

REFINING NEW ZEALAND'S OIL

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New Zealand has had its own refinery since 1964 which ran on imported crude oils and naphthas. As part of the *Think Big* plan of the previous Government the Refinery was expanded between 1982 and 1985 to be capable of meeting New Zealand's domestic demand up until the year 2000 complemented by the Motouui Synfuels plant. The design only recognised the availability of Maui condensate as indigenous feedstock. Since then, however, New Zealand has produced a considerable quantity of low sulphur waxy crudes which have a different yield structure to the refinery's design crudes.

The Refinery's hydrocracking route is suited to the conversion of some New Zealand crude oils but there are limitations in terms of pour point, C4 minus content, nitrogen content, minimum sulphur levels and acidity which prevent the refinery running on 100% indigenous crudes and condensates.

The Refinery's substantial upgrading capacity results in a high value yield compared to other regional refineries and this is achieved at operating costs of less than \$2 US/barrel.

The availability of the NZ coastal tanker fleet to convey crude overseas or to the Refinery is presented and the ability of NZRC to offer other services to the oil producing companies, such as laboratory analyses, crude assays, safety audits and inspection services.

INTRODUCTION

Like many smaller nations, New Zealand has a single oil refinery sized to meet its own present and future needs. The New Zealand Refining Company Limited (N.Z.R.C.) is a public company which owns and operates the refinery at Marsden Point, near Whangarei. The company was established in 1962 and a simple refinery was commissioned in 1964. In those days heavy crude oils and naphthas were imported and residues exported so that the rather unbalanced product demand pattern in N.Z. could be met:

As New Zealand condensates became available in the mid to late 1970s they were routed to the refinery and being light, displaced some of the imported naphthas. These condensates were suited to the production of gasolines and diesels but, lacking any substantial quantities of residues (350°C plus material) they could never displace the imported crudes. A comparative material balance for this period vs the present day is given in Table 1.

Although N.Z.R.C. still continued to produce a substantial share of the domestic markets it was unable to produce aviation gasolines and jet fuel and its desulphurisation capacities were extremely limited, such that it could not cope with proposed reductions in sulphur contents of gas oil and fuel oils.

In 1978 the Government initiated its *Think Big* policy and N.Z.R.C. set about preparing for its expansion.

EXPANSION

The expansion objectives as agreed between the Ministry of Energy and N.Z.R.C. were:

(a) To meet domestic demands of year 2000 in conjunction with synfuel production.

- (b) To maximise distillate yields from crude.
- (c) To reduce lead in premium gasoline from 0.84 g/l to 0.45 g/l.
- (d) To reduce sulphur in gas oil from 0.49 wt per cent to 0.3 wt per cent maximum.
- (e) To be able to process a wide range of crude oils.
- (f) To reduce foreign exchange by processing cheaper crude oils.

The company also decided to include within the scope of the project a pipeline to Auckland with its terminal at Wiri, three tanks for the blending of synfuel at the Refinery, upgrading of the refinery jetties to take larger ships, and residue/waxy crude import facilities.

Construction commenced in 1981 and the first units were commissioned in mid 1985 with final units coming on line eighteen months later. It was New Zealand's largest ever construction project, and during its project life experienced difficult industrial relations. Final project cost was in the order of 1900 million New Zealand dollars, but this substantial expenditure has given the country an almost totally new refinery which has extensive flexibility in its processing.

DESIGN

In designing the expanded refinery little, if any, thought was given to the regional supply situation, let alone the small but increasing quantities of McKee crude that were being discovered. The refinery design was based on processing Arab Heavy, Maui condensate, and Iranian Light crudes only.

Two designs were made in the scouting study; one incorporating a catalytic cracker and the other a hydrocracker. In hindsight it would have been nice to have had both upgrading units but few had foreseen in 1978 the rapid growth

Pre-Expansion		Post-Expansion	
Intake			
Kuwait	300 299	Arab Light	673 984
Iran Light	68 343	Arab Heavy	412 515
Arab Light	661 238	Kuwait	87 760
Arab Medium	23 399	Murban	248 119
Arab Heavy	339 330	Iran Light	189 694
Qatar	128 035	Dubai	65 470
Maui	125 441	Maui	626 510
Kapuni	174 643	Arun	118 072
		Cooper Basin	13 382
Miri	82 178	Kapuni	276 833
Arun	275 286	Petrocorp	302 096
Seria	61 840	Tapis	44 040
Attaka	39 160	Gippsland	570 833
		Shengli	49 308
Blendstocks			
Naphtha	606 986		
Distillate	29 783	LSWR	33 292
	2 915 961	Syngas	429 031
			4 140 939
Outturn			
Premium	1 165 775	Premium	1 430 939
Regular	55 675	Regular	135 810
AGO	623 778	Jet A1	645 505
MDO	31 031	Prem Kero	11 465
LFO	161 377	AGO	1 191 993
HFO	556 686	LFO	114 557
BFO	46 648	HFO	164 703
Bitumen	103 669	HBFO	965
Residue	19 886	Bitumen	133 224
Fuel & Loss	151 436	Residue	12 578
	2 915 961	Sulphur	11 424
		Fuel & Loss	288 430
			4 140 939

Table 1: Material balance (tonnes)

of the Asia-Pacific region, the demand for unleaded gasoline and deregulation of the New Zealand oil industry.

The Hydrocracker option was eventually selected because of its greater ability to handle a wider range of residue types than the catalytic cracker, plus its ability to produce very high grade, very low sulphur products.

Table 2 gives a list of all the main Refinery processing unit capacities and Fig. 1 shows the basic configuration of these units. Table 3 shows the design material balance.

REFINERY YIELDS AND COSTS

The Refinery's design gives for most feedstocks a greater than 95 volume per cent saleable yields. As there is no ready market for additional propane and butane this is put into the refinery fuel gases, but if recovered would put the saleable yield at a level far higher than most other refineries in the world.

	Tonnes/Stream Day	000 BBLs Cal. Day
Crude Distiller 1	7 200	46.95
Crude Distiller 2	5 500	34.72
Naphtha Hydrotreater Platformer	4 150 3 000	32.10 23.25
Gas Oil HDS	900	6.00
Kero HDS	1 600	11.54
HVU 1	1 100	6.76
HVU 2	5 200	31.95
Hydrogen	140	-
Hydrocracker	3 400	20.71
Butane Deasphalting	1 600	9.10

Table 2: Refinery unit capacities.

A comparison of the refinery saleable yield versus typical Singapore refineries is shown in Fig. 2.

The refinery yields and processing costs for the existing New Zealand feedstocks are given in Table 4.

The costs are extremely competitive when matched against the yield advantage that the refinery gives to its customers against using other regional refineries.

In the last two years this has led the Refinery to run fully loaded on all its major units, with the balance of production, some 15 to 20 per cent on intake, being exported to Australia, Japan, Korea and the Pacific Islands.

FEEDSTOCK LIMITATION

The Refinery classifies its feedstocks in the following manner:

- Condensates
- Low sulphur crudes

Intake	(Tonnes/Annum)
Maui	624 000
Kapuni	192 000
Iran Light	1 125 000
Arab Light	750 000
Arab Heavy	1 010 000
	3 701 000
Outturn	
Premium	813 000
Regular	237 000
Jet/Kero	455 000
Gas Oil	1 125 000
LFO	140 000
HFO	390 000
BFO	70 000
Bitumen	115 000
Sulphur	25 000

Table 3: Design material balance.

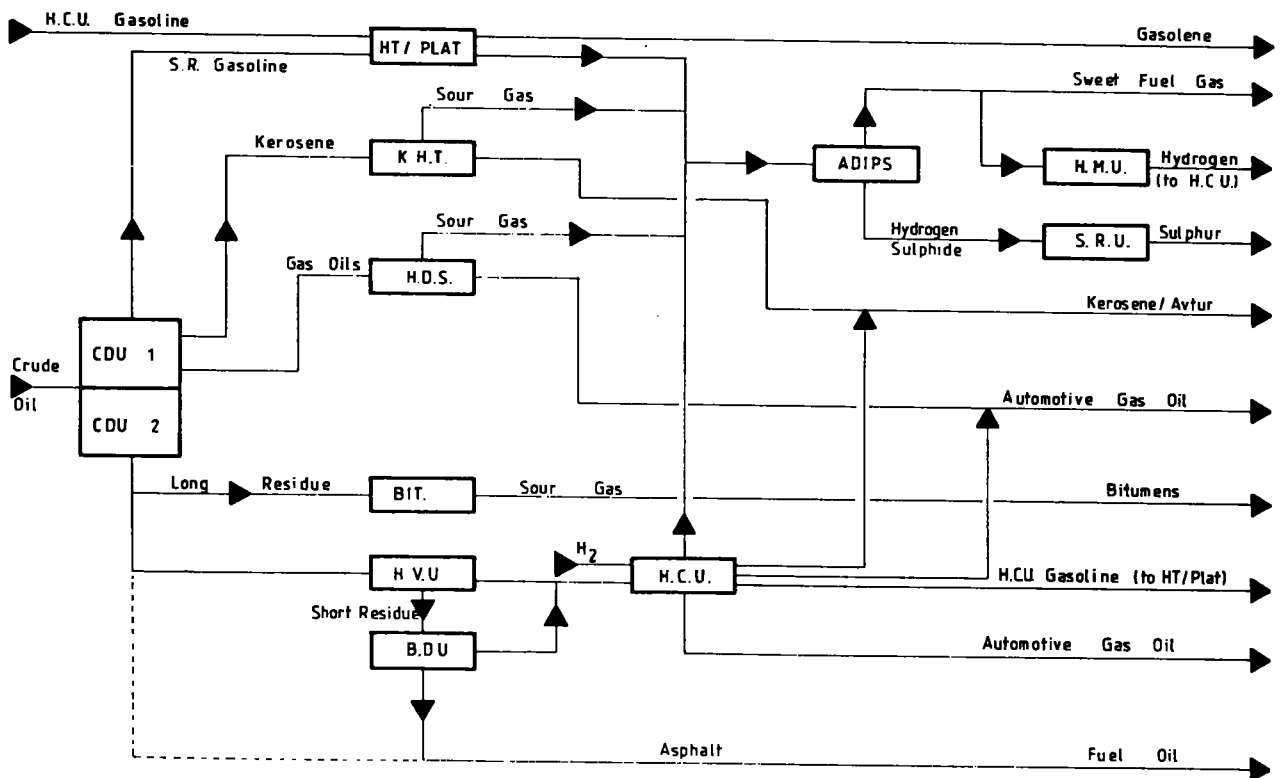


Fig. 1: Refinery flow scheme.

Refinery yield (Wt %)

	Maui Cond.	Kapuni Cond.	McKee Crude
Gasoline	60.7	44.9	12.4
Jet/Kero	20.7	21.1	25.5*
Gas Oil	13.4	29.6	57.5
Fuel Oil	0	0	30.0*
Bitumen	0	0	0
Costs(NZ\$/bbl)**	1.8	1.9	2.3

* Assumes other components available from non waxy crudes for blending

** Excludes cost of lead for premium Mogas production.

Table 4: Refinery yields for New Zealand feedstocks (typical).

- (c) High sulphur crudes
- (d) Bitumen feedstocks
- (e) Residues.

Within each of these categories there are, at the present time, some limited restrictions imposed because of physical storage capabilities, catalyst sensitivities, corrosion potential or product quality constraints.

Storage

Because the Refinery has four customers each supplying their own feedstocks within a regulated feedstock call up procedure, tannage has to be controlled to ensure good segregation to optimise refining. In this regard condensate parcels are limited to 60 000 tonnes maximum, and residues 40 000 tonnes maximum.

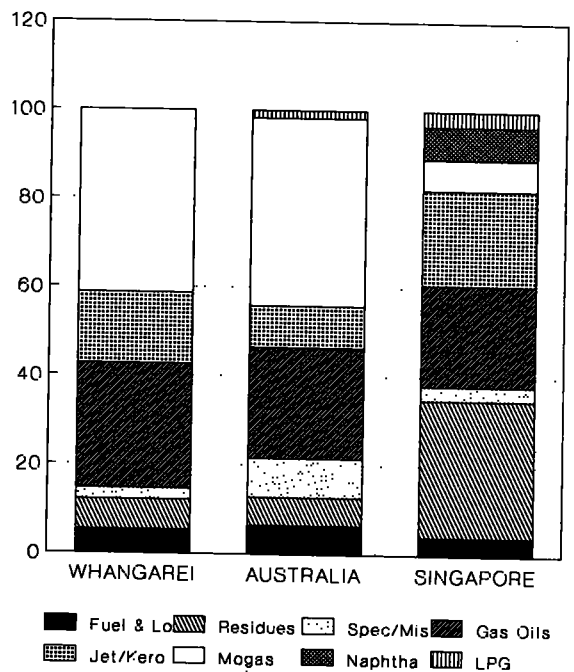


Fig. 2: Cut of the barrel.

Although the Refinery has recently upgraded its storage facilities it cannot import those few crudes whose pour point exceeds 35°C, and those with pour points between 30 and 35°C are limited to 80 000 tonnes maximum per parcel.

Jetties

For all other types of crudes the maximum quantity is usually limited to 140 000 tonnes by the draft availability at the jetty, viz 16.2 m.

Corrosion potential

The Total Acid Number (TAN) of crude is carefully monitored because it is an indication of the corrosion potential to the Refinery. In particular we limit crudes whose TAN exceeds 0.5mg KOH/g in any crude cut. These crudes have high potential to cause corrosion in the flash zones of crude distillation columns and any other two phase situation within processes.

They can be processed if arrangements can be made to physically pre-blend in the Refinery with a low TAN (<0.2mg KOH/g) crude. For example, Shengli with Maui condensate was an acceptable combination.

The Refinery's crude units both have electrostatic desalters thus high salt contents are not a problem for the crude distillers.

Catalyst sensitivities

It is in this area that the Refinery has to look carefully at the feedstock it processes. The Hydrocracking process is particularly sensitive to possible catalyst *poisons*, and the degree of reaction attained in the process is characterised by these properties:

- (a) Carbon content
- (b) Hydrogen content
- (c) Sulphur
- (d) Nitrogen - total
- basic
- (e) Boiling range
- (f) Molecular weight
- (g) Aromatics
- (h) Ring Index
- (i) Ni + V
- (j) Conradson carbon
- (k) Asphaltenes

Each of these properties has an effect on the cost of hydrocracking either by deactivating the catalyst at a higher rate, by needing more hydrogen to saturate the cracked molecules, and to remove sulphur and nitrogen, or by using more energy in the process.

Generally the New Zealand McKee and Waihapa crudes are highly paraffinic, i.e. they have a low carbon to hydrogen ratio. This makes them *refractory* or hard to *crack* the molecules apart. This, however, is compensated by a low total and basic nitrogen level, low sulphur and low CCR/asphaltenes content.

Against Middle East, Arabian Light feedstock the McKee/Waihapa would cost about 40 per cent less to process via the Hydrocracker. Because of its *refractory* nature, however, it is not such a desirable feedstock to run for long periods.. Table 5 shows the difference in Hydrocracker yields between a Far East waxy crude feedstock and a Middle East high sulphur feedstock.

If hydrocracking feedstocks are processed with high Ni + V contents (i.e. greater than 10 ppmw) they may cause rapid deactivating of the demetallisation *guard beds* and pre-

	Wt. % on feed	
	Far East	Middle East
Fuel Gas	1.6	1.6
Propane	0.5	0.6
Butane	1.7	1.8
Tops 85	4.5	5.4
Naphtha 140	10.2	11.6
Light Kero 180	8.0	8.3
Medium Kero	6.0	6.2
Heavy Kero	16.0	16.5
Gas Oil	55.0	51.7

Table 5: Hydrocracking yields (typical).

cipitate an end-of-run catalyst state before the hydrocracking catalyst itself deactivates.

The design of the Refinery was, as previously noted, based on conversion of higher sulphur crudes in order to minimise foreign exchange.

Product quality

Although the Refinery is highly flexible it would never be able to run fully on the current types of indigenous crudes because of several factors that are limited by current product qualities:

- (a) The necessity for there to be no more than a five degrees Celsius gap between the freeze point of Jet A-1 and the wax crystallisation temperature; some pure indigenous feedstocks do not meet this condition, but it can be met when they are co-processed with other imported crudes.
- (b) Limitations on the waxy crude content of light and heavy fuel oils preclude making any fuel oils from indigenous feedstocks, processed alone.
- (c) Bitumen has to be produced from pure Arabian Heavy or Kuwait feedstocks.

OTHER SERVICES TO OIL INDUSTRY

Coastal tankers

The four major New Zealand oil companies own four coastal tankers, details of which are given in Table 6. Their primary task is to distribute products from the Refinery around the coastal ports, as scheduled by the coastal co-ordination committee. They also lift indigenous feedstocks and Synfuel from New Plymouth for delivery to the Refinery. Due to greater efficiencies in scheduling these tankers, there are a number of occasions when one or other are available for single voyage charters. BP acts as the shipping manager for such arrangements.

Laboratory analyses

The Refinery has a TELARC registered, modern laboratory which can carry out most tests related to crude oil quality.

	Kotuku/Kuaka	Amokura	Taiko
Summer draught	9.57	10.37	9.9
Length (m)	171.45	192.00	180.00
Beam (m)	25.02	27.12	28.0
Deadweight (summer)	2550	32290	30282
Max. cargo (tonnes)	24500	31500	29000
Built	1975	1976	1984

Table 6: Coastal tanker particulars.

It's *Fischer* automatic distillation equipment is the only one in New Zealand and allows for the prompt preparation of crude assays, either full or partial, to the customer's wishes, at a competitive fee.

Specialist advice

As New Zealand's major bulk oil handler the Company has built up specialist expertise in the following fields:

- (a) Safety auditing
- (b) Bulk tank cleaning
- (c) Inspection of equipment
- (d) Rotating machinery
- (e) Computerised maintenance management systems.

It is willing, given availability of personnel at the time, to proffer assistance in these areas for a reasonable fee.

CONCLUSION

The existing refinery configuration does not confine itself to wholly refining New Zealand's existing feedstocks. The location of large quantities of higher sulphur, heavier feedstocks in New Zealand would ensure that all of the country's fuels could one day come from its own crude oils. Until that day is reached, or the refinery configuration is changed, it is likely that no more than fifty percent of the Refinery's crude oil diet will come from our own production.