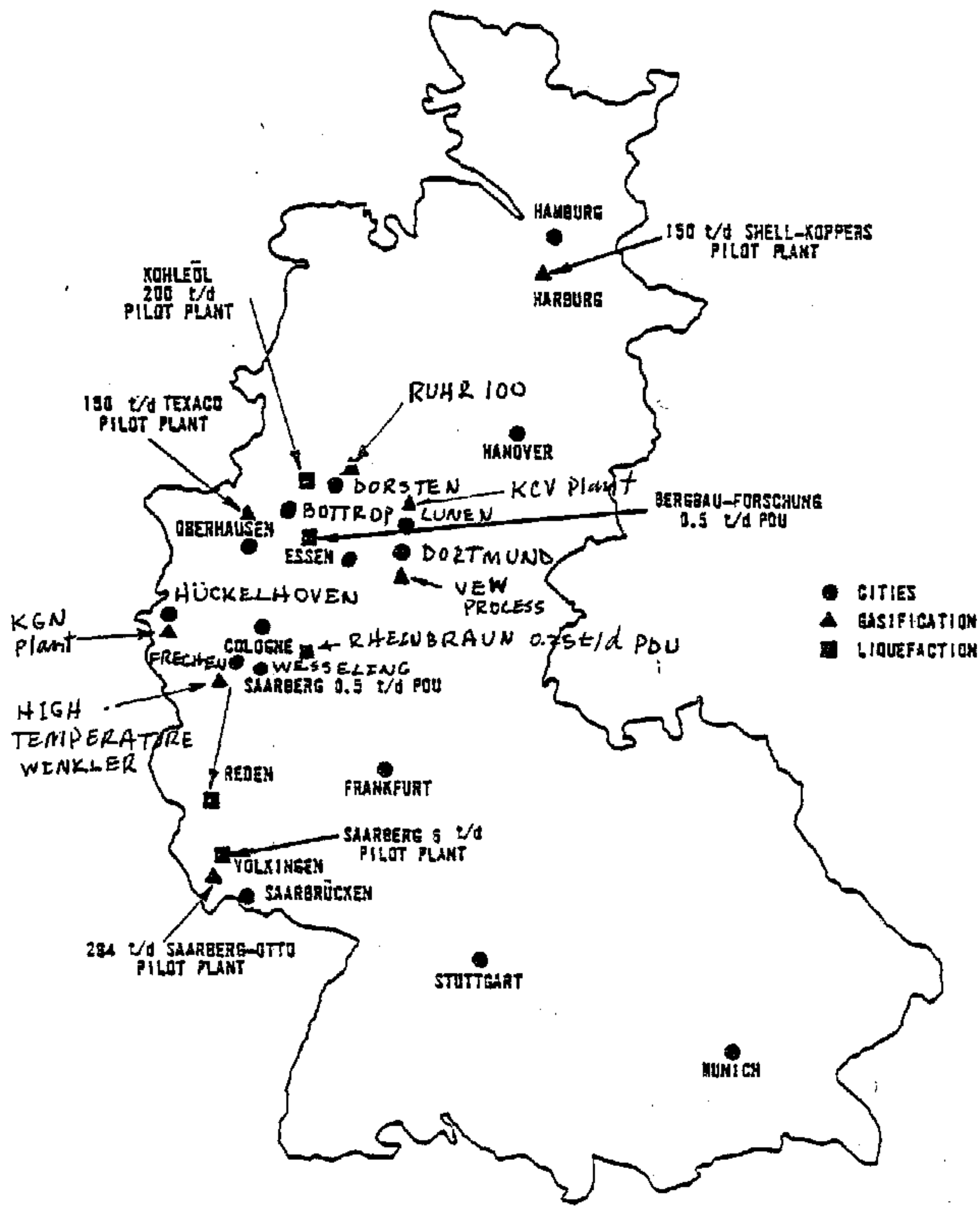

FIGURE 1.2
COAL GASIFICATION AND LIQUEFACTION PILOT PLANTS
IN THE FEDERAL REPUBLIC OF GERMANY

The Koppers-Totzek process has its roots in work done in Germany in the forties by H. Koppers (GmbH) of Essen and the first demonstration unit was a 36 t/d unit for the USBM coal/oil plant in Louisiana, MO. The first commercial plant was built in Finland in 1952. Subsequently, some 53 units have been installed at 17 sites in the world, mainly for ammonia production with a nominal coal requirement of about 8000 t/d. One of the latest with a four-headed burner design is now in operation in India with a capacity of 600 t/d of coal. [UM]

In Germany the brown coal industry sees gasification as an insurance policy to provide markets for their product if nuclear generation becomes the cheapest method of supplying the country's electricity demand. The German government, however, recognizes the expertise that has been built up by their industry over the last century and sees potential markets for the export of technology and equipment, as well as internal benefits. They are therefore prepared to contribute towards a number of developments and have invested some $1 billion since 1975. There are 28 research projects on coal gasification and 21 projects on liquefaction being followed up in the Republic.

After the oil crisis in 1973, the Federal Government initiated the development of modern technologies for coal gasification in the Federal Republic of Germany (FRG). The objectives of this program were:

- the extension of the range of coals that could be used
- the improvement of coal conversion efficiency
- the increase of coal throughput and gas output per gasifier unit
- the production of gas with compositions that are desired by potential customers
- environmental acceptability

Table 1.3 FRG coal gasification projects - 1979

Projects	Partners	Total costs $ and time period	Process data	Products
Texaco Oberhausen-Holten	Ruhrkohle AG Ruhrchemie AG	18 million 1975-1979	Entrained bed pressure gasification according to Texaco - 150 t/d, 4 MPa, 1450°C (580 psi, 2650°F)	290,000 m^3/d (10 million ft^3/day) Synthesis gas
Ruhr 100 Dorsten	Ruhrgas AG Ruhrkohle AG/ Steag AG	75 million 1975-1984	Fixed bed pressure gasification according to Lurgi - 70-170 t/d, 10 MPa, 700-1000°C (1450 psi, 1290-1830°F)	100-236,000 m^3/d (3.5-8.3 million ft^3/day) Synthesis gas 40-95,000 m^3/d (1.4-3.4 million ft^3/day) SNG
PNP Prototype Plant Nuclear Process Heat	Bergbau-Forschung GmbH Gesellschaft fur Hochtemperatur-reaktor-Technik mbH Hochtemperatur-Reaktorbau GmbH Kernforschungsanlage Julich GmbH Rheinische Braunkohlenwerke AG	675 million 1975-1984	Fluidized bed gasification - 1500 t hard coal/d, 4000 t lignite/d Hydrogasification: 8 MPa, 820-930°C (1600 psi, 1500-1700°F) Steam gasification: 4 MPa, 630-800°C (580 psi, 1170-1470°F)	1,000,000 m^3/d (35 million ft^3/day) SNG from hard coal 640,000 m^3/d (23 million ft^3/day) SNG from lignite Synthesis gas Reduction gas
KCV-Plant Lunen	Steag AG	105 million 1974-1982	Lurgi pressure gasification - 1700 t/d, 2.5 MPa, 700-1000 °C (360 psi, 1290-1830°F)	Electric power by gas and steam tubine: 170 MW
Shell-Koppers Hamburg-Harburg	Shell International Deutsche Shell AG Krupp-Koppers GmbH	31 million	Entrained bed gasification according to Shell - 150 t/d, 3 MPa, 1150-1800°C (435 psi, 2100-3270°F)	Synthesis gas Reduction gas

Table 1.3 (continued)

Projects	Partners	Total costs $ and time period	Process data	Products
Saarberg/Otto Furstenhausen/Saar	Saarbergwerke AG Dr. C. Otto & Co. GmbH	22 million	Slag bath gasification - 250 t/d, 3 MPa, 1450-1850 C (435 psi, 2640-3360°F)	Synthesis gas Reduction gas
High Temperature Winkler Process Frechen	Rheinische Braunko-hlenwerke AG	17 million	Fluidized bed gasification - 25 t/d, 1 MPa, 870-1070 C (145 psi, 1600-1960°F)	Synthesis gas Reduction gas
KGN-Plant Hückelhoven	PCV and Gewerkschaft, Sophia Jacoba	10 million	Fixed bed gasification - 35 t/d, 600 kPa, 920-1120 C (870 psi, 1690-2050°F)	Low Btu gas Synthesis gas
VEW-Process Dortmund	Vereinigte Elektrizitatswerke Westfalen AG	9 million 37 million	Pilot Plant - 24 t/d, 100 kPa (14.7 psi) Demonstration Plant - 380 t/d, 100 kPa (14.7 psi)	Electric power Electric power

Pilot plants for various processes have been under construction or put into operation. Table 1.3 gives a survey of these projects.[12] From 1979 until late 1980, seven pilot facilities for coal gasification started their operation and one more is still under construction.[4,13] The largest of these facilities (Saarberg/Otto gasifier) has a throughput of 264 t/d.

First-generation gasifier technologies such as Lurgi, Koppers-Totzek, and Winkler were used as the basis for the corresponding new projects, respectively: Ruhr 100, Shell-Koppers, and High Temperature Winkler. Of the nine gasification projects listed in Table 1.3, Saarberg/Otto, Shell-Koppers, Texaco, and Ruhr 100 have been proposed for gasification of solids-containing residues from liquefaction processes to generate hydrogen required for liquefying coal. A brief description of these four projects is given below.

1.2.1.1 Texaco Oberhausen-Holten[12]

Ruhrkohle AG and Ruhrchemie AG jointly operate the 150 t/d pilot plant based on a license from the Texaco Development Corp. The plant is situated on the Ruhrchemie site in Oberhausen-Holten and has been in operation for almost two years. Component tests began in January 1978 and in April 1978 the Federal Minister of Research and Technology, as sponsor of this project, performed the official start-up.

With the existing infrastructure at Ruhrchemie, it was possible to construct the plant within nine months and to keep construction costs to approximately $5 million.

Total costs are about 50 million DM (about $30 million) to 1981.

They will license their know-how [primarily coal preparation and waste-heat boiler (WHB)] for the Texaco plant for producing synthesis gas to be installed by the Tennessee Eastman Company in Kingsport, TN.

More than 6500 hours of operation were achieved with several continuous test runs for periods up to 80 hours. Approximatley 36,000 t of different coals have been converted to synthesis gas at a maximum rate of about 13,000 m^3/h (460,000 ft^3/hr).

Further development and process optimization is planned to provide reliable design data for large-scale gsification plants. The test program includes the evaluation of alternative components, alternative concepts for heat recovery, and the gasification of other types of coal.

1.2.1.2 RUHR 100 Dorsten[12]. Since 1974, Ruhrgas AG, Ruhrkohle AG and Steag AG in cooperation with Lurgi Kohle and Mineraloltechnik GmbH have jointly improved the conventional Lurgi Process by the development of the new Ruhr 100 gasifier, installed at Dorsten. The pilot plant has been designed for a maximum throughput of 170 t/d of run-of-mine coal. The plant began operation in September 1979. Six test runs with a total of 808 hours of operation have been made up to April 1980. The plant will produce synthesis gas, SNG or low-Btu gas during the planned four-year experimental period. Gasification of compacted coal feedstock and cocurrent gasifier operation are also on the program.

Particular features of the program include:

- Increasing the specific coal throughput and gas output per unit by increasing the operating pressure up to 10 MPa (1450 psi).
- Increasing the methane content of the crude gas up to 18% by increasing the operating pressure, using the heat of the methanation reaction directly in the reactor to save coal and oxygen.
- Using various coal qualities including low-caking coals with a range of particle sizes between 3 and 30 mm (0.12 and 1.18 in).
- Decreasing liquid by-products such as tar, oil and phenols.
- Adapting the gas composition to the gas quality desired by catalytic or thermal thermal gas treatment.

The costs of constructing the pilot plant and converting existing facilities amounted to approximately 65 million DM ($37 million). Seventy-five percent of the project's total cost of $75 million is sponsored by the Federal Ministry of Research and Technology.

A preliminary study of a commercial-size plant built for a coal throughput of 3 million tonnes/yr (3.3 million tons/yr) is being prepared for the State of North-Rhine Westphalia. The plant will produce SNG and synthesis gas.[UL]

The RUHR 100 gasifier is shown in Fig. 1.3. The gasification reactor is equipped with an externally driven rotating grate through which the gasification agent is fed into the gasifier and distributed. The coal is fed to the reactor through two coal lock hoppers operated in an alternating mode to minimize lock gas losses. The ash is removed through an ash lock. Gas can be tapped from the clear gas and the carbonization gas outlets; in full-load operation, all the raw gas produced will leave the gasifier through the carbonization gas outlet. Both gas streams are cooled separately to approximately 200°C (390°F) in the scrubbers and the waste heat boilers. The coal distributor and the water-cooled stirrer are arranged in the center of the gasifier.

Conventional Lurgi gasifiers did not allow operators to influence the rate of gas flow and the coal heat-up rate in the carbonization zone. The second gas outlet of the RUHR 100 gasifier makes it possible to control plastic coal heating. Due to the second gas outlet, the rate of flow in the carbonization and drying zones is reduced and less fines are entrained into the scrubber. The RUHR 100 gasification reactor is also equipped with a stirrer with three blades for breaking up caking coal.

The reactor itself weighs approximately 135 tonnes (150 tons). The inner shaft diameter is 1.5 m (5 ft) and the structure has a height of 11.50 m (38 ft) (excluding the coal locks which are flanged to the vessel).

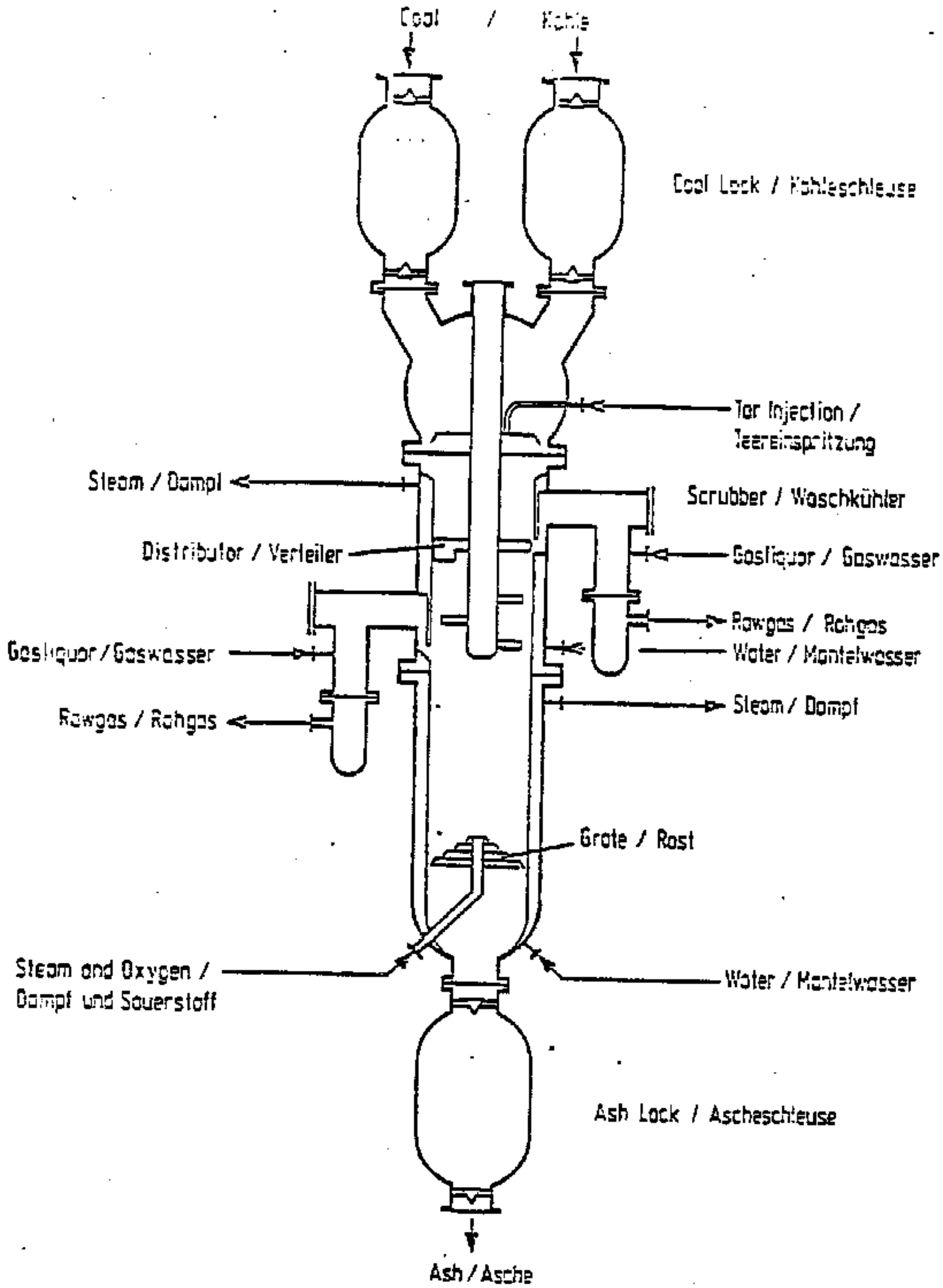

Fig. 1.3. Ruhr 100 Lurgi gasifier[UL]

1.2.1.3 Shell-Koppers Hamburg-Harburg[12]. Shell's experience on high pressure oil gasification combined with the Krupp-Koppers know-how of construction and operation of Koppers-Totzek gasifiers has been the basis for the joint development of the Shell-Koppers process up to industrial scale. Following the successful operation of a 6 t/d bench-scale plant at the Shell laboratories in Amsterdam since late 1976, a pilot plant with a coal throughput of about 150 t/d has been operated at the Shell refinery complex in Hamburg-Harburg since November 1978.

The first mechanical test runs followed by short trial runs under gasification conditions have been performed. The results obtained so far have confirmed the design data. This project has not been subsidized by public funds and therefore the results are proprietary data. Shell's scenario for further development is to have a 1000 t/d plant operational by 1985 and to make 2500 t/d commercial gasifiers available by 1988. In conjunction with their Shell-Koppers gasifier program Shell is developing two new indirect liquefaction processes.

1.2.1.4 Saarberg-Otto Furstenhausen[12]. Saarbergwerke AG and Dr. C. Otto and Company are demonstrating the Rummel/Otto system for pressurized coal gasification up to 2.5 MPa (360 psi) for various feed coals. Their pilot plant, with a 260 t/d coal throughput, was commissioned in 1978. The specific feature of the gasifier is the liquid slag bath at the reactor bottom and a system of tuyeres directed tangentially towards the bath surface, which is rotated by the impulse of the injected coal dust. The test runs are focused on the key problems of this gasifier: the controlled feedstock injection into the pressure vessel and the slag removal. The costs of approximately $27 million are sponsored by the Ministry of Research and Technology.