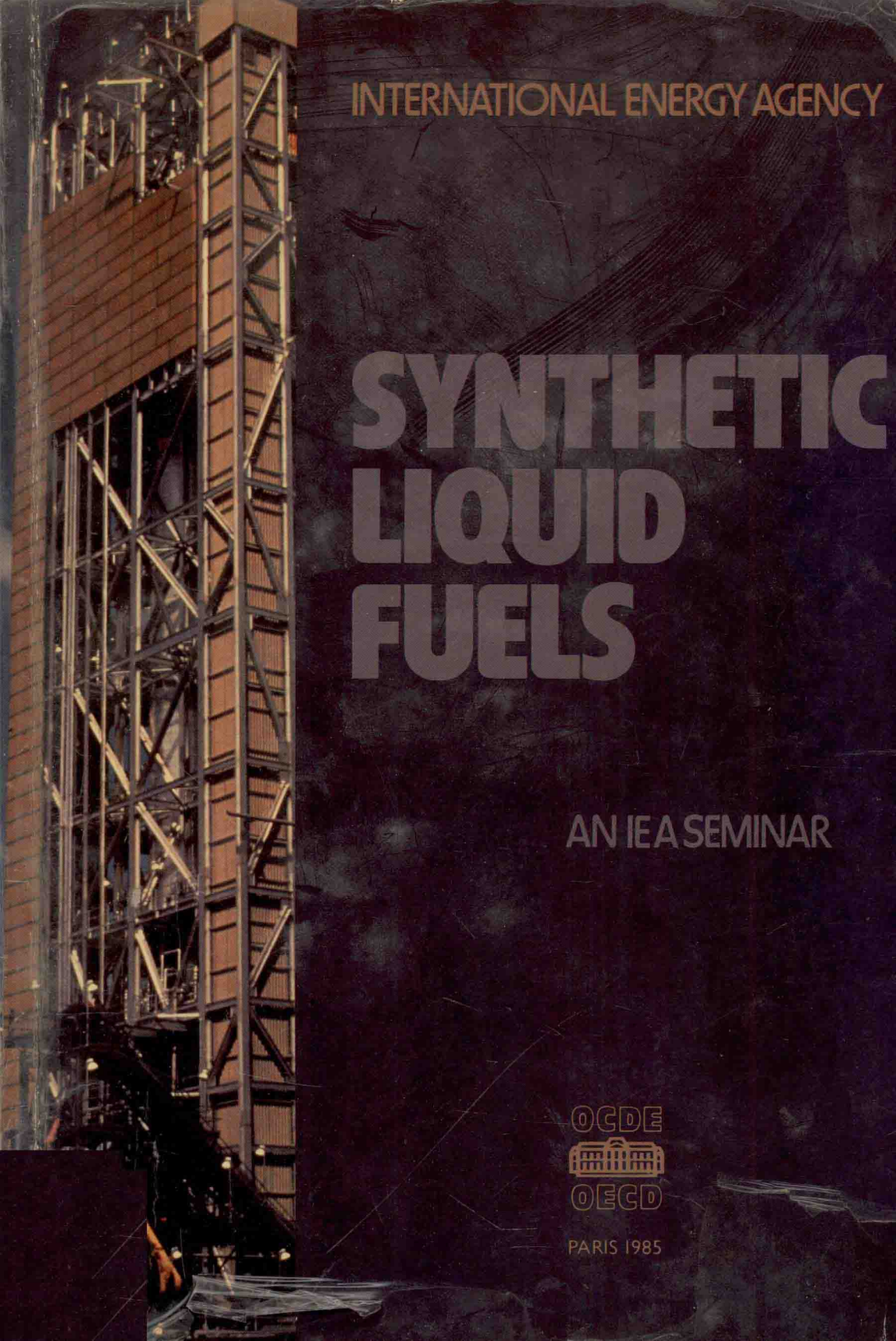

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SYNTHETIC LIQUID FUELS

AN IEA SEMINAR

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SYNTHETIC LIQUID FUELS

An IEA Seminar

INTERNATIONAL ENERGY AGENCY

2, RUE ANDRÉ-PASCAL 75775 PARIS CEDEX 16, FRANCE

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Program.

It carries out a comprehensive programme of energy co-operation among twenty-one* of the OECD's twenty-four Member countries. The basic aims of IEA are:

i) co-operation among IEA Participating Countries to reduce excessive dependence on oil through energy conservation, development of alternative energy sources and energy research and development;

ii) an information system on the international oil market as well as consultation with oil companies;

iii) co-operation with oil producing and other oil consuming countries with a view to developing a stable international energy trade as well as the rational management and use of world energy resources in the interest of all countries;

iv) a plan to prepare Participating Countries against the risk of a major disruption of oil supplies and to share available oil in the event of an emergency.

**IEA Member countries: Australia, Austria, Belgium, Canada, Denmark, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.*

Pursuant to article 1 of the Convention signed in Paris on 14th December, 1960, and which came into force on 30th September, 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The Signatories of the Convention on the OECD are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries acceded subsequently to this Convention (the dates are those on which the instruments of accession were deposited): Japan (28th April, 1964), Finland (28th January, 1969), Australia (7th June, 1971) and New Zealand (29th May, 1973).

The Socialist Federal Republic of Yugoslavia takes part in certain work of the OECD (agreement of 28th October, 1961).

SEMINAR ON SYNFUELS

OECD Cinema
Wednesday 12th June 1985

Introduction

The purpose of the Seminar was twofold:

i) to provide an overview of major synthetic liquid fuel developments in six IEA countries with significant activities in the field, and which were the subject of recent in- depth review visits; and

ii) to facilitate understanding of the synfuel technologies currently deemed most attractive for future deployment, and their likely evolution.

It was considered that this dual approach would assist in placing individual national synfuel strategies in an overall programme perspective.

Contents **Page**

These presentations cover:

a) principal current activities, including:

— scope and extent of current RD&D activities in synthetic liquid fuels;

— details of process, feedstock, throughput, product slate, and projected economics for each major demonstration plant; and

— major research thrusts; and

b) policy issues and conclusions (e.g. on appropriate future RD&D programme directions to meet policy goals) emerging from the country visits.

This discussion includes questions on country presentations, as well as a more general discussion of principal national programme issues.
It attempts to identify the major issues for Governments, and to suggest appropriate conclusions, both for individual national programmes and generically, arising from national public sector experiences in synthetic liquid fuel developments.

This was a general discussion led by rapporteurs and industry representatives on how technology-specific issues are related to future national strategies for synthetic liquid fuel development. The aim of this technology-based session was to provide an analysis of the current status and prospects, and general applicability of the technologies under development. As such, it complements the country/policy-based session in the morning.

Editorial note: The following text does not constitute a verbatim transcript of the proceedings, but rather an effort to convey the sense of the original. It has been amplified where additional facts were available and, in part, edited to clarify the meaning of the discussion.

Cover photograph — Coolwater Coal Gasification Plant, U.S.A.

CHAIRMAN'S INTRODUCTION

The decision to hold a synfuels seminar here today, in conjunction with the 34th meeting of the Committee on Energy Research and Development, grew out of the in-depth reviews of national energy RD&D programmes which were reinstituted this year after several years' moratorium. When it was decided that a return to in-depth reviews would be beneficial, it was also decided that each year's group of in-depth reviews should focus on a topic identified as one of particular current importance. This year's topic was chosen to be synthetic liquid fuel developments.

As the review teams completed their country visits and preliminary conclusions began to emerge, we decided that, since we had had such an interesting and full series of country reviews, it would be a great mistake just to put this in the annual National Programme Review book. It seemed much better to hold a seminar at the time of the CRD meeting so that CRD members themselves could realise the issues which were involved and that those that took part in one in-depth review could see what their counterparts in the other countries discovered and what their reactions were. Thus we, the CRD as a whole, could gain a better feeling for what was happening in the synfuels area amongst all our IEA countries. The six countries chosen for in-depth reviews this year were those which we felt were probably the most interested and active in the synthetic fuels area, namely, Australia, Canada, Germany, Japan, New Zealand, and the US.

Now today we have before us a full schedule. This morning we are going to hear the reviews of the various countries, and in the afternoon we've got with us some of our friends from industry who have kindly come to give us their perspectives on specific technologies. In addition, we plan to put together the proceedings of this meeting to be published as an independent volume.

We have felt, going through the Energy Technology Policy Study*, that synthetic liquid fuels was a really important area to look at. Why? Because we noticed in our review that while electricity-related technologies were getting a lot of attention in R&D funds throughout the whole of the IEA, liquid fuels in general were not. Now there may be some good reasons for that, but in fact the energy security of our IEA countries depends very heavily on the liquid fuels segment and, in particular, the transportation sector is almost totally dependent on liquid fuels at the moment and well into the foreseeable future. Therefore, we asked ourselves what options were being pursued amongst our countries to address any eventuality that the liquid fuel situation might go from a period of glut to a much tighter market. We recognise, of course, that at the moment the production of synthetic fuels is expensive, but that's not really the issue. The issue is that of safeguarding our future economies against shortages of liquid fuels by ensuring that options are available at such a time to counteract any economic or geopolitical threat.

So with that, I will ask my friends and colleagues here to start with the trip to New Zealand, because they have a particularly innovative process, the first of its kind, for converting gas into gasoline through the Mobil process.

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* *Energy Technology Policy*, OECD/IEA 1985

NATIONAL SYNFUELS STRATEGIES

NEW ZEALAND

Review Team: Dr. Harold Jaffe (U.S.), Dr. David Metz (U.K.), and Ms. Susan Pearce (IEA Secretariat)

Presentation by: Dr. Jaffe and Dr. Metz

Introduction

New Zealand's unique position in the development of synthetic liquid fuels stems from the existence in New Zealand of one of the world's ten largest natural gas fields, together with a rather low level of domestic demand for that gas for the usual purposes, and from the decision of the New Zealand government in 1978 that liquid fuels for transportation were the greatest vulnerability of the New Zealand energy economy. This latter decision resulted in two major actions:

— a determination by the New Zealand Government that the gas to which it was entitled under a "take or pay" contract would be better utilised for the production of synthetic liquid fuels than for alternative uses; and

— the establishment of the Liquid Fuels Trust Board (LFTB) whose charter was "to promote ... any activity which has as its purpose ... the reduction of the use of imported fuels for transport purposes in New Zealand" - a very mission-oriented agency, therefore.

Since 1978, New Zealand has mounted a comprehensive RD&D programme to look at the present and future availability of transport fuels. Many technologies have been considered, with some identified as not likely to be attractive in the New Zealand context, and others as promising to pursue.

Table 1
Overall Approach to Transport Fuel Supply

Gas to Gasoline	1979 - Decision to proceed in 1982 - Begin construction 1985 - Expected production
CNG/LPG	1978 - Investigations begun 1985 - 80,000 conversions, growing at around 30,000 per year - Established North Island distribution system
Alcohol fuels	
Ethanol	Preliminary investigations indicated uneconomic - work terminated
Methanol	*As additive,* distribution system problems - work terminated
	100% methanol Diesel engine bus trials Dual gas/methanol internal combustion engines Both are viewed as promising and activities are ongoing
Tallow esters	Additive to diesel fuel, initial investigations promising, further compatability testing and economic evaluation required
Lignite	Resource evaluation ongoing; as in preliminary analysis of alternative routes to liquid fuels
Peat	Resource deemed suitable by pyrolysis to be used as refinery feedstock. As with lignite, investigation of the resource and of plans for its use are ongoing

Publicly-funded RD&D into synthetic and alternative transport fuels is carried out by the LFTB as well as the New Zealand Energy Research and Development Committee (NZERDC), the Department of Scientific and Industrial Research (DSIR) and several government departments. Total Government funding in this area in 1983/84 equalled NZ$3.9 million, or about 30% of the New Zealand energy RD&D budget (this includes no funds for the gas-to-gasoline plant, as it is now in the construction phase). In addition, some work is being carried out by other organisations such as universities and private sector companies.

Table 2 shows current and forecast demand for transport fuels to the year 2000 and projections of the availability of transport fuels from indigenous sources, based only upon those supplies already available or to become available because of decisions already taken. As you can see, this includes compressed natural gas, LPG, synthetic gasoline (which comes on stream later this year), crude oil and condensate from the large gas field. Perhaps

the key figure to note is that it is projected that New Zealand will reach 51% self-sufficiency in transport fuels in 1987-88, declining to 41% in 1998-99. Therefore, additional indigenous sources of transport fuels are being investigated.

Table 2

Fuel Type \ Year	1983-84	1987-88	1992-93	1998-99
Petrol/CNG/LPG	83.6	86.9	89.8	94.2
Avgas	0.7	0.7	0.7	0.6
Avtur	12.9	14.4	17.4	20.6
Diesel	41.1	45.1	50.4	54.7
Fuel Oil	5.3	6.8	8.4	9.7
TOTAL DEMAND	143.6	153.9	166.7	179.8

Forecast demand for transport fuels (PJ/yr)

Fuel Type \ Year	1983-84	1987-88	1992-93	1998-99
CNG	3	6	9	11
LPG	1	3	4	5
Synthetic Gasoline	-	27	27	27
Crude Oil/Condensate	31	43	39	31
TOTAL INDIGENOUS SUPPLY	35	79	79	74
PERCENTAGE OF TOTAL TRANSPORT FUELS DEMAND	24.4	51.3	47.4	41.2

Projected Availability of transport fuels from indigenous sources (PJ/yr)
(PJ = 10^{15} JOULE)
(This data is based on information provided by the Ministry of Energy)

Table 3 shows some of the possibilities. The major indigenous resources identified by New Zealand as sources of transport fuels are coal (including lignite and peat), natural gas, biomass and petroleum. Minor feedstocks include waste biomass and animal fats. As can be seen, in principle

Table 3

Resource	Resources	
	Proven Reserves	Indicated and Inferred
COAL		
Lignite	600	65,600
Sub-bituminous	4,500	10,900
Bituminous	1,100	3,700
Peat (Chatham Is.)	450	3,000
NATURAL GAS		
Maui	5,300	
Kapuni	430	
Other	30	
PETROLEUM-BASED MATERIALS		
Condensate	870	
Crude Oil	50	
Oil Shale		200-4000
BIOMASS (Renewable)		
Forest Biomass (Exotic)	60-80 PJ/y	200-250 PJ/y
Agricultural Crops	4-9 PJ/y	6-15 PJ/y
Waste Materials	minor	minor

Proven and inferred reserves of raw materials for potential production of transport fuels (PJ)
(PJ = 10^{15} JOULE)

New Zealand has adequate resources to be totally self-sufficient in transport fuels for a considerable period if, that is, these very large resources of lignite, coal and peat can be deployed. However, self-sufficiency is not sought as an end in itself in the short or medium term as there are other social and economic criteria that need to be met, and the economic considerations are clearly important here.

Therefore, investigations into each of these resources are ongoing, with the objective of developing plans for the production and utilisation of indigenous transport fuels so that, if economic or strategic considerations were to dictate implementation, the Government would have on hand a number of fully investigated and costed alternatives.

Principal Current Activities

The focus of energy RD&D in New Zealand is on the transport fuel area. The following is a discussion of the overall effort undertaken by New Zealand to develop alternatives to conventional transport fuels and is intended to amplify the brief summary contained in Table 1.

Natural Gas-to-Methanol-to-Gasoline Plant

By far the major synthetic fuel project in New Zealand is the gas-to-gasoline plant, a joint venture between the New Zealand Government and Mobil Oil with the equity split 75%-25%. This is also the largest demonstration of this technology world-wide, with a planned output of 14,500 bbl/d of synthetic gasoline. Construction of the plant began in March 1982. The work is currently on schedule and within budget - it's really a remarkable feat - and the plant is expected to be in production in the latter half of 1985. It will provide up to 30% of New Zealand's demand for gasoline.

The general schematic of the plant is shown in Figure 1. Natural gas is taken in and converted through steam reformers in a methanol synthesis into methyl alcohol which is supplied to four catalytic reactor conversion systems. There are a total of five (one on standby) with one reactor available for catalyst regeneration at all times. The crude gasoline stream is fractionated into heavy fractions and light fractions and these products are ultimately fed into the New Zealand refinery.

The methane-to-methanol process is well established, but the methanol-to-gasoline step has previously only operated on a 4 bbl/d pilot plant. However, the process used does not involve large technical uncertainties as the same depth of fixed bed zeolite catalyst is being used in the full scale plant as was used in the pilot plant. The overall process is about 53% efficient. It produces a very high-grade gasoline - About 92-93 RON - and will be blended with gasoline from crude oil at the sole New Zealand refinery, which is currently being expanded.

The economics of the gas-to-gasoline plant depend upon the availability of low cost natural gas surplus to the requirements of the local market. The cost of the plant is now estimated at US$ 1.475 billion, financed 80% by debt, 20% by equity. The original economic analysis showed the gas-to-gasoline process as economically attractive compared with exporting the gas as LNG at US$ 2.50/m BTU, provided the real price of crude oil rose at 3% yearly. In the intervening period, the crude oil price has declined in real terms. However, because of the controlled price of gasoline in New Zealand, intended to yield an appropriate return on current investment, the return from sales of synthetic gasoline will cover the costs of production as well as service the debt. The debt is scheduled to be repaid over ten years, after which the profits will increase substantially.

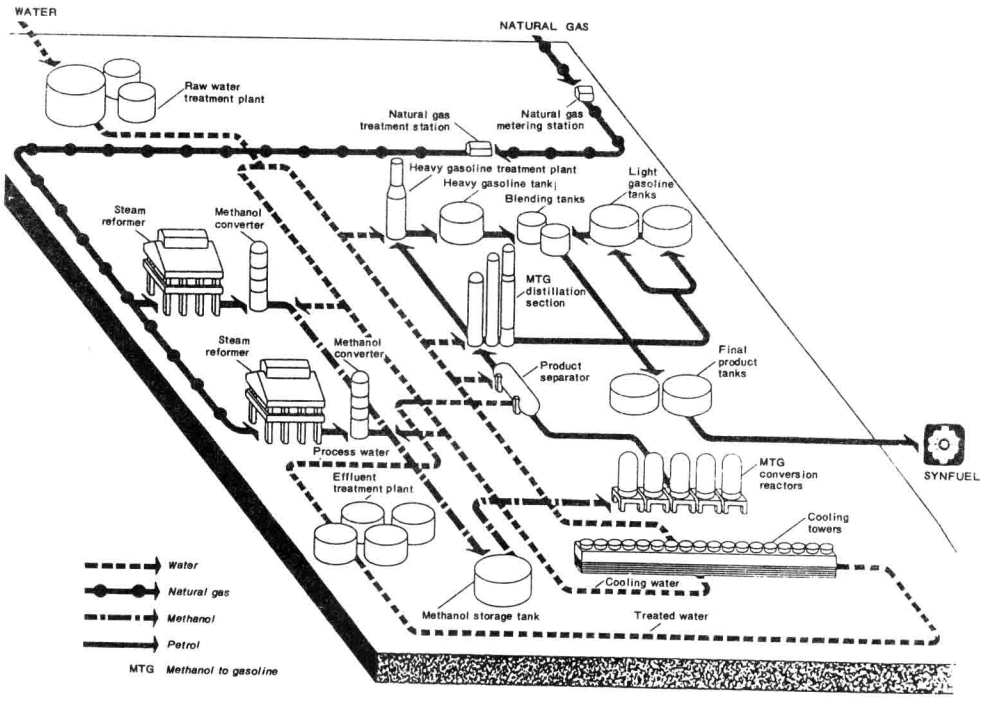
CNG/LPG

The next area, which is compressed natural gas/liquefied petroleum gas, is not really a synthetic fuel, but illustrative of the approach New Zealand has taken to meet their transport fuel requirements.

Beginning in 1978, investigations were undertaken concerning the suitability of CNG and LPG as vehicle fuels in New Zealand. This work was largely

Figure 1

Changing Gas to Methanol then to Petrol



undertaken at the initiative of the NZERDC, and is generally viewed by them as a successful example of a focussed programme initiated by the goverment resulting in effective technology transfer to industry. To date, about 80,000 vehicles have been converted to CNG and, although there is no formal target for conversions under the present government, the present rate of 30,000 conversions per annum should result in 200,000 converted vehicles by the early 1990s. This is equivalent to about 12% of the North Island vehicle population. CNG use in vehicles is confined to the North Island because there is no pipeline gas in the South Island, although LPG use is increasing here.

The technology involves the conversion of existing petrol engine vehicles to dual firing, through a system controlled by the driver. The incentive to use CNG is its cost relative to that of motor gasoline (about 40¢ per litre equivalent compared to 90¢ per litre). However, the cost of conversion to the motorist is quite high, about 10% of new vehicle cost. The economics of conversion is favoured by high vehicle usage; it is estimated that the break-even point is about 10,000 kilometres per year.

Because of the average age of the New Zealand motor vehicle fleet, any conversion technology must be amenable to retrofit to have a significant impact. The "conversion kits" for retrofit were developed in New Zealand and have been improved on the basis of several years' experience. The absence of a domestic car industry limits the potentially broader diffusion of this technology.

The New Zealand experience has indicated that the major problems with CNG and LPG as motor vehicle fuels are consumer acceptance and infrastructure. A programme of public information, loans, grants, tax advantages and special incentives to distributors to establish CNG outlets has overcome much initial resistance. In addition, initial quality control problems with the installation of conversion equipment are being addressed through establishment of test centres, a warranty programme, and a CNG Development Centre, funded by the gas industry, for ongoing technical development and training.

Alcohol Fuels

The investigation of alcohol fuels for motor transport initially considered a range of alternatives. Subsequent work, however, indicated that ethanol was, and was likely to remain, uneconomic and that methanol used as a blend or diluant presented distribution system problems. Therefore, work has tended to focus on the use of 100% methanol as a vehicle fuel.

The LFTB is currently conducting fleet trials of methanol-fuelled buses in conjunction with the Auckland Regional Authority. The objective is to carry out operational testing of different approaches to using methanol as a fuel for diesel engine buses. Because methanol cannot be used in diesel engines