Alternative fuel cost study

ALTERNATIVE FUEL COST STUDY

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SECTION 1 - INTRODUCTION

1. INTRODUCTION

The OPEC oil embargo of 1973 and two major increases in the price of internationally-traded crude oil in the decade stimulated investigation of the supply of alternatives to petroleum-based fuels which, together with oil conservation practices, have recently succeeded in capping the price of oil and even temporarily reversing the price trend. The current international surplus of oil producing capacity still leaves most countries in the industrialized world dependent upon imports of oil which beyond the late 1980's must increasingly be drawn from OPEC sources. A consensus view is that world dependence on OPEC supplies will increase from the current 40% of demand to 54-55% of demand by the year 2000, once again expanding the consuming nations' vulnerability to supply disruptions and price shocks.

In Canada, the constraints to self-sufficiency lie not with the volume of the oil resource available but to the quality of that resource and the high cost of oil recovery from the Arctic and offshore from these areas and from the intractable heavy oil and tar-sands bitumens which form the majority of Canada's oil endowment.

In contrast, Canada's surplus gas resources and gas liquids associated with that gas are ready to exploit directly as heating and transport fuels, or for conversion to liquid fuels such as methanol. Biomass and coal resources are also abundant and widely distributed in Canada, and technologies for their low cost conversion to transport fuels are under investigation. Unfortunately for Canada, the non-petroleum alternative fuels and the hydrocarbons available from the more intractable resources are not yet sufficiently price-effective or well-known to users to permit large scale substitution of oil by these alternatives. Canada's prospects, even to the year 2000, are that significant imports of crude oil will continue at high cost.

One of the factors contributing to this continued dependence on oil is a lack of targets for the economic exploitation of the alternatives and a lack of knowledge on the economics of these alternatives and the comparative economics of their use compared to the conventional petroleum-based fuels.

The Transportation Energy Division of the Coal and Alternative Energy Branch of the department of Energy, Mines and Resources has attempted to close the information gap by the publication of a number of analyses of the costs, markets and impediments to the use of alternative fuels in the transport sector. One of these studies, "Alternative Fuels Production Costs", prepared for EMR by the R.F. Webb Corporation and Padgett Process Services Ltd. (Report TE82-7, dated February 1983) developed a database on the capital and production costs for 45 alternative fuels and processes and a computer-based analytical technique for projecting future costs at any given location in Canada and for comparing the plant gate or ex-refinery costs of the alternatives with conventional petroleum-based fuels.

Under the auspices of the Ministry of State for Science and Technology (MOSST) and EMR an extension of the alternative fuel cost analysis methodology has now been explored in which the end users' costs of alternative fuel systems can be examined and compared with the end users' costs with conventional fuels and vehicles. The work reported here involves the incorporation of the established alternative fuel cost analysis methodology into a new system which also considers the cost of transporting, storing and distributing transport fuels (capital and operating cost components are defined), fuel taxes and tax concessions on alternative fuels, the cost of the alternative fuel vehicle (or conversion cost) with and without tax concessions and grants for conversion, and the variable and fixed cost of owning and operating the vehicle over the expected lifetime. The transport industry uses the concept of life-cycle cost to encompass all elements of cost encountered over the lifetime of a vehicle and life-cycle costing is a frequently used technique for examining the absolute and relative cost of owning and operating different classes of vehicles, or the relative cost of different transport fuels. A frequently used example will involve the comparison of gasoline and diesel vehicles.

The preliminary investigation reported here develops and then uses a large database on fuel and vehicle costs to explore the utility of a new economic analysis tool for use by system designers in industry and government in their evaluation of the many contributions of alternative fuels and engines available in Canada. The analytical tool provides a means to express and compare life-cycle costs, annual costs, cost/passenger kilometer or cost/tonne kilometer of conventional and alternative fuel-based transport systems. It also provides a means to examine and compare the details of operating and ownership costs such as the cost of fuel, maintenance, or other variable costs and the cost of financing the vehicle and other elements of fixed costs. The format of the analytical displays of life-cycle cost developed in this preliminary investigation facilitates the manipulation of transport cost data and the comparison of fuels, vehicles, payload levels, vehicle financing methods and other interacting cost variables. The analytical process can be accelerated by the use of a microcomputer and typical "spread-sheet" software but is not restricted to computer users.

The investigators are grateful to Mr. R. Clayton (Policy Advisor, Government Branch, MOSST) and Mr. J. Legg (of EMR's Office of Energy Research and Development) for their constructive criticism and patience.

SECTION 2 - SUMMARY

2.1 OBJECTIVES

The principal objectives of the investigation are:

- To prepare a methodology for the comparative evaluation of life-cycle costs (LCC) of alternative and conventionally fuelled vehicles
- To test the methodology.

2.2 LIMITATIONS AND ASSUMPTIONS

The cost-related database assembled for this study has been drawn from a variety of reference sources in which some areas are relatively well-documented (e.g. conventional vehicle cost and performance data), and others (e.g. fuel plant/terminal/refuelling station throughputs/costs, fleet garage costs, alternative fuels performances), are less well documented. The individual data obtained from these sources has been evaluated and then incorporated into the database when it appeared to give end results (e.g. wholesale/retail fuel prices, alternative fuel consumptions) which were consistent with, or a reasonable extrapolation from, current 4Q83 practice.

However, while every effort has been made to use a representative set of data for each vehicle/fuel case selected, the range of possible variations in return on investment, fuels throughput, fuel transportation distances, vehicle fuel consumption within each cost element selected (the fuel plant, fuel transportation, terminal, refuelling station and vehicle service module) will result in a range of vehicle life-cycle costs scattered around the value presented in this study. The generalized methodology used to develop these life-cycle costs will, however, allow the user to input his own values for any of the key cost parameters in each cost element of the system so as to arrive at costs specific to each investigator's own area of interest.

The database used to illustrate the life-cycle cost methodology was developed for a 4Q83 time-frame and a Toronto location, but in most respects (excluding terminal-retail outlet costs) would also be applicable to other S. Ontario locations. An expanded database can provide the same level of information for other locations in Canada with the general framework established. The effects of time in terms of fuel costs, engine conversion costs and efficiency have been accounted for in the sensitivity analyses given in Appendix B and in the discussion presented in Section 4.

As currently structured, the methodology presented here facilitates life-cycle cost comparisons between engine/fuel combinations for a given vehicle type and end use. The methodology should only be used with caution at this stage of development to make broader comparisons, such as those between the costs of different vehicle types and end uses (e.g. public bus versus private auto), since items such as driver cost, garaging, ticket marketing costs and government subsidies are not dealt with in the same degree of detail as the items which relate specifically to alternative fuels.

2.3 THE METHODOLOGY

2.3.1 Definition of Life-Cycle Cost

It was determined that the most appropriate means of comparing passenger and freight transport costs was on a cost per passenger kilometer (passenger modes) and cost per tonne kilometer (freight) basis.

2.3.2 Elements of the Life-Cycle Cost (LCC) (p. 3-4)

The Variable Cost Component

Fuel Cost Subcomponent of Variable Cost

This includes the following:

- Fuel Plant Gate Cost (or ex-refinery costs)
- Distribution Cost (road, pipeline, barge, truck)
- Fuel Terminal Cost (investment, administration, maintenance, labour)
- Refuelling Station Cost (investment, labour, maintenance)
- Fuel Taxes (federal and provincial taxes minus grants, tax concessions.

Other Variable Cost Subcomponents

- Driver associated costs
- Maintenance of vehicle costs
- Miscellaneous vehicle materials (tires, oil, etc.) costs.

The Fixed Cost Component

This is the set of Fixed Costs associated with the vehicle ownership and garaging and includes:

- Fleet Garage/Terminal Costs (investment, labour, administration, maintenance, but excludes vehicle maintenance and refuelling station cost components)
- Fixed Vehicle Costs (licence, insurance, investment, financing less grants, vehicle sales and tax concessions)

The total of the annual variable and fixed costs provides the annual cost of ownership and operation of the vehicle during its period of service with the fleet, or in private ownership. The LCC can be calculated from this annual cost using payload and annual kilometerage data.

2.3.3 Scope of Developed Database

The following vehicle and fuel types were selected to form the basis for developing life-cycle costs for a broad and representative range of the prevailing and "under development" transportation system. The methodology presented here will also allow for the inclusion of any other vehicle/alternative or conventional fuel type combination that is of interest.

Vehicle Types

The database and derived cost elements used in the current investigation were confined to the following set of passenger vehicle types (characterized in Appendix B "Notes on LCC Worksheets"):

- commuter automobile (example: Honda CRX)
- standard automobile (4 cylinder, example: Ford Fairmont Futura)
- taxi (6 cylinder automobile, example: Pontiac Parisienne)
- school bus (example: International Harvester)
- city (urban) bus (example: GM "New Look")
- interurban bus or coach (example: Prévost Marathon)
- passenger truck or van (example: Dodge Pick-up, D150 RAM)

and a set of freight-carrying vehicle types:

- light duty urban truck (example: Ford F150 Pick-up)
- medium duty urban-interurban truck (example: International Harvester Loadmaster)
- heavy duty interurban truck (examples: Ford and Cummins engine)

Fuel Types

For the present investigation of the LCC methodology only the following fuels or combinations were considered in selected vehicles:

- leaded regular gasoline ("LR gasoline"))
- diesel fuel
- compressed natural gas (CNG) used alone or in conjunction with LR gasoline
- compressed natural gas (CNG) as dual fuel with LR gasoline (70%, 30% respectively)
- liquid natural gas (LNG)
- propane, used alone
- propane, used concurrently with diesel (80%, 20% respectively)
- methyl alcohol used alone
- methyl alcohol (4.75%) as a blend with t-butanol (4.75%) and LR gasoline (90.5% (=Oxinol)
- methyl alcohol (90%) as a blend with LR gasoline (10%)
- methyl alcohol fortified with cetane enhancer DII-3 to produce a "synthetic diesel fuel"
- ethanol (10v%) as a blend with LR gasoline (=Gasohol).

2.3.4 Data Assembly

The data on each element of the operating and ownership charges was assembled for a typical set of vehicles operated on a typical set of fuels. The data was taken from the extensive literature (pertinent references cited are given in Section 7) and from interviews with fleet managers and the staff of certain transport associations in Canada and the U.S., such as the Canadian Trucking Association and the American Bus Association. The information gaps were filled by calculation and extrapolation from the assembled data and, where merited, averaged by selection of common data from several sources and elimination of poorly substantiated or extravagent claims (for example, certain of the fuel economy claims that were eliminated were judged to be promotional in intent and content).

The averaged data on operation and ownership for the vehicle-fuel combinations is summarized in the tables given in Appendix B (vehicle classes; base case fuel consumption by vehicle type; comparison of vehicle conversion costs; comparison of miscellaneous materials and maintenance costs; comparison of fleet annual garage/terminal costs per vehicle; comparison of licence and insurance costs; summary of LCC; methodology used in alternative fuel life-cycle cost summary sheets; and sensitivity analysis of vehicle annual variable costs and life-cycle costs).

2.3.5 Life-Cycle Cost Worksheets

The process used in the calculation of life-cycle costs is detailed in Section 3 "Methodology". Each of the 64 vehicle fuel combinations examined (see p. 3-2 for the matrix of these examples) was characterized in a common worksheet format. The set of worksheets are assembled as Appendix A of this report ("Life-Cycle Cost Worksheets").

The details of the fuel cost at the plant (or refinery gate) followed the format and methodology developed in an earlier study ("Alternative Fuels Production Costs", Report TE82-7, EMR, 1983) which was updated, reworked for the specific cases under current investigation and summarized for the present purpose in Appendix C ("Fuel Plant Gate Cost Worksheets") and Appendix D ("Notes on Plant Gate Cost Worksheets").

To simplify the worksheets and the task of developing and verifying the methodology only data relevant to the fourth quarter 1983 in Ontario are presented. The commodity prices used are summarized in Appendix E ("Commodity Prices in 4Q83"). As with the prior investigation of "Alternative Fuels Production Costs", cost data from other locations can be substituted for the given 4Q1983 Ontario set in the worksheets and data extrapolated into the future using models (or projections) of the rate of growth of costs.

The sensitivity analysis component of this methodology (see Appendix B9 and the interpretation of the sensitivity analysis given in Section 4) illustrates for certain of the vehicle/fuel combinations, the effect of different locations and time frames by determining the effect on the variable and life-cycle costs of the following changes:

- cost changes associated with advances in technology to 1990
- cost changes associated with deletion of fuel tax and vehicle subsidies
- cost reduction in fuel (price change or fuel economy improvements)
- cost changes associated with a break-even operation policy at the fuel plant or refinery
- cost changes associated with increased intensity of vehicle use (system efficiency).

2.3.6 Resource Utilization Efficiency

Although fuel costs at the pump in the examples analysed varied from only 4% of life-cycle costs (CNG in a commuter automobile) to 27% (gasoline in taxi service), and although pump fuel costs are determined more by the combined effect of taxes, refining, transportation and distribution costs than by the fundamental resource cost, it is of interest to determine the efficiency of utilization of the primary resource (oil, gas, wood, coal, biomass) in the transport chain.

The parameter used in this study to measure resource utilization efficiency has the following definition: payload x fuel plant conversion efficiency (%) ÷ vehicle fuel consumption (GJ/km). It is therefore expressed as either passenger km/GJ resource for passenger vehicles or tonne km/GJ resource for freight vehicles. Section 6 discusses the approximations inherent in this definition.

Each worksheet (in Appendix A) contains an entry which reports the efficiency of conversion of the natural resource to the refined or blended transport fuel, the fuel consumption per driven vehicle kilometer (as GJ/km) and the average vehicle payload (as number of passengers or tonnes of freight per trip).

The data on resource efficiency and resource utilization are displayed in summary form in Figures 5.1a and 5.1b.

2.4 POTENTIAL APPLICATIONS OF THE METHODOLOGY

a. The provision of a new assembly (database) on vehicle-fuel and highway transport system costs for reference purposes.

b. The provision of a standardized routine (the LCC worksheet and other worksheets) for the assembly of cost information in highway transport systems; this facilitates comparisons between fuels, engines, vehicles and methods of operation at a given time and location.

c. The ability to vary the input values to the worksheets to reflect local costs and management strategies, different timeframes and the effect of improved vehicle or fuel technologies.

d. The provision of a basic framework which could be expanded to provide:

- greater detail and sophistication on costs (e.g. DCF analysis)
- an expanded set of examples in the highway sector (other fuels, engines, practices)
- information on cost and efficiency in other systems: highway and off-highway (rail, air, pipelines)
- a rapid cost enquiry system for exploration of the effects of changes to any input variables on vehicle life-cycle cost and system efficiency. This could facilitate planning for the selection among policy options (such as changes in taxation, vehicle ridership levels, fuel freight costs) and investigation of

the cost effects of major perturbations (such as effect of a sharp increase in the price of oil or gas, changes in leaded gasoline, or pollution legislation) or technical developments (to facilitate choice among competing technologies and R&D proposals). This cost enquiry system would be economic to operate if used in a microcomputer-spread sheet software environment.

- an energy (or resource) efficiency audit system.

2.5 ANALYSIS OF RESULTS OF THE METHODOLOGY

Interfuel Comparisons (Cost and Efficiency)

Section 4, "Life-Cycle Costs by Vehicle Type" provides detailed information on the effect of fuel choice on life-cycle costs in each transport service environment. Comparisons are provided between the costs when operating appropriately-engined private automobiles, taxis, trucks and buses on:

- gasoline or diesel fuel
- blends of gasoline or diesel fuel with alternative fuels compared to gasoline and diesel
- alcohol fuels compared to hydrocarbon fuels
- propane and natural gas compared to gasoline, diesel, and each other in monofuel and dual fuel operating regimes

with changes in subsidies, relative fuel cost and technology discussed.

The conclusions of the detailed enquiries are summarized in Figures 5.1a and 5.1b, where two aggregate numbers - life-cycle cost and resource efficiency - have been used to characterize each vehicle/fuel combination for passenger and freight services. The overview of costs with different fuels provided by Figures 5.1a and 5.1b have been used (see Section 5) to identify the highest and lowest cost fuels for each type of service under the 4Q1983 Ontario conditions. Clearly, the ranking of fuels for each service will vary with location (tax changes may not be the most significant variant between locations) and time (technology is developing more rapidly for some fuel options than others). Figures 5.1a and 5.1b summarize information on resource efficiency for each fuel/vehicle combination, and a resource efficiency ranking for the options can be assembled, similar to that noted above for ranking of the options by cost. Other relationships can be explored and displayed using information provided in the worksheets and other appendices, such as the effect of tax concessions on life-cycle and variable costs, or the incremental benefit of improved payloads.

Intermodal Comparisons

The methodology and the results displayed in Figures 5.1a and 5.1b permit some comparisons to be made between the costs of providing transportation services by different modes. The data reveal the lack of cost competition between the high convenience taxi and light duty commuter automobile and public transportation (irrespective of the fuel chosen), and the life-cycle cost competition that exists between the more intensively used personal automobile and the city bus and intercity coach where change in fuel type could change the competitive cost position. Similar comparisons show that at the average loadings reported, buses have a resource efficiency superior to that of the mid-size passenger automobile and far superior to that of the taxi. The small commuter automobile, in contrast, can be as resource-efficient as the city bus.

In the case of freight transport, the heavy duty truck has extraordinarily low life-cycle costs and high resource efficiency which are little altered by the choice of fuel. The mid-size truck has lower costs than the light duty truck but the superior resource efficiency of the mid-size truck compared to the light truck can be compromised by an inappropriate choice of fuel.

SECTION 3 – METHODOLOGY

3.1 GENERAL

The methodology presented in this section can be used to develop life-cycle costs (LCC) for any vehicle, fuel, time frame and geographic location. For testing purposes the methodology was used to derive the LCC of a limited number of vehicles and fuels for a 4Q83 time frame and a Toronto-based vehicle location. Figure 3.1 summarizes the matrix of cases that was developed for this study.

In essence the methodology consists of first identifying the major cost elements that make up the total vehicle LCC and secondly, identifying and quantifying the many smaller items that constitute each major element of LCC. This quantified cost and cost related data, although limited to particular fuels, time frame, vehicle types, location etc., is itself a part of the methodology, since it represents a valid database from which deviations may be extrapolated. Appendices A & B contain LCC worksheets and back up data for each of the LCC cases examined and therefore represent a summary of both the methodology and database.

One of the prime objectives of the methodology is to provide a means of comparing the benefits of alternative fuels based on a given vehicle type, time frame, location, etc. As such, the focus of the methodology has been to analyze the cost components of the fuel rather than the vehicle. (Note that the breakdown of garage costs for certain buses and trucks would involve a large number of additional cost elements and make the analysis exceedingly complex).

Cost data used in building up the various LCC cases was based on 4Q83 actual market prices where possible. The depressed state of the economy at that time resulted generally in modest to low profit margins. This is consistent with the approach taken in this study with respect to an owner's expected return on invested capital, namely that a "reasonable" or modest return on investment is compatible with the

Fig. 3.1. Alternative Fuels Life-Cycle Costs Matrix

CASE #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
REF #	1a	1b	1c	2a	2b	2c	2d	2e	2f	2g	2h	3a	3b	3c	3d	3e	3f	3g	3h	3i	3h	3k	3l	3m	3n	4a	4b	4c	4d	4e
COMMUTER AUTO	x	x	x																											
AUTO				x	x	x	x	x	x	x	x																			
TAXI												x	x	x	x	x	x	x	x	x	x	x	x	x	x					
BUS SCHOOL																										x	x	x	x	x
GASOLINE	x			x								x	x													x				
DIESEL					x																									
DIESEL/C3																														
LNG						x								x	x															
CNG		x					x									x	x										x			
PROPANE			x					x										x	x									x		
MEOH 100%									x											x	x									
MEOH+CETANE																														
MEOH BLEND										x												x	x						x	
ETOH BLEND											x													x	x					x
SI ENGINE	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CI ENGINE					x																									
RETAIL PUMP	x	x	x	x	x	x	x	x	x	x	x	x		x		x		x		x		x		x						
FLEET PUMP													x		x		x		x		x		x		x	x	x	x	x	x

CASE #	34	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
REF #	5a	5b	5c	5d	5e	5f	5g	6a	6b	6c	6d	7a	7b	7c	7d	7e	7f	7g	7h	7i	7j	7k	8a	8b	8c	8d	8c	8d	8e	9a	9b	9c	9d
BUS URBAN	x	x	x	x	x	x	x																										
BUS INT/URBAN								x	x	x	x																						
TRUCK PSNGR												x																					
TRUCK URBAN													x	x	x	x	x	x	x	x	x	x											
TRUCK INT/URB-3																							x	x	x	x	x	x	x				
TRUCK INT/URB-8																														x	x	x	x
GASOLINE												x	x										x										
DIESEL	x							x						x										x	x					x			
DIESEL/C3		x																															
LNG			x																												x		
CNG															x																		
PROPANE				x					x							x										x							
MEOH 100%					x	x											x	x									x					x	
MEOH+CETANE							x			x									x									x					x
MEOH BLEND											x									x									x				
ETOH BLEND																					x	x											
SI ENGINE			x	x	x				x		x	x	x		x	x	x			x	x	x	x			x			x				
CI ENGINE	x	x				x	x	x		x				x				x	x					x	x		x	x		x	x	x	x
RETAIL PUMP												x	x	x		x					x			x									
FLEET PUMP	x	x	x	x	x	x	x	x	x	x	x				x		x	x	x	x		x	x		x	x	x	x	x	x	x	x	x

"cost" item in "life-cycle costs". For cost items involving long term investments, a pretax return of 20% on the 4Q83 replacement cost of the item was used when the return could not be readily determined from 4Q83 market cost data. Investment in the vehicles themselves was treated differently, depending on whether they were operated for domestic or business purposes: for domestic vehicles (autos and passenger trucks) no return on investment was included, while business vehicles had an ROI included in their fixed cost element. Natural resource and other commodity costs used in developing fuel plant gate costs were based on 4Q83 market prices which are listed in Appendix E.

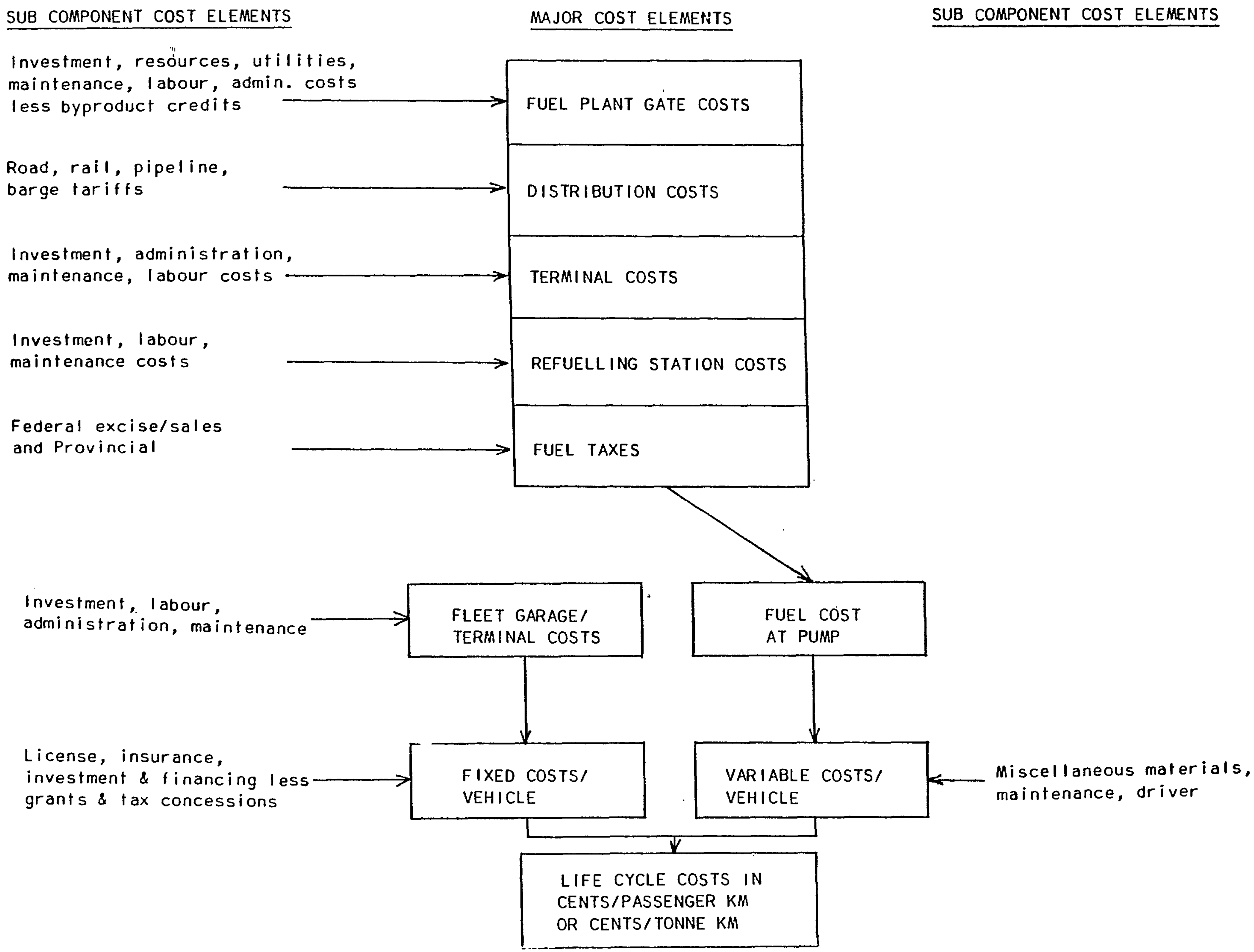
Although the database developed in this study and presented in the Appendices A through D has been derived where possible from actual market data, the prime purpose of the methodology is to indicate how life cycle costs can be developed, rather than to provide definitive costs and specific examples. The reader may readily substitute his own data to arrive at the LCC applicable to his own requirements and locations.

3.2 MAJOR ELEMENTS OF LIFE-CYCLE COST

Figure 3.2 illustrates the major cost elements that are used to build up the total vehicle life-cycle cost. As described in 3.1, since the emphasis of the present study is to compare benefits of one fuel versus another, most of the cost analysis has been devoted to fuel rather than vehicle-related cost elements. For this reason a detailed breakdown of basic vehicle costs, for example, or fleet garage/terminal costs, has not been undertaken.

Each major cost element identified in the Figure is built up from its constituent sub-component costs. For example, total distribution costs are built up from the sum of rail, road, pipeline and barge shipping costs incurred from fuel plant gate to refuelling station.

Fig. 3.2 Major Elements of Life-Cycle Cost



In certain cases a major cost element is in fact a composite of several separate cost elements of the same type. For example, some alternative fuels such as Oxinol blend (gasoline, methanol and butanol mixture) are manufactured in several process plants; the Oxinol blend constituents are manufactured in refining, methanol and butanol plants. The plant gate cost of this fuel is therefore a blend of all three plant gate costs. CNG, on the other hand, involves no process manufacturing facility since all that is required is compression of the primary resource itself at the refuelling station location.

Similarly, certain fuel infrastructure systems involved several fuel terminals. For example, the bulk of western Canadian propane delivered to Toronto passes through terminals located at Edmonton and Sarnia (as NG condensate) and Toronto (as propane) before reaching the refuelling station. In other cases it is possible that no terminal is required. This may occur for LNG fuel when fleet demand is sufficient to justify a dedicated LNG plant (see urban bus-LNG cases).

The life-cycle cost worksheets presented in Appendix A are formatted in a generalized way so as to summarize major cost elements and their sub component costs for any fuel/vehicle combination and to develop a life-cycle cost according to the flow path shown in Figure 3.2. The methodology employed to generate each major cost element is discussed in detail below.

3.3 PLANT GATE COSTS

Appendix C presents worksheets that furnish plant gate costs for the fuels considered in this study. Worksheets for all the alternative fuels were produced by running the EMR "Alternative Fuels Economics Model" program AFEM (available from EMR) using updated commodity, capital costs, etc. Worksheets for conventional fuels (i.e. LR gasoline and diesel) were obtained using an in-house refinery program and detailed refinery printouts are shown in Appendix D to supplement each refinery case worksheet.

The cost of commodities, used as input to the AFEM program, are of course dependent on plant location and have been taken where possible from actual market prices. Their values are summarized in Appendix E.

Selections of plant location and size (capacity) can involve many complex factors but for the purposes of this study they have been based on a preliminary assessment of minimum product cost. For example, methanol produced from natural gas in Toronto at $4.7/GJ is estimated to cost about 7.8¢/litre more than in Edmonton where gas cost is about $2/GJ. The bulk methanol shipping cost by rail to Toronto in 4Q83 was only about 4.4¢/litre and therefore an Edmonton plant location was selected. The 2000 Te/d selected methanol plant capacity is "world scale" and therefore achieves most of the benefits of economy of scale.

The following discussion highlights some key aspects of the fuel plant gate costs.

3.3.1 Gasoline and Diesel

Contract and retail prices of refinery fuels at a typical refinery plant gate in S. Ontario, 4Q83 were derived from Energy Pricing News and EMR Statistics Handbook respectively by substracting the appropriate amounts for taxes, distribution and marketing costs and retailer margin. Using a typical 80,000 BCPD capacity fuels refinery model (see Appendices C and D) operating at about 70% throughput and producing a 4Q83 product slate per Statscan's Supply and Disposition of Petroleum Products data (Cat#45-004), a pretax ROI of 14.7% and -7% on replacement cost of investment was calculated for retail and contract sales respectively. Since the refinery sold to retail and wholesale customers simultaneously, the actual pretax ROI was in fact somewhere between these two values, and assuming a two thirds retail, one third wholesale split, the calculated ROI for the refinery in 4Q83 would have been about 7.5% overall. This low return was a reflection of the particularly poor state of the gasoline market at that time.

3.3.2 Oxinol and Ethanol Blends

The Oxinol blend used in this study comprises a 9.5v% blend of the Oxinol (50:50 methanol:butanol) in LR gasoline. The ethanol blend comprises 10v% ethanol in LR gasoline. It is assumed that these components will be shipped to the refinery for blending and that their cost to the refiner is plant gate (Edmonton) plus rail shipping costs to Ontario.

Since these blending components contribute to both octane and RVP of the gasoline pool, the refinery model was run to determine the optimum operation to suit each blend. In general terms gasoline butane content, reformer throughput and severity were reduced while maintaining the same BPD of blended gasolines and lead content (0.4g Pb/litre). Oxinol and ethanol incremental costs were spread amongst all refinery products so as to keep the same product plant gate price ratios as before.

The same ROI as for conventional fuels operations (retail and wholesale cases) was used and a comparison between conventional and derived blended fuel plant gate costs is shown below:

		Retail	Wholesale
Oxinol blend	\$/GJ (¢/litre)	8.67 (28.6)	7.42 (24.5)
Ethanol blend	\$/GJ (¢/litre)	9.01 (29.7)	7.73 (25.5)
Base case LR gasoline	\$/GJ (¢/litre)	8.4 (28.6)	7.17 (24.4)

If the Oxinol or ethanol costs had been born by the gasoline product only, then blend plant gate costs would of course be higher. However, the cost of production of individual refinery products is not normally known or used by refiners to set product prices: he latter are normally determined by the marketplace. Product prices were maintained in the same ratio as in the base case, i.e. conventional fuels, refinery.

3.3.3 Propane

This plant is modelled on a large natural gas liquids straddle plant located in Empress, Alta. which produces ethane, propane, butanes and C5 condensate. Product prices reflect Alberta 4Q83 market conditions and are consistent with a pretax ROI of 20% on replacement cost of plant investment.

3.3.4 Methanol

4Q83 plant gate costs of $7.91/GJ (14.3¢/litre) based on a 2000 Te/d Edmonton natural gas-fed plant are equivalent to a 10% pretax return on the replacement cost of plant investment. Again, the depressed state of the methanol market is reflected in this number. In fact, the prevailing lower selling price of export sales, which is not accounted for in the above analysis, would have generated a still lower ROI.

3.3.5 Ethanol

A 1075 Te/d Edmonton plant based on ethylene feedstock and a pretax ROI of 20% of replacement cost of investment was used. A plant gate cost of $18.5/GJ (43.8¢/litre) was calculated.

3.3.6 LNG

A 1000 GJ/d plant located in Toronto was used together with a 20% ROI to obtain the plant gate cost of $10.3/GJ. Such a plant could serve a large LNG dedicated fleet or be the equivalent of a small scale "LNG refinery".

3.4 DISTRIBUTION COSTS

Distribution costs are incurred in moving fuels from plant gate to distribution terminals and from there to the refuelling station. Although distribution costs are also incurred in shipping resource and other commodities to the fuels plant for use in the manufacturing process, these costs are incorporated into the commodity prices which are inputted to the AFEM program (see 3.3).

The modes of distribution used for fuels distribution in Canada are pipeline, marine, rail and road tanker, arranged in order of increasing cost (long hauls only). There is no significant use of marine transport at present to supply the Toronto market. These distribution modes are discussed below.

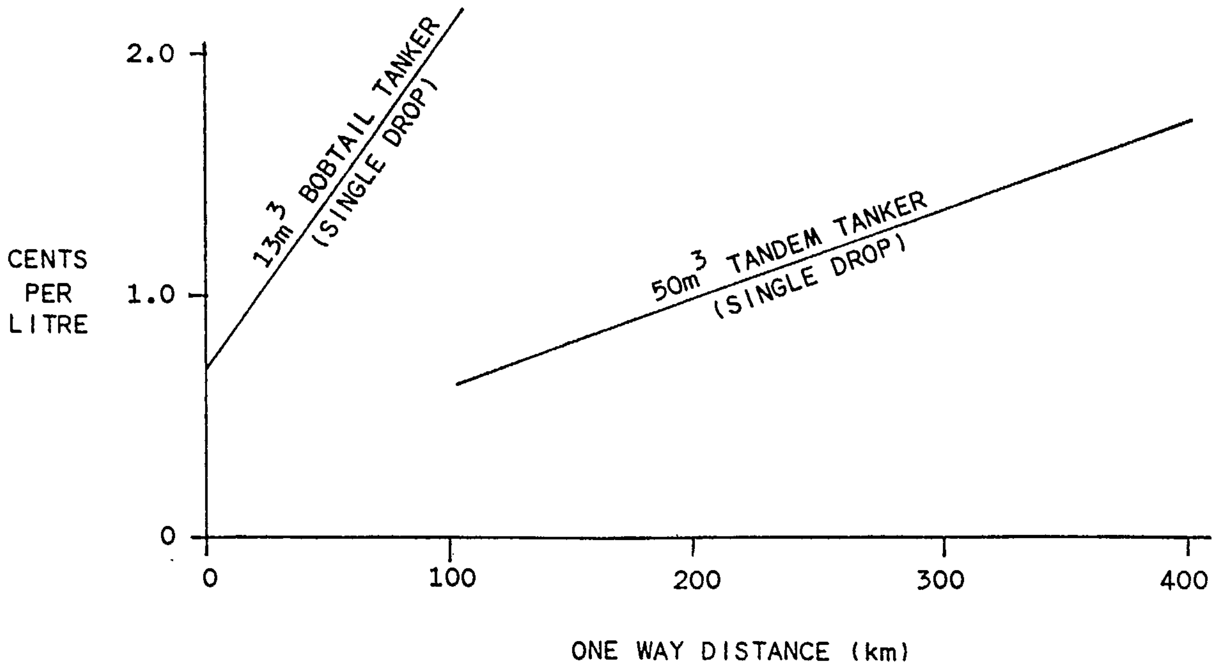
3.4.1 Road Costs

Conventional fuels, i.e. gasolines and diesel, are generally distributed in 60 cu.m. capacity tandem tankers for long distance/high volume and 30 cu.m. tankers for shorter distance/lower volumes. Available tanker capacity may be divided into compartments so as to carry several grades of fuel at the same time. Conventional fuels are generally distributed to the Toronto vicinity by pipeline. Road tankers are used to deliver from receiving terminals to refuelling stations: the small 30 cu.m. tankers are generally used in this service. Most propane fuel reaches the Toronto market from Sarnia (Dome plant) via tandem road tankers carrying about 50 cu.m. of the fuel (more ullage is required than for conventional fuels cf. 60 cu.m.) for delivery to Toronto-based terminals. Smaller 13 cu.m. (bobtail) tankers distribute the propane to refuelling stations within the city.

Figure 3.4.1 indicates the road distribution costs for propane and conventional fuels based on a "single drop" disposition of tanker payload at the delivery point.

Fig. 3.4.1 Fuel Distribution Costs by Road Tanker

PROPANE



CONVENTIONAL FUELS

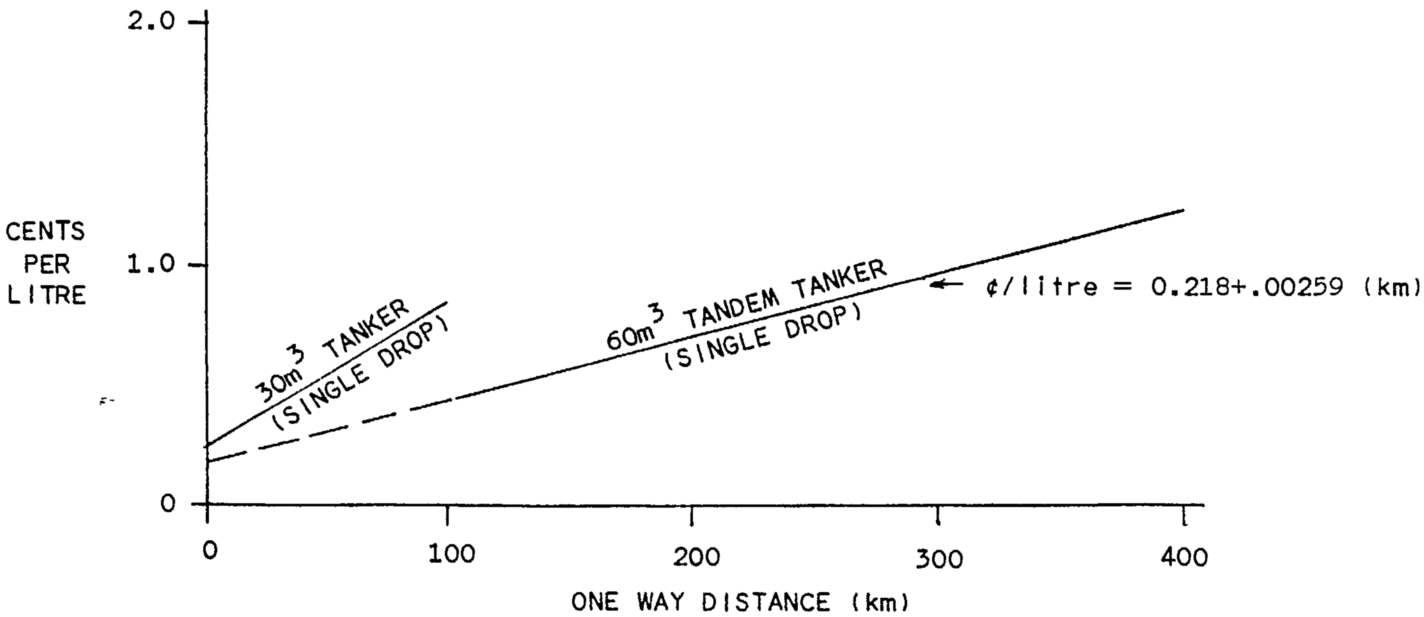


Table 3.4.1 gives examples of the methodology employed in arriving at the conventional fuels distribution costs for large capacity long distance and smaller capacity shorter distance trucks. The methodology is consistent with that presented for alternative fuels in general and which is the subject of this report.

Methanol is generally delivered to the Toronto vicinity (from western Canada) by rail and distributed from receiving terminals using 25 and 40 cu.m. compartmented road tankers (containing also other chemicals in addition to the methanol).

For the purposes of this study, LNG and methanol rich (90%+) fuels are assumed to have the same distribution costs as propane and lean (10%-) blends of methanol and ethanol in gasoline are assumed to have the same distribution costs as conventional fuels.

Partial drops are assumed to be 50% more costly than single drops and to be necessary whenever refuelling station average volumetric inventory is less than tanker capacity. Volumetric inventory is 7 times average throughput per calendar day for conventional fuels and methanol/ethanol blends (these latter are treated as completely substitutable with gasoline) and 4 times average throughput for all other fuels. Road distribution costs are not applicable to CNG fuel.

In general the large (60 cu.m) tankers are used for distribution between plant gate and terminals and between primary and secondary terminals. The smaller 13-30 cu.m. tankers are used for distribution between terminal and refuelling stations. For propane which is transported in bulk carriers 245 km from Dome's Sarnia receiving terminal and fractionation facility to Toronto-located secondary terminals, Fig. 3.4 indicates a distribution cost of 1.15¢/litre and this number is in good agreement with Superior Propane's* estimated best rate of 1.04¢/litre for this trip.

[* private communication with Superior]

Table 3.4.1 Basis for Fig. 3.4.1

1. Example for 60 cu.m. Tandem Fleet Road Tanker (conventional fuels, single drop)

One way trip distance (D)	= 400 km	
Avg. speed and turnarounds	= 70 km/hr	
Total turnaround time	= 4 hrs	
Vehicle utilization factor	= 70%	
Payload per trip	= 60,000 litres	
Round trip time	= (2)(400)/(70)+4	= 15.4 hrs
No. trips/yr (N)	= (.7)(8736)/(15.4)	= 397
Total vehicle lifetime (2)	= 880000 km	
Total vehicle km/yr	= (397)(400)(2)	= 317600
Total vehicle lifetime	= 880000/317,600	= 2.77 yrs
Total operating time/yr	= (.7)(8736)	= 6115 hrs
Total fuel cost/yr (2)	= (317600)(41.64/100)(52/100)	= $68770
Misc. material cost/yr (2)	= (317600)(32/1000)	= 10163
Maintenance cost/yr (2)	= (317600)(62/1000)	= 19691
Driver costs/yr (3)	= (6115)(17)	= 103955
Cost of investment/yr (2)	= 91500/2.77	= 33032
Cost of financing/yr (2)	= (.3)(33032)	= 9910
Garage cost/yr (2)		= 46000
Licence & insurance/yr (2)		= 7094
Total cost/yr		$298615
Total cost/trip	= 298615/397	= $752
Distribution cost (¢/litre)(C)	= (752)(100)/60000	= 1.25¢/litre

(1) When D=0,N=(.7)(8736)/4=1529,
C=(100)(103955+33032+9910+46000+7094)/1529/60000=0.218¢/litre (i.e. value of intercept in fig 3.4)

(2) Based on ref case #10a (3) Based on $17/hr

Table 3.4.1 continued

2. Example for 30 cu.m. Fleet Road Tanker (Conventional fuels/single drop) (2)

One way trip distnace (D)	= 100 km (1)	
Avg speed excl turnarounds	= 40 km/hr	
Total turnaround time	= 3 hrs	
Vehicle utilization factor	= 70%	
Payload per trip	= 30,000 litres	
Round trip time	= (2)(100)/(40)+3	= 8 hrs
No. trips/yr (N)	= (.7)(8736)/8	= 764
Total vehicle lifetime	= 560,000	
Total vehicle km/yr	= (764)(100)(2)	= 152,800
Total vehicle lifetime	= 560,000/152,800	= 3.66 yr
Total operating time/yr	= (.7)(8736)	= 6115 hrs
Total fuel cost/yr	= (152,800)(41.64/100)(38.5/100)	= $24,496
Misc material cost/yr	= (152,800)(33/1000)	= 5,042
Maintenance cost/yr	= (152,800)(100/1000)	= 15,280
Driver costs/yr	= (6115)(15)	= 91,725
Cost of investment/yr	= 75,000/3.66	= 20,492
Cost of financing/yr	= (20,492)(.3)	= 6,148
Garage cost/yr		= 26,000
License + insurance/yr		= 4,500
Total cost/yr (C)		=$193,683
Total cost/trip	= 193,683/764	=$253.5

Distribution cost (¢/litre)= (253.5)(100)/30,000 = 0.85¢/litre

(1) When D=0, N=2038, C=(100)(91725+20492+6148+26000+4500)/2038/3000 = .24¢/litre (i.e. value of intercept in Fig. 3.4).

(2) This vehicle type is intermediate between the class 3 (ref case 9c) and class 8 (ref. case 10a) trucks considered in this study (see Appendix A).

A value of 20 km has been assumed for the average distance between a Toronto- located fuels terminal and its satellite refuelling stations (both fleet and retail) and for all fuels this leg of the distribution network is provided by the smaller (13-30 cu.m.) road tankers.

3.4.2 Rail Costs

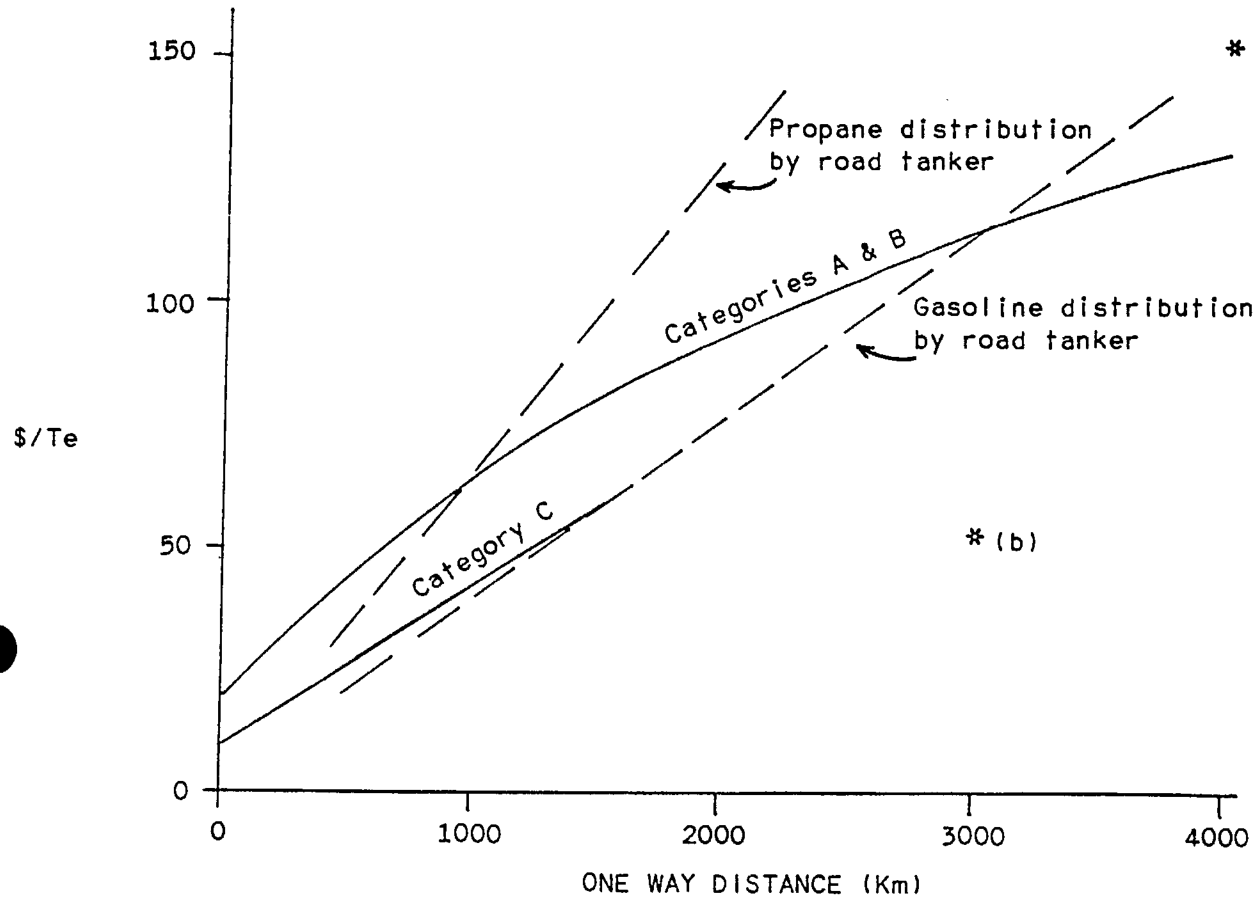
Figure 3.4.2 presents smoothed curves of posted freight tariffs for LPG, i.e. propane and butane and for conventional fuels as a function of one way distance assuming use of CP Rail's tank cars. Bulk contract rates might be 20-25% lower than the posted rates for these commodities. It can be seen that intra-regional distribution costs are significantly higher than inter-regional costs (the inter-regional boundary is defined by Thunder Bay).

In the case of methanol, which is normally shipped to Ontario in large quantities by rail from western Canada, the rate for delivery to that market is considerably less (about 40% lower) than for propane and conventional fuels. For example, a typical bulk contract rate from Edmonton to Toronto was about $54/Te (4.3¢/litre) versus $115/Te (posted) or about $90/Te (contract) for propane and conventional fuels. This cost advantage for methanol does not hold for the smaller markets located further east as suggested by the posted rate for Moncton, N.B. shown on Fig. 3.4.2.

As mentioned above, the bulk contract rate for propane delivery from Edmonton to Toronto is about $90/Te or 4.57¢/litre. The sum of propane gathering costs in Alberta (1.12¢/litre) plus Edmonton/Sarnia pipeline costs (0.77¢/litre) plus primary (Dome, Sarnia) terminal costs (1.74¢/litre) plus Sarnia/Toronto road distribution costs (1.15¢/litre) comes to a similar cost of 4.78¢/litre so that the incentive to ship directly by rail to Toronto is small.

Fig. 3.4.2 also shows for comparative purposes the costs of

Fig. 3.4.2 1983 Posted Rail Tariffs for LPG and Conventional Fuels (1)



CATEGORIES FOR LPG AND CONVENTIONAL FUELS:

A: W. Coast to/from Calgary/Edmonton ($\$/Te = .046(km) - 4.64E-6(km)^2 + 20$)

B: INTER-REGIONAL i.e. distribution between Western and Eastern regions (inter-regional boundary located at Thunder Bay)

C: INTRA-REGIONAL i.e. distribution within Western and Eastern regions excluding Category A. ($\$/Te = .032(km) + 10$)

NOTES:

(1) Per tariff 103-U: Canadian Freight Association and CP Rail (bulk contract rates are about 20-25% less).

* Methanol tariff (a) Kitimat-Moncton posted price (b) Edmonton-Toronto bulk contract price.

distribution of gasoline and propane via tandem road tanker. Because rail tariff is on a weight basis compared to volume for road tanker, commodities such as propane with low specific gravity are favoured for rail distribution. Gasoline distribution by road may be more economic than by rail (at bulk contract rates) up to about 1500km for inter-regional transfers.

3.4.3 Pipeline Costs

Only existing applications of in-place pipelines are considered in this analysis of distribution costs since it is unlikely that any new pipeline or reapplication of existing pipelines could be justified until a substantial market penetration of alternative fuels has been achieved. An exception to this might be the conversion of existing Sarnia/Toronto pipelines to handle propane service or of the Cochin pipeline to allow extension of propane handling facilities between Milford, Ind. and Windsor. The following pipeline tariffs have been used in this study in the development of LCC worksheets.

Fuel	Pipeline	Source/Destination	Tariff
Propane/butane/crude	IPPL	Edmonton-Sarnia	0.74¢/litre
Diesel/gasoline	Trans-Northern	Nanticoke-Toronto	0.30¢/litre
Natural gas	Trans-Canada	Alberta-Toronto	$0.94/GJ

The Nanticoke location has been selected as the location for a typical fuels refinery because its distance by pipeline from the Toronto market (refinery-terminal distance is 150km) is about average for the Sarnia, Nanticoke, Trafalgar refineries serving the area. All of these refineries ship product to Toronto via pipelines (Sun Oil and Imperial Oil pipelines from Sarnia and Trans-Northern from Nanticoke) and the tariff structure for Trans-Northern should be fairly representative of all three pipelines, namely ¢/litre=0.076+.00148(km)*.

* Source: Trans-Northern, private communication. Adjusted to 4Q83.

Tables 3.4.2 (a and b) illustrate simplified economic models of the Trans-Northern pipeline system "as is" and "as new" respectively. A 55% utilization factor has been used based on estimated pipeline capacity and the pipeline distribution cost is inversely proportional to this factor. If the Trans-Northern pipeline had been built and put into operation at the 55% utilization rate in 4Q83 it is estimated that the tariff rate would be about 70-90% higher than for the existing system but still be competitive with distribution costs by large road tanker.

The pipeline distribution costs for crude oil and natural gas have been factored into the Toronto-based commodity costs for these items given in Appendix E.

3.4.4 Barge and Marine Tanker Costs

Although no significant marine movement of conventional or alternative fuels is employed or anticipated for deliveries to the Toronto market, this is a major distribution mode for the Maritimes, West Coast and Western Arctic regions and to a lesser extent for the Great Lakes and St. Lawrence region. The scope of this study involves the Toronto market only and therefore marine costs have not been considered. However, marine shipping costs (escalated to 4Q83) published* by IOL for Toronto-Montreal (500 km @ 1.2¢/litre) and Montreal-Quebec City (250km @ 0.5¢/litre) suggest that this mode can be 20-40% lower than road costs for certain routes.

* Third submission to Restrictive Trade Practices Commission, 1983.

Table 3.4.2a Oil Products Pipeline Economics Model

(existing pipeline)

STATUS : EXISTING PIPELINE BUILT 1952

LOCATION: SOUTHERN ONTARIO
SPECIFICATION: 800 km x 250 mm plus 8 terminals

CAPACITY m3/calendar day			9450			
ORIGINAL INVESTMENT $MM			66			
REQUIRED RETURN ON INV %			17			
ANTICIPATED THROUGHPUT (% CAPACITY)			55			
ANTICIPATED AVG DIST TRANSPORTED km			800			
ANTICIPATED OIL PIPED km.m3(10)6/yr			1518			
ANNUAL COSTS:						
PRETAX ANNUAL RETURN ON INVESTMENT				11.22		
MAINTENANCE				2.1		
GENERAL & ADMIN				4.9		
OIL TRANSPORT COSTS @	.0028	$/km.m3	=	4.25		
					22.47	
LIFTING/DELIVERY COSTS @	.76	$/m3	=	1.44		
TOTAL ANNUAL COSTS				23.91		

REQUIRED TARIFF STRUCTURE ($/m3): (.076 + .0014805245 (km))

TOTAL ANTICIPATED PRETAX REVENUE:
REVENUE FROM 5198 m3/day TRANSPORTED 800 km = $MM/yr 23.91

TARIFF FOR TRANSPORTING OIL VARYING DISTANCES:

DISTANCE km	TARIFF cents/litre
100	0.22
200	0.37
300	0.52
400	0.67
500	0.82

Table 3.4.2b Oil Products Pipeline Economics Model

(new pipeline)

STATUS: NEW PIPELINE 4Q 1983

LOCATION: SOUTHERN ONTARIO					
SPECIFICATION: 800 km x 250 mm plus 8 terminals					
CAPACITY m3/calendar day	9450				
ORIGINAL INVESTMENT $MM	200				
REQUIRED RETURN ON INV %	17				
ANTICIPATED THROUGHPUT (% CAPACITY)	55				
ANTICIPATED AVG DIST TRANSPORTED km	800				
ANTICIPATED OIL PIPED km.m3(10)6/yr	1518				
ANNUAL COSTS:					
PRETAX ANNUAL RETURN ON INVESTMENT			34		
MAINTENANCE			2.1		
GENERAL & ADMIN			4.9		
OIL TRANSPORT COSTS @	.0028 $/km.m3	=	4.25		
				45.25	
LIFTING/DELIVERY COSTS @	.76 $/m3	=	1.44		
TOTAL ANNUAL COSTS			46.69		
REQUIRED TARIFF STRUCTURE (c/l)	= .076	+		.0029815096 (km)	
TOTAL ANTICIPATED PRETAX REVENUE:					
REVENUE FROM	5198 m3/day TRANSPORTED		800 km = $MM/yr		46.69

TARIFF FOR TRANSPORTING OIL VARYING DISTANCES:

DISTANCE km	TARIFF cents/litre
100	0.37
200	0.67
300	0.97
400	1.27
500	1.57

3.5 TERMINAL COSTS

For the conventional and alternative fuels considered in this study for use in the Toronto market there is, in general, only one terminal required between the fuel plant gate and refuelling stations. In the case of propane and conventional fuels, the Toronto-based terminals may distribute to smaller secondary terminals but these are located outside the Toronto market and are therefore not considered in the present study. The existing propane distribution system involves a primary terminal located in Sarnia and a secondary terminal in Toronto. LNG does not require a terminal for product distribution since the LNG plant throughput is small enough in relation to assumed refuelling station demands that distribution can be direct from the plant gate to refuelling stations. CNG does not require a terminal. Each fuel's terminal cost model used in the methodology is discussed below (note that all rates are on a calendar day basis).

3.5.1 Conventional Fuels

Each of the major Canadian oil marketing companies has a primary product distribution terminal located in the Toronto area. Typically a major part of the output from the S. Ontario refineries reaches these Toronto terminals via pipeline for distribution to refuelling stations and private brand retailers' terminals within the area or to secondary terminals located outside the area. The approach used in this study addresses only the flow of product direct from primary terminal to refuelling stations (which may be fleet or retail operations).

For the purposes of modelling a conventional fuels terminal , its operating and investment costs are apportioned (see LCC worksheets in Appendix A) to the three major transportation fuels as follows:

LR gasoline	37%
UR gasoline	38%
Diesel	25%

Total throughput of all fuels is assumed to be about 2890 cu.m./day split in the above proportions. Total investment is based on a 4Q83 replacement cost of $23MM for the fixed portion, i.e. land and facilities, and $10MM for working capital, of which $9MM is associated with inventory (equivalent to 10 days throughput).

Total labour costs exclude marketing services and road tanker maintenance (this latter item is included in distribution costs) and are based on round-the-clock terminal operation and 10 men/shift plus daytime staff and supervision.

Marketing costs are intended to cover all sales activities, including direct transfers from refinery to customer, associated with gasoline and diesel. A cost of 1.0¢/litre has been assigned to this activity when applied to retail sales only. For wholesale, i.e. contract sales, the marketing costs are assumed to be negligible.

Maintenance covers mainly snow removal, security, road and equipment repairs; "other costs" include insurance, property tax; utilities consists mainly of electric power to heating, pumps, lighting, etc. Total maintenance and utilities are assumed to be $300/d and "other costs" are taken as 2% of fixed investment.

3.5.2 Propane

Propane is piped to Sarnia from Edmonton in the form of natural gas condensate comprising propane, butane and pentanes plus. Dome's fractionation plant in Sarnia is capable of separating about 7160 cu.m./d of propane and a value of 90% of this plant capacity has been assumed for daily throughput. For the purposes of the present methodology the Sarnia plant is categorized as a primary distribution terminal since the propane has already been produced in an upstream gas processing plant(s) located in Alberta. Ref. case 2e LCC worksheet (included in Appendix A) presents the costing model bases for both the primary and secondary terminals, the latter being modelled on Superior Propane's Toronto terminal.

Because only 42% of the Dome plant product, on an energy basis, is propane (46% on volume basis) the operating and investment costs were apportioned to propane on that basis. Total 4Q83 replacement value of the plant was estimated at $25MM of which the propane portion was $10.5MM. Working capital associated with propane inventory, assumed to be equivalent to 20 days throughput, is about $19.5MM.

Marketing costs have been assigned to both primary and secondary terminals in order to bring total terminal costs on a ¢/litre basis into line with costs reported or derived from the literature and propane marketing sources*. Marketing costs associated with sales from the secondary terminal are reduced by 50% for bulk sales, e.g. to fleet operators.

The estimated 4Q83 replacement cost of investment for the secondary terminal is $3.5MM for land and fixed capital and $0.5MM for working capital including inventory. A secondary terminal throughput of 300 cu.m./d has been assumed and this is consistent with a well-established wholesale and retail customer market. A new secondary terminal operator entering the Toronto market would likely build facilities to initially handle about 100 cu.m./d and terminal costs per litre of propane would then be higher (due to economy of scale, fixed labour costs, etc).

* 4Q83 wholesale price in Toronto from Superior Propane marketing sources. Wholesale price in Sarnia from EPN, Nov.'83. Fractionation plant costs from EMR report on Propane Vehicle Carburetion Market Development, 1980-83, p.13.

Utilities, maintenance, labour and other costs have been estimated for primary and secondary terminals based on an analysis of the types of operations involved and scale of operations and are shown on the propane-based LCC worksheets in Appendix A, e.g. ref. case 2e.

3.5.3 Methanol

Existing methanol primary terminals are operated in the Toronto area by several methanol producers such as Celanese, Ocelot and AGC. These terminals all receive methanol by rail from western Canada and typically distribute the product by compartmented road tanker (carrying also other chemical products handled by the terminal) to various non-fuel end use customers.

It is envisaged that, if a methanol fuel market becomes established in the Toronto area, methanol will likely be shipped (a) by rail directly into existing conventional fuel terminals for the fuel cases: 90% methanol, 100% methanol and methanol + cetane enhancer considered in this study, or (b) shipped by rail to S. Ontario refineries for low methanol blends using, for example, Oxinol (see 3.5.4. for latter discussion). For the former three fuel types the conventional fuels primary terminal would be converted as an "add-on" to the existing fuels handling facilities with relatively low additional investment and operating costs during the early (low throughput) market penetration period. Incremental terminal investment is assumed to increase linearly with terminal throughput as this alternative fuels market increases, i.e. no economies of scale are allowed. Incremental terminal operating costs at low throughput benefit from the fact that no additional labour is required but include a marketing cost. Reference cases 2f, 3i, 3j, 8e, 8f, 9e and 9f in Appendix A illustrate the costing model basis for the low market penetration case when terminal throughput is limited to about 25 cu.m./d of these methanol or methanol-rich fuels. For the case of more substantial market penetration a throughput of 250 cu.m./d has been assumed, as illustrated by ref. cases 5e, 5f, 5g, 6c, 6d, 8g, 9g and 10d. In these cases the primary terminal throughput of these fuels (250 cu.m./d) is a substantial percentage of total terminal fuels throughput and therefore additional labour costs have been allocated. Marketing costs have been reduced to zero for these high throughput cases where a substantial proportion of sales are likely to bulk contract sales to fleet operators.

3.5.4 Methanol and Ethanol Blends

These consist of low blends, i.e. about 10v% or less of the alcohol in gasoline and the blending is assumed to have been performed in the refinery because of its impact on gasoline RVP, octane and on refinery operations in general (see 3.3.1). These blended gasolines (both leaded and unleaded) are shipped to the primary terminal in the same way and at the same cost as the conventional gasoline fuels and this also holds true for terminal operations and costs. It has been assumed that if these alcohol blends are introduced by the refiner, then all of the gasoline produced will contain the alcohol blend so that no additional tankage (other than methanol storage and blending in the refinery) is required.

Terminal throughput on a GJ/d basis of leaded regular (LR) gasoline is the same for alcohol blended and unblended fuels. Only LR gasoline and diesel conventional fuels have been considered in the LCC worksheet examples.

The small initial costs of cleaning and drying tanks plus costs of maintaining a water-free environment have been neglected in the costing model for these cases.

3.6 REFUELLING STATION COSTS

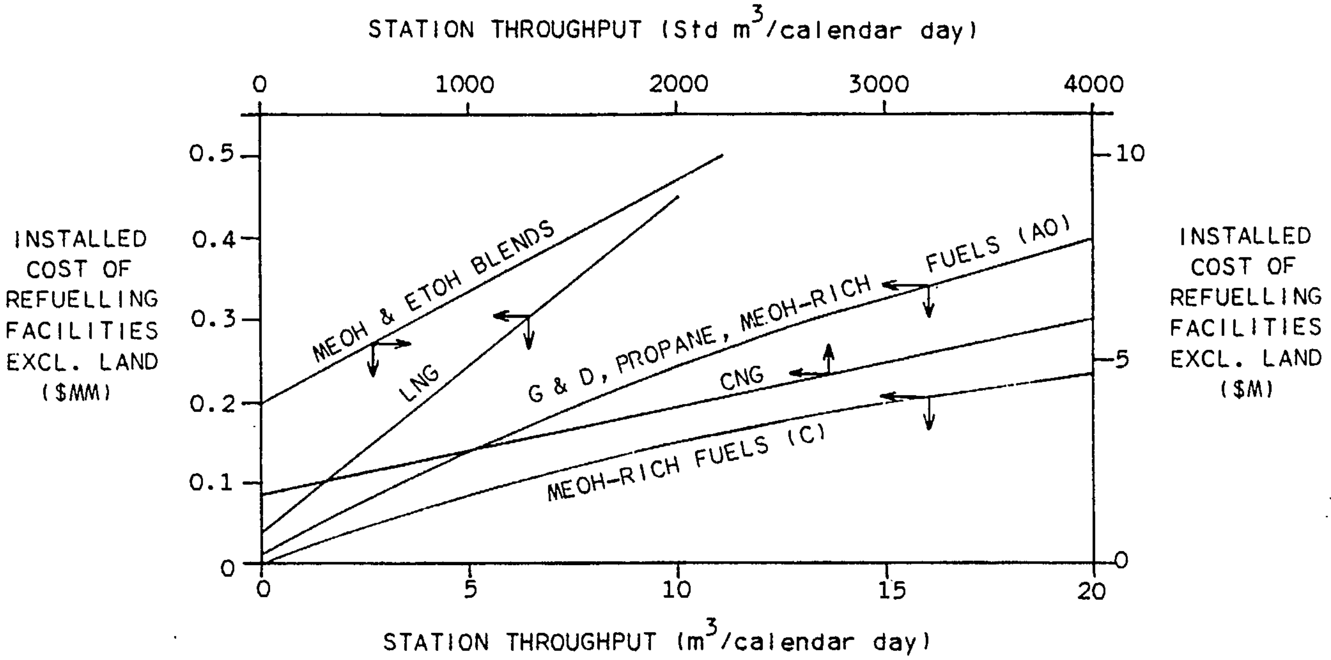
Refuelling station costs for alternative fuels are strongly dependent on station costs of conventional fuels. This is because alternative fuels refuelling facilities are likely to be introduced by either adding on (AO) to an existing station or by converting (C) the existing, conventional fuel facilities to the new fuel. The former option is considered most likely for retail and the latter for fleet refuelling stations and this pattern has been adopted in the costing methodology incorporated in LCC worksheets. New refuelling station stand-alone (SA) facilities using alternative fuels only, have not been considered in this study but costs are likely to be similar to converted station costs.

The cost of land for conventional fuels retail outlets is high (about 50% of total investment) due to the need for prime locations and because of the high cost of land in Toronto. In the case of fleet stations, land is included in garage costs (see "other fixed costs" on LCC worksheets). Figure 3.6.1 summarizes the basis for refuelling station investment costs, excluding land, for the various alternative fuels considered in this study.

Table 3.6.1 summarizes the basis used to develop station operating costs. The costing model used to represent a conventional retail refuelling station marketing gasolines and diesel has been simplified so that total fuels throughput (all throughputs are given on a calendar day basis) is expressed in terms of the fuel under consideration in the vehicle LCC analysis (see Appendix A worksheets for examples).

Refuelling station costs are virtually independent of throughput so that for an existing station the cost/litre is inversely proportional to throughput. The major oil companies are continuously reviewing their retail outlets so as to maintain acceptable throughputs and station costs by disposition and acquisition of properties. A throughput of

Fig. 3.6.1 Refuelling Station Investment Cost Bases



BASIS FOR CURVES:

Methanol/Ethanol blends (C): No change necessary to tankage volume. Gasoline + alcohol blends substituted for gasoline. Small cost required to convert existing station to clean tanks, add dry protection and adjust meters.

LNG (AO or C): Same costs/GJ as for CNG station (ref "Evaluation of Alternative Fuels for Urban Mass Transit Buses": Feb. 1983, Booz, Allen & Hamilton Inc., p.IV-12). Case 5c is exception since no LNG storage required (see worksheet, note 7).

G&D (SA): Based on actual cost of 2 bay, 6 dispenser, self-service installation in mid-1983 built for anticipated 8-10 cu.m./calendar day of total G+D in E. Toronto with 150 cu.m. total storage capacity (land cost $260000). Some allowance made for economy of scale.

Propane (AO or C): Same cost as for G&D(SA). Propane tanks and dispensers are more expensive than G&D but extra cost is largely offset by savings due to (AO) or (C) status, i.e. no cost for civil work.

Methanol-rich blends (AO): Same cost as for G&D (SA), i.e. cost of additional tanks and dispensers same as for G&D (this group includes 100% methanol).

Figure 3.6.1 continued

Methanol-rich blends (C): Incremental cost equal to 60% G&D cost on same GJ/d basis to account for additional tankage (this group includes 100% methanol).

CNG (AO or C): Based on FAST FILL, 15 psig suction pressure, compressor capacity equal to 3-4 times std cu. m./calendar day throughput. Ref. sources "Market Potential for CNG", Canadian Resourcecon, Oct. 1982 & "Natural Gas - An Alternative Transport Fuel", Oct. 83, EMR.

Construction status:

SA = original facility construction dedicated to fuel under consideration
AO = retainment of original conventional fuelling capacity plus add-on alternative fuel capacity
C = conversion of original conventional fuelling capacity (in GJ/d) to alternative fuel capacity.

Table 3.6.1 Refuelling Station Operating Cost Bases

1. LABOUR COSTS

(a) Retail outlets: G&D, MeOH/EtOH blends

16 hrs/day, $6.5/hr, 25% burdens and benefits

(b) Retail outlets: other fuels

All alternative fuels facilities are added on to existing outlet. Existing labour, services alternative fuels facility at no charge to keep costs low and encourage market penetration.

(c) Fleet outlets: all fuels

Taxi	16 hrs/d,	$6.5/hr,	25% burdens	& benefits
Urban bus	"	"	"	"
Inter-urban bus	"	"	"	"
Inter-urban truck (class 8)	"	"	"	"
School bus	8 hrs/d,	$7/hr	"	"
Urban truck	"	"	"	"
Inter-urban truck (class 3)	"	"	"	"

2. MAINTENANCE COSTS (Snow removal, road maintenance, etc)

1% of total investment (excluding land cost) per year except for CNG which uses 2.5% per year.

3. UTILITIES COST (@ 3.2¢/kwh)

Liquid fuels	0.3 kwh/GJ fuel (1¢/GJ fuel)
CNG fuel	7.5 kwh/GJ fuel (24¢/GJ fuel)

4. OTHER COSTS (Insurance, property tax, etc.)

2% of total installed cost except, for retail propane case only, add 2¢/litre. This latter cost is included to account for higher expected ROI than 20% assumed for other cases.

about 10 cu.m./d of conventional fuels is considered to be better than average for a Toronto location and has been used in the present study as representative of a typical retail station. This throughput is equivalent to 356 GJ/d or 395 GJ/d when expressed as LR gasoline or diesel equivalents respectively.

New alternative fuel retailing facilities are considered to be built as an add-on to an existing conventional fuels retail outlet. A 50 GJ/d throughput has been assumed for all retailed alternative fuels (cf 33 GJ/d present throughput for CNG retail outlets operated by Shell-CNG Fuel Systems in Toronto). Throughputs of fuels handled by fleet refuelling stations are a function of fleet size, vehicle type, service and average distance travelled. Fleet station throughputs assumed in this study are listed below:

Fleet station fuel consumptions

	GJ/d	Litres/day
Taxi	150	4410 (gasoline)
School bus	50	1470 (gasoline)
Urban bus	700	18330 (diesel)
Interurban bus	700	18330 (diesel)
Urban truck	30	882 (gasoline)
Interurban truck (class 3)	50	1470 (diesel)
Interurban truck (class 8)	700	18330 (diesel)

Although labour costs represent a significant portion of conventional fuels retail outlet costs, for the "add-on" alternative fuels facilities considered in this study it has been assumed that existing labour will service the new facility at no charge to the alternative fuels retail price, thereby keeping costs low and encouraging market penetration.

3.7 FUEL TAXES

Little methodology is involved in the determination of fuel taxes since they are set by government regulation. They are, however, a major element of conventional fuel costs and would likely become a major element of alternative fuels costs if the latter displaced a significant portion of the conventional fuels market.

Taxes levied at the resource production level upstream of the manufacturing plant gate are included in the resource costs which are inputted to the "Alternative Fuel Economics Model" (AFEM) program used in this study to calculate plant gate costs. These resource costs are listed in Appendix E. The following taxes were applicable in 4Q83 in Toronto to the fuels considered in the present study:

Fuel Type	Federal Taxes (¢/litre)		Ontario Provincial
	Sales	Other	Tax (¢/litre)
Gasoline	note (5)	1.5 (3)	7.6
Diesel	"	0	9.6
LNG	0	0	0
CNG	0	0	0
Propane	.07	.74 (4)	0
MeOH 90%	note (5)	0	0
MeOH 100%	"	0	0
MeOH blend (1)	"	0	(.905)(7.6)
EtOH blend (2)	"	0	(.90)(7.6)

(1) containing 90.5v% gasoline, 4.25v% methanol, 4.25% butanol

(2) containing 90v% gasoline, 10v% ethanol

(3) excise tax rebatable to business users only

(4) .36¢/litre COSC, .38¢/litre NGGLT*, added to plant gate price

(5) 9% of pretax price of fuel at pump.

* set at zero in 1984

The annual "cost" of vehicle investment is assumed for present purposes to be the total initial investment divided by the number of years of vehicle lifetime. Total initial investment is the sum of base vehicle cost plus conversion cost plus sales tax less any applicable grants and tax concessions associated with the use of alternative fuels. Appendix B includes tables comparing base vehicle costs and estimated present and future conversion costs for various vehicles/fuel combinations. Ontario provincial sales tax rebates are applicable to all alternative- fuelled vehicles. Federal grants for the vehicle/fuel combinations under consideration are shown below for 4Q83:

Fuel Type	Vehicle Category	Federal Grants ($)
Propane/Diesel	buses only considered here	400
CNG	all	500
Duel CNG/Gasoline	all	0 (1)
Propane	commercial vehicles	400 (2)
LNG	buses only considered here	500
MeOH rich fuels	all	0
EtOH & MeOH blends	all	0

(1) 400 in 1984

(2) all vehicles in 1985

3.8 VEHICLE FIXED COSTS

Fixed costs are defined as those costs which are associated with fixed investments relating to the vehicle, garage, terminal facilities (excluding refuelling facilities) etc. and to operating costs that are not directly related to vehicle kilometrage per year. Fixed costs include the following:

License and insurance cost
Annual cost of investment
Annual cost of financing
Other fixed costs.

These items are discussed below in more detail.

3.8.1 License and Insurance Cost

A comparison of license and insurance costs for all the vehicles and services studied is shown in Appendix B. Of note is the low cost of insurance for buses and to a lesser extent for heavy duty inter-urban trucks. These costs, which are derived from the listed references, are believed to be low on account of the operating companies assuming part of the insurance liability. A value of 5-7% of base vehicle cost may cover total insurance costs. The lower insurance cost allocated here would be compensated by a higher garage/maintenance cost.

3.8.2 Annual Cost of Investment

The methodology used in this study to develop vehicle life cycle costs does not use a DCF analysis of the effect of money devaluation with time (although it is recommended for future refinement and sophistication of the methodology presented here). In this methodology the annual cost of vehicle investment is simply the original investment value divided by the vehicle lifetime in years.

3.8.3 Annual Cost of Financing

Vehicle investments are assumed to be funded as 80% debt, 20% equity. The debt portion is assumed to be financed over a 4 year term at 15% interest compounded semi-annually. On this basis approximately $30 must be paid in interest charges on every $80 borrowed initially so that financing costs represent 30% of the original investment. This financing cost is spread over the total vehicle lifetime to obtain the annual cost. The discounting of money value with time (DCF method) has not been considered in the present study. In addition, a constant financing term has been employed to simplify methodology, rather than using vehicle lifetime. Incorporation of a DCF approach and variable financing term is recommended for refinement of the methodology presented here.

3.8.4 Other Fixed Costs

"Other fixed costs" refers to costs associated with vehicle fleet operation and include the following items:

ROI and/or rental cost of:

administration and sales offices investment
non-maintenance equipment investment
garage investment (excluding vehicle maintenance and refuelling operations)
terminal investment (buses only)

cost of:

dispatch operations (taxis only)
ticket sales operations (buses only)
administrative staff
cost of facilities maintenance.

Appendix B includes a comparison of annual garage/terminal costs per vehicle. Although these costs make a significant contribution to vehicle life cycle costs, they are independent of fuel type. A more detailed breakdown of the costs would not be helpful in evaluating the effect of alternative fuels on various vehicle classes and services.

3.9 VEHICLE VARIABLE COSTS

Variable costs are defined as those costs which are directly related to vehicle kilometrage per year. These costs relate to: fuel; tires; miscellaneous materials, such as lube oil, windscreen washer fluid, antifreeze, etc., but excluding maintenance materials; driver costs per hour, including burdens and benefits plus any other driver-related costs and expenses; and vehicle maintenance costs. Appendix B includes a comparative table which summarizes miscellaneous materials and maintenance costs for each vehicle class and fuel type.

Vehicle lifetime is calculated from total vehicle kilometrage divided by km/yr. Values for each vehicle type are shown on the LCC worksheets in Appendix A and represent a "base case" only; the number of kilometers per year is of course highly dependent on vehicle service. Total vehicle kilometrage is largely determined by the vehicle type. The cut-off has been taken as the industry (service) average. Maintenance costs are consistent with engine replacement and other schedules.

Annual fuel costs are computed from the fuel usage in litres/100km, kilometrage/yr and fuel cost at pump in cents/litre. Appendix B includes a comparative table summarizing current and estimated future (1990) values for fuel consumption by vehicle and fuel type.

3.10 RESOURCE UTILIZATION

Each LCC worksheet in Appendix A contains a value for overall resource utilization expressed as either passenger kilometers per GJ of resource or tonne kilometers per GJ of resource. Although this data appears to be outside the scope of the present study on alternative fuels transportation costs, it does in fact impact on the "cost effectiveness" of fuels in a broader national sense, and has therefore been included.

Resource utilization data has been calculated by dividing the product of payload (either passengers or tonnes) and fuel plant process fractional efficiency by vehicle fuel consumption (in GJ fuel/km). This methodology does not take account of energy consumed in distribution, but since this is relatively small in relation to manufacturing plant and vehicle energy consumption, the approximation is believed to be justifiable.

The resource utilization factor for various fuel/vehicle/service combinations is discussed in Section 6.

SECTION 4 - LIFE-CYCLE COSTS BY VEHICLE TYPE

4.1 VEHICLE-RELATED COSTS

Individual owners and fleet vehicle operators have a broad choice of fuels, engines and vehicle configurations available to meet their transport requirements. The wider availability of alternative fuels and the outcome of current research on engines will multiply the choice. Routines for the analysis of vehicle life-cycle costs can be of assistance to users in their selection from the many competing options. As currently structured the methodology of this investigation facilitates life-cycle cost comparisons of engine/fuel combinations within a given operating environment. The methodology should not be used at this stage of development to compare costs in different environments - such as the cost of bus transport versus private automobile use - since items such as driver costs, the cost of the garaging and transportation service sales costs apply to commercial but not private transport and it is difficult to compare costs of subsidized public transport (city buses) with its profit-oriented service equivalent (taxis).

With this proviso established we can proceed with an examination of the factors affecting operating cost and capital-related and fixed cost elements of life-cycle costs.

Vehicle Operating Costs are highly dependent upon:

a. the efficiency of the combustion process: very dependent on engine type

b. the efficiency of conversion of engine power to vehicle performance related to vehicle loading factors (payload), empty vehicle weight, vehicle aerodynamics, drive-train efficiencies (design and engine drive-train matching), tire-related energy losses

c. the after-tax cost of the transport fuel used (retail or fleet cost, which will include refuelling costs)

d. other operating expenses including consumables such as lubrication oil, spark plugs, maintenance labour and materials
e. where applicable, other costs such as driver costs (commercial vehicles), tolls, parking costs.

Vehicle Capital and Fixed Cost elements of the life-cycle costs are principally dependent upon:

f. annual cost of vehicle ownership (annualized cost of the after tax investment plus financing charges)
g. vehicle license and insurance costs
h. for commercial vehicles only: the cost of sales services, cost of financing and maintaining the garage and terminals, fuelling facilities are included in life-cycle costs.

4.2 COMMENTARY ON VEHICLE-RELATED ELEMENTS OF LIFE-CYCLE COSTS

4.2.1 Engine Types Available

Figure 4.2.1a illustrates the principal types of heat engines (as distinct from electric engines) which are potential contenders for highway transport. Of these only the internal combustion types: the spark ignition (Otto) engine and the compression ignition (Diesel) engine are of current significance. The external combustion engines - the Rankine (steam) engine, the Stirling engine and various gas turbine (Brayton) engines have been known for decades but are unlikely to be used on highways until it becomes necessary to use fuels that are not suitable for the diesel or gasoline engine (such as coal, hydrogen) or to have engines which tolerate a variety of fuels, or when pollution standards are so stringent as to make these low pollution emission level engines competitive with highly modified Otto and diesel engines. Of the external combustion engines, the gas turbine may be the first to be used since it has been adopted as the power pack for the Abraham's tank

Figure 4.2.1a Engines for Transport

	ENGINE EFFICIENCIES (PERCENT) FULL LOAD	25 PERCENT LOAD	10 PERCENT LOAD	POWER/MASS RATIO KILOWATT/ KILOGRAM	EMISSIONS	MANUFACTURING COST
SPARK-IGNITION (OTTO) ENGINE	26 / 30	18 / 27	15 / 24	.3 / .8	ACCEPTABLE WITH CONTROLS; LIKELY TO DEGENERATE	VERY LOW
COMPRESSION-IGNITION (DIESEL) ENGINE	26 / 36	20 / 35	18 / 32	.2 / .5	HIGH IN NITROGEN OXIDES (NO_X)	MODERATE
VAPOR-CYCLE (RANKINE) ENGINE	20 / 30	18 / 26	15 / 22	.2 / .5	VERY GOOD; NOT LIKELY TO DEGENERATE	HIGH
STIRLING-CYCLE ENGINE	30 / 42	30 / 40	28 / 38	.2 / .5	VERY GOOD; NOT LIKELY TO DEGENERATE	HIGH
OPEN BRAYTON-CYCLE ENGINE (GAS TURBINE)	25 / 44	10 / 30	8 / 25	.6 / 1	VERY GOOD; NOT LIKELY TO DEGENERATE	MODERATE; POTENTIALLY LOW (CERAMIC)
CLOSED BRAYTON-CYCLE ENGINE	22 / 36	22 / 36	20 / 34	.2 / 1	VERY GOOD, NOT LIKELY TO DEGENERATE	VERY HIGH

KEY: [shaded box] ENGINE EFFICIENCY ATTAINABLE WITH PRESENT TECHNOLOGY [open box] ENGINE EFFICIENCY ATTAINABLE IN ADVANCED ENGINES BY 1990

Source: Wilson, David G., "Alternative Automobile Engines," Scientific American, Vol. 239, No. 1, July 1978, p. 48.

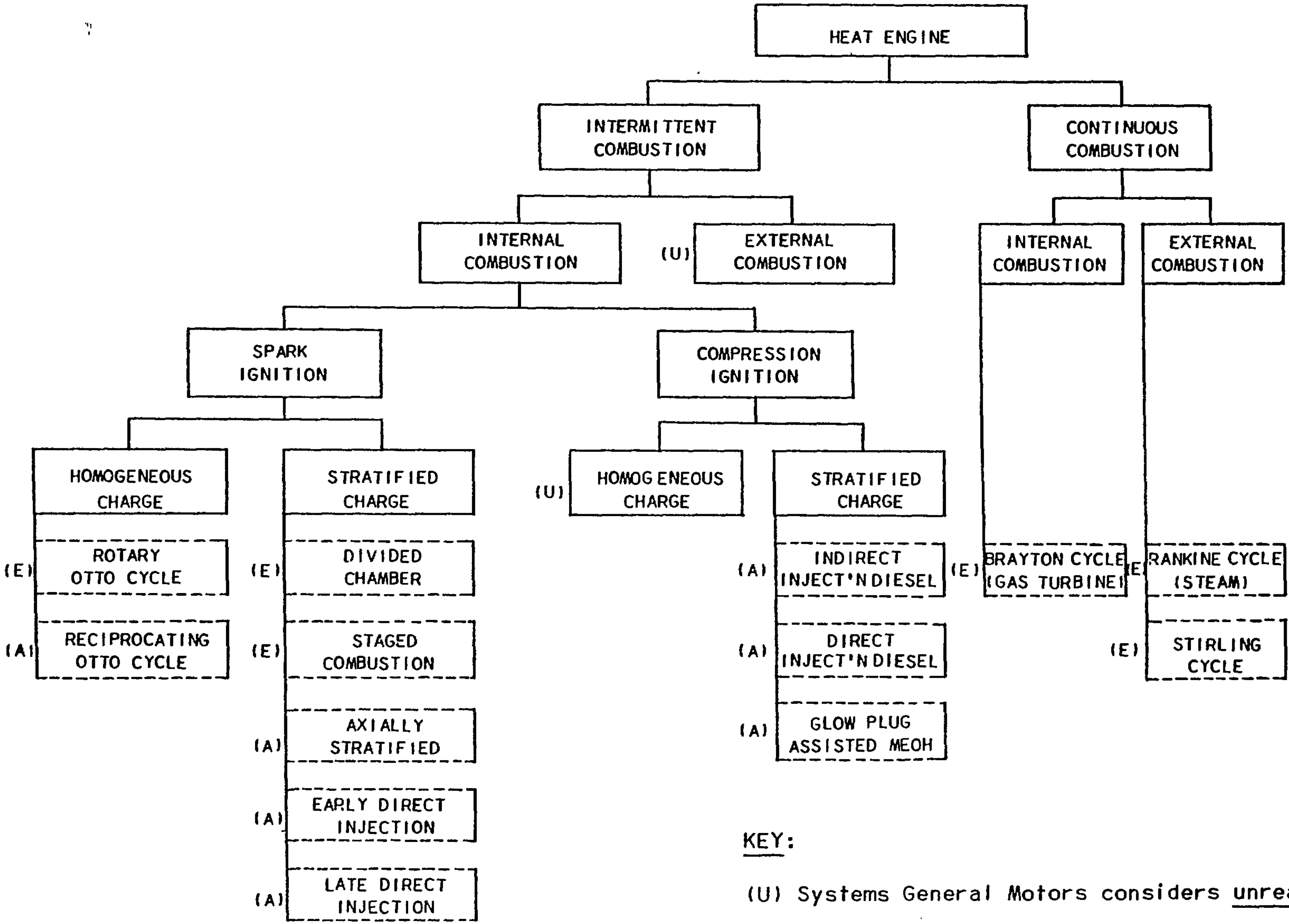
and track tested for use in heavy duty trucks.

However, in the period to 1990 and most probably to 2000 and beyond, Otto and Diesel engines will continue to dominate road transport. Diesels and Otto engines can still be substantially improved with respect to power output (power/kilogram of engine) and fuel efficiency: this, coupled with requirements to reduce toxic emissions and noise, explains the emphasis still placed on research into these engines. See Figure 4.2.1b for a summary of GM's engine research. No property, cost or pollution emission advantage has been brought to light which would justify the early development of alternative fuels in highway engines other than the Otto or Diesel engines, or simple hybrids of these engine types, such as direct fuel injection in the gasoline engine (derived from diesel practice) and glow-plug assisted combustion in diesel engines.

The alternative fuels now undergoing market development (propane, CNG, methanol, ethanol, LNG) are all high octane fuels (see Table 4.2.1) suitable for use alone or with gasoline in spark-ignition engines. They offer the prospect of high efficiency in the combustion process when advantage can be taken of the high octane value to increase the compression ratio of the engine beyond the 8.5 to 9:1 compression ratios encountered with modern gasoline engines (a 1% to 2.5% gain in fuel economy normally accompanies an increase of 1 in the compression ratio in the gasoline range - see Figure 4.2.1c). With natural gas and methanol used alone as fuels, their exceptional octane values permit compression ratios in the 14:1 range to be used when engine efficiencies close to those of the diesel engine can be attained at full load conditions.

The use of high octane alternative fuels in compression ignition engines requires formulation with additives and/or significant engine modifications. However, there is a substantial incentive to develop this route to diesel fuel substitutions since diesel fuel supply,

Figure 4.2.1b Heat Engine Research



KEY:

(U) Systems General Motors considers unrealistic

(E) Systems already evaluated by GM Research Labs

(A) Systems still in active research programs

Source: General Motors Research quoted in Ward's Engine Update, May 1, 1984.

Table 4.2.1 Properties of Alternative Fuels

Fuel	Density kg/litre	HHV MG/litre	RON
MeOH 90% (2)	.788	19.67	108
MeOH + cetane enh. (6)	.804	18.52	-
MeOH 100%	.796	18.08	110
LNG	.425	22.16	130
Gasoline (LR)	.718	34	94
MeOH blend (3)	.724	32.99	110
EtOH blend (4)	.725	32.91	110
CNG (1)	.114	6.04	130
Propane (7)	.508	25.59	110
Diesel	.829	38.18	-
C3-Diesel (5)	.508	25.59	-

(1) at 16.5 MPa fuel tank pressure

(2) blend comprises 90V% MeOH, 10V% LR gasoline

(3) " " 90.5V% MeOH, 4.75V% t-butanol, 4.75V% MeOH

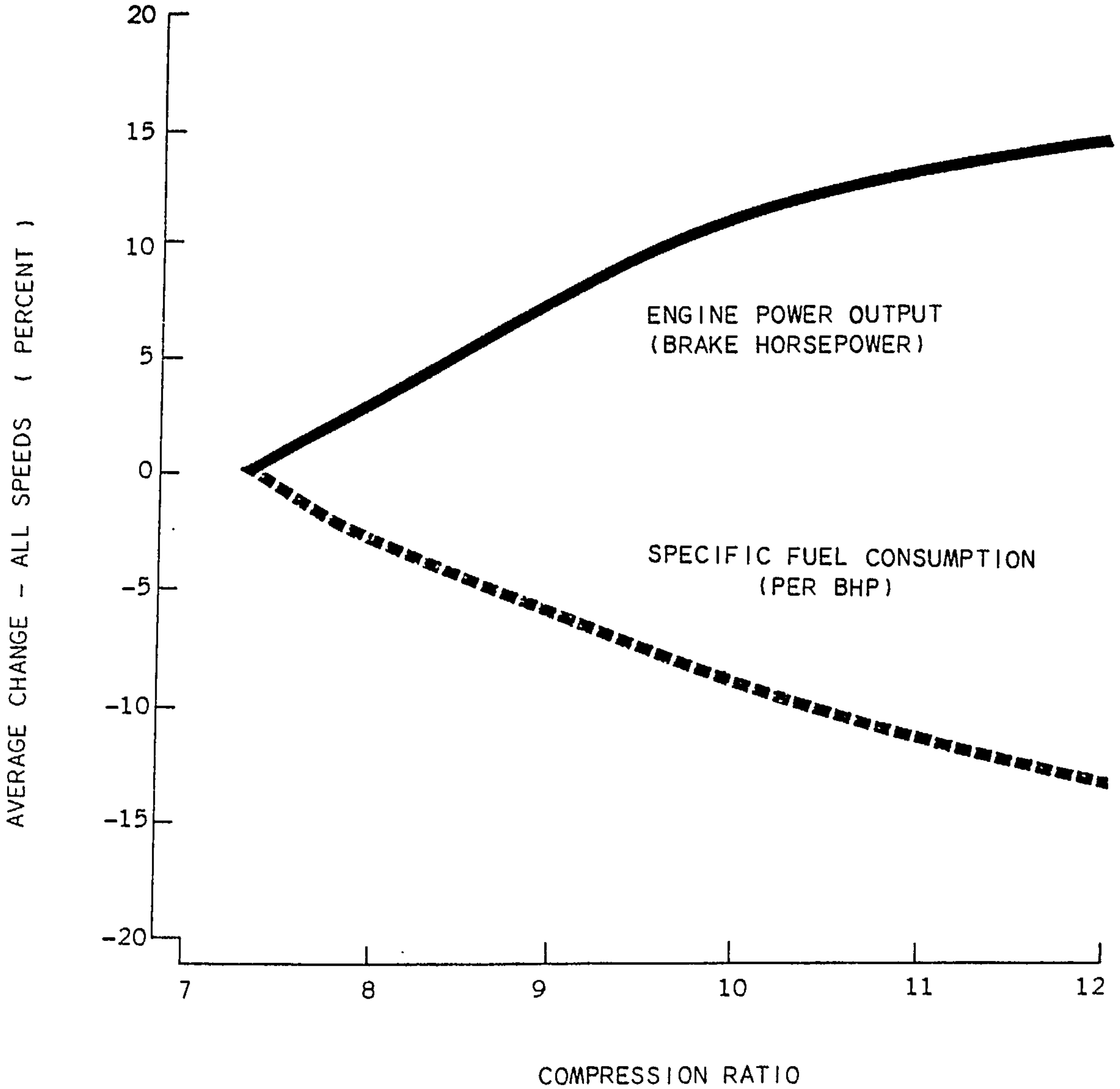
(4) " " 90V% MeOH, 10V% EtOH

(5) " " 80V% Propane, 20V% Diesel

(6) " " 95V% MeOH, 5V% DII-3 cetane enhancer

(7) automobile grade HD-5 comprising 90V% min propane, 5V% max propylene, 2.5V% max butane plus

Figure 4.2.1c Effect of Compression Ratio on Fuel Economy and Engine Power Output in Internal Combustion Engine



Source: Ethyl Corporation

quality and price problems are forecast for the future. The demand for diesel fuel is projected to grow faster than for gasoline at a time when lower quality crude oil and the greater use of synthetic tar sands-derived crudes will reduce the ignition quality (cetane index) of the diesel fuel provided and require the installation of additional refining equipment to upgrade the diesel pool to acceptable quality levels. The concern over the cost of engine modification necessary to meet emerging exhaust emission control standards for particulates and nitrogen oxides is another driving factor behind the development of alternatives to diesel fuel.

4.2.2 Diesel/Gasoline Engine/Fuel Comparison

The competition between diesel fuel and gasoline lies in the middle size vehicle range. Large heavy duty intercity trucks and buses and heavy duty city buses require a level of engine reliability (service factor) that has not been available in large gasoline engines. Further, large gasoline engines have high fuel consumption and short lives compared to diesel-fuelled compression ignition engines. The major U.S. manufacturers of large gasoline engines (International Harvester, Ford) have announced their termination of large gasoline engine manufacture. At the small vehicle end of the spectrum the high speed engines required are best serviced by the Otto engine since the added initial cost and added weight of the diesel engine cannot be recovered from the fuel cost savings involved. For example, in Case 1a (Appendix A) a small "commuter" automobile at current gasoline costs may incur fuel costs below $150/year - too small a number to justify a $400-500 premium on the initial cost for a diesel-engined automobile. Experience in N. America with small diesels is that no saving in maintenance costs is available compared to the gasoline fuel-engine option.

The annual fuel cost saving for a standard automobile (Cases 2a, 2b) equipped with a diesel engine can be in the range of 18-20% ($150/year at present costs for a vehicle with 18,000km/year use) compared to the gasoline equivalent due to the lower volumetric fuel consumption (6.82litres/100km diesel versus 8.6litres/100km or 21% for the gasoline automobile in our "averaged example"). The lower fuel consumption in the diesel case reflects not only the higher energy efficiency of the high compression diesel engine compared to the gasoline engine (12% in our example), but also the higher energy content of the higher density diesel fuel (diesel heating value and density typically: 38.2MJ/litre and 0.829kg/litre; gasoline 34.0MJ/litre and 0.718kg/litre). The effect of added initial vehicle costs for the diesel automobile - $975 including tax - almost eliminates the gain derived from the lower fuel cost compared to the gasoline vehicle. Annual costs for the particular N. American diesel and gasoline automobiles are almost identical.

In the case of a small urban truck (Cases 8a, 8b) typically operating 19,350km/year, fuel savings of 50% ($490/year) and maintenance savings of $135/year over the 8 year vehicle life compensate for the $1860 added initial cost of the diesel-engined truck. More intensive vehicle use and vehicles with bigger engines (intercity trucks and typical heavy duty city, intercity and school buses) show correspondingly larger cost savings from diesel use. Savings between diesel and gasoline are increased when diesel fuel is substituted for unleaded gasoline which on average cost 2.3¢/litre more than the leaded grade in the 4th Quarter 1983 (a 4.7% differential).

The trend to lead-incompatible gasoline engines (with lead-sensitive catalytic converter systems) and legislation to reduce the allowable levels of lead additives in leaded grades will increase the impact of the diesel-gasoline price differential in the future. By 1990 it may well be that no lead is permitted in highway grades of gasoline and the increased costs of unleaded gasoline, if passed on to commercial fleets, will accelerate the shift to diesel or other alternatives to gasoline.

Turning to the future, the fuel efficiency of both gasoline and diesel engines and vehicles will increase. The exhibit "Comparison of Base Fuel Consumptions by Vehicle Type" given in Appendix B shows the magnitude of the energy efficiency changes which are expected to be implemented by 1990. Gasoline engine efficiencies are projected to increase by 5-12% over 4th Quarter 1983 levels, with the large engines enjoying the largest improvement. This improvement in gasoline engine efficiency will occur while diesel engines are also being improved, but the impact of the concurrent search for reduced particulates, reduced NOx and reduced noise in diesel engines is expected to restrict the commercially implemented diesel fuel economy improvement to an average of about 6%.

The engine and vehicle technologies which will form the basis for these fuel economics are summarized in Figures 4.2,2a 4.2.2b. The effect of vehicle weight reduction on fuel consumption illustrated in Figure 4.2.2c has already been exploited in automobiles by the manufacturers with light-weight construction (aluminum and plastics replacing steel in remodelled vehicles); the engine developments will be slower to implement.

The effect of vehicle downsizing and weight reduction can have an impact on the cost and feasibility of conversion from high energy density gasoline or diesel to alternatives. All of the alternatives under review here require larger storage volumes than gasoline or diesel if vehicle range is to be maintained. In addition, propane and CNG must be contained in heavy and bulky pressure storage vessels, LNG in bulky cryogenic insulation. The volume of fuel storage limits the fuel economy possible through downsizing; the added weight of the alternative fuel storage systems also compromises the fuel economy. These effects are illustrated for the case of an intercity bus in Table 4.2.2. This Table also shows the energy savings possible through engine upgrading in a conventional diesel-fuelled intercity bus.

Figure 4.2.2a Gasoline Engines, Fuel Economy Options 1983-1990 and Beyond

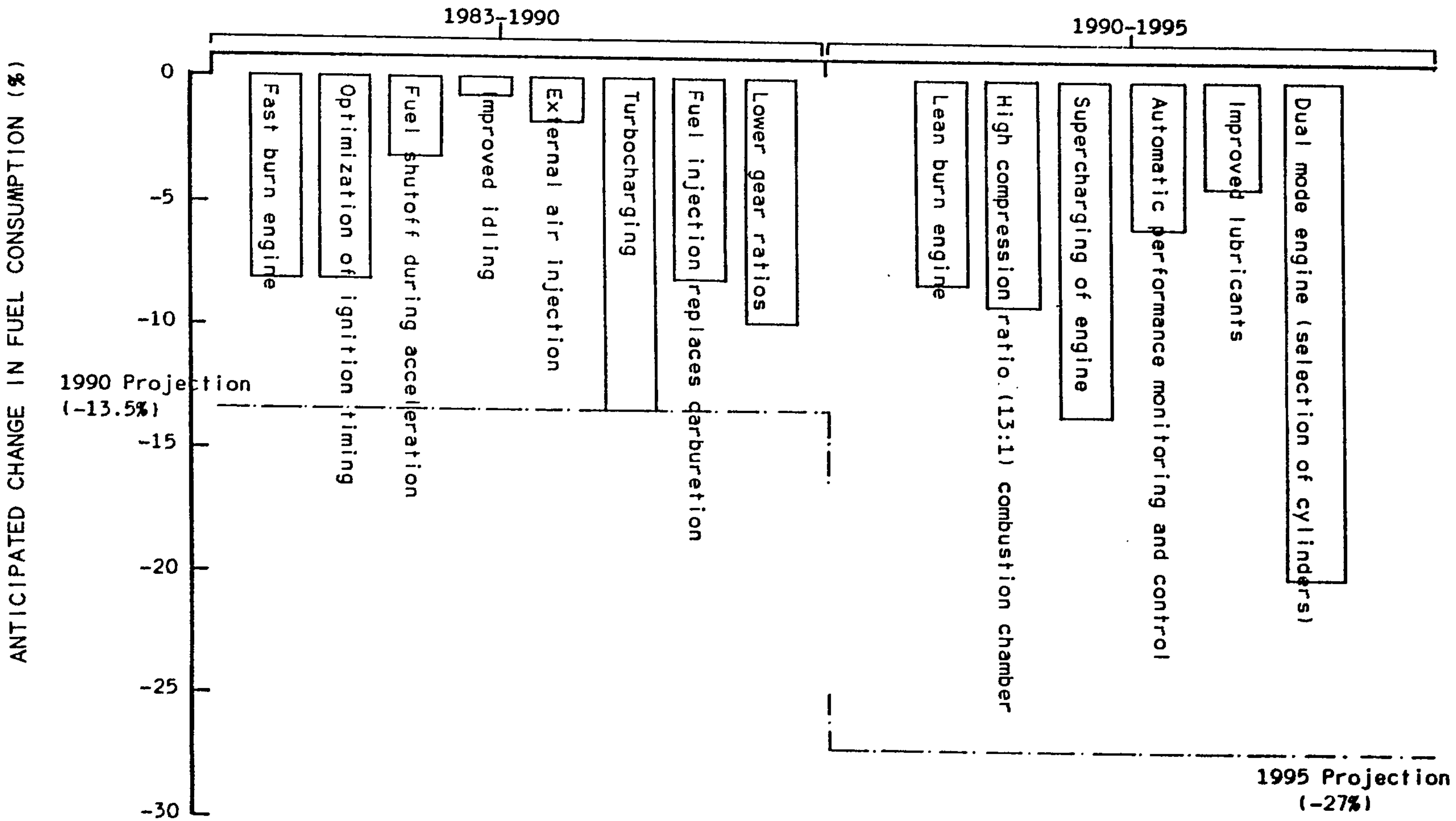
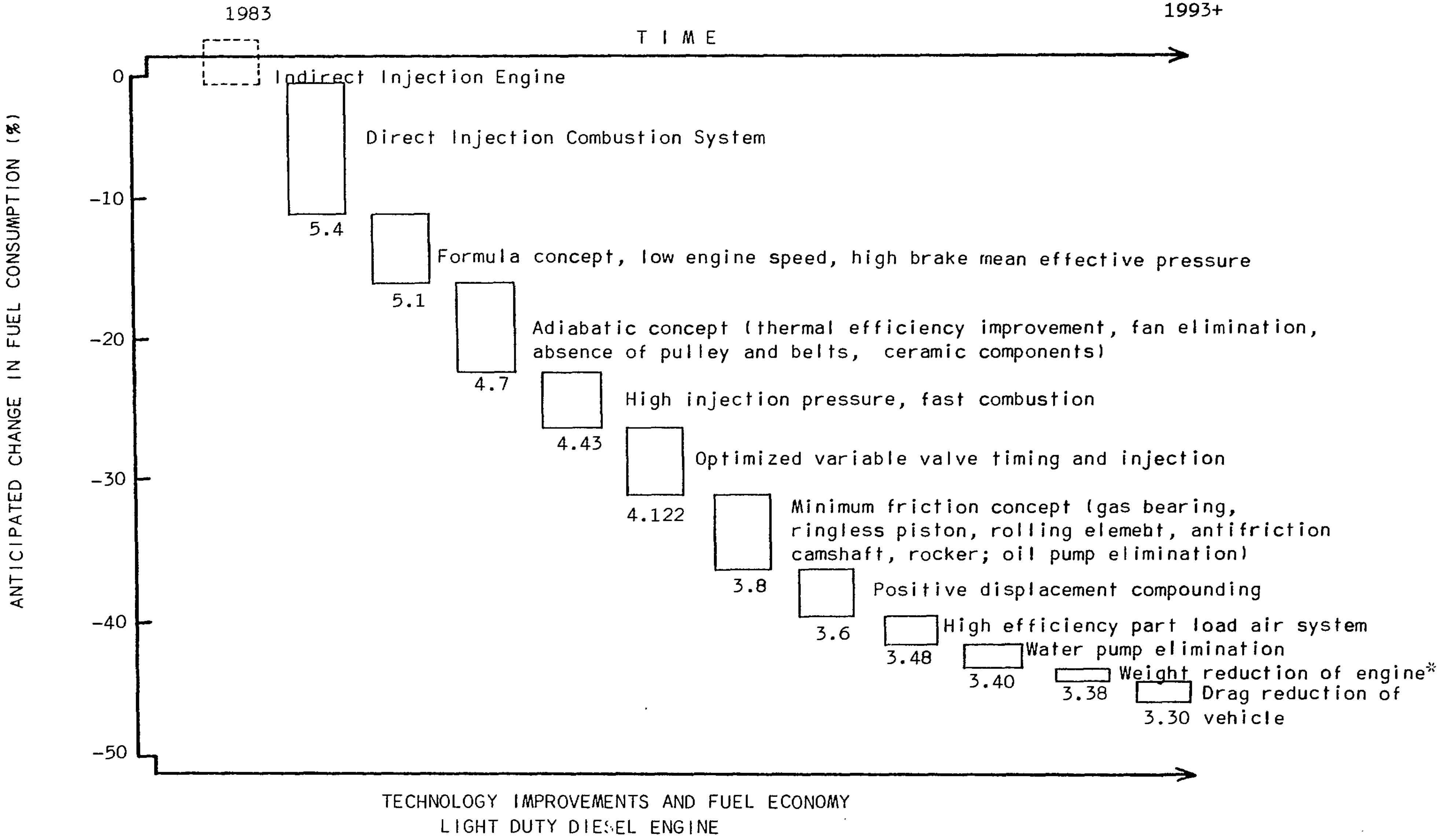


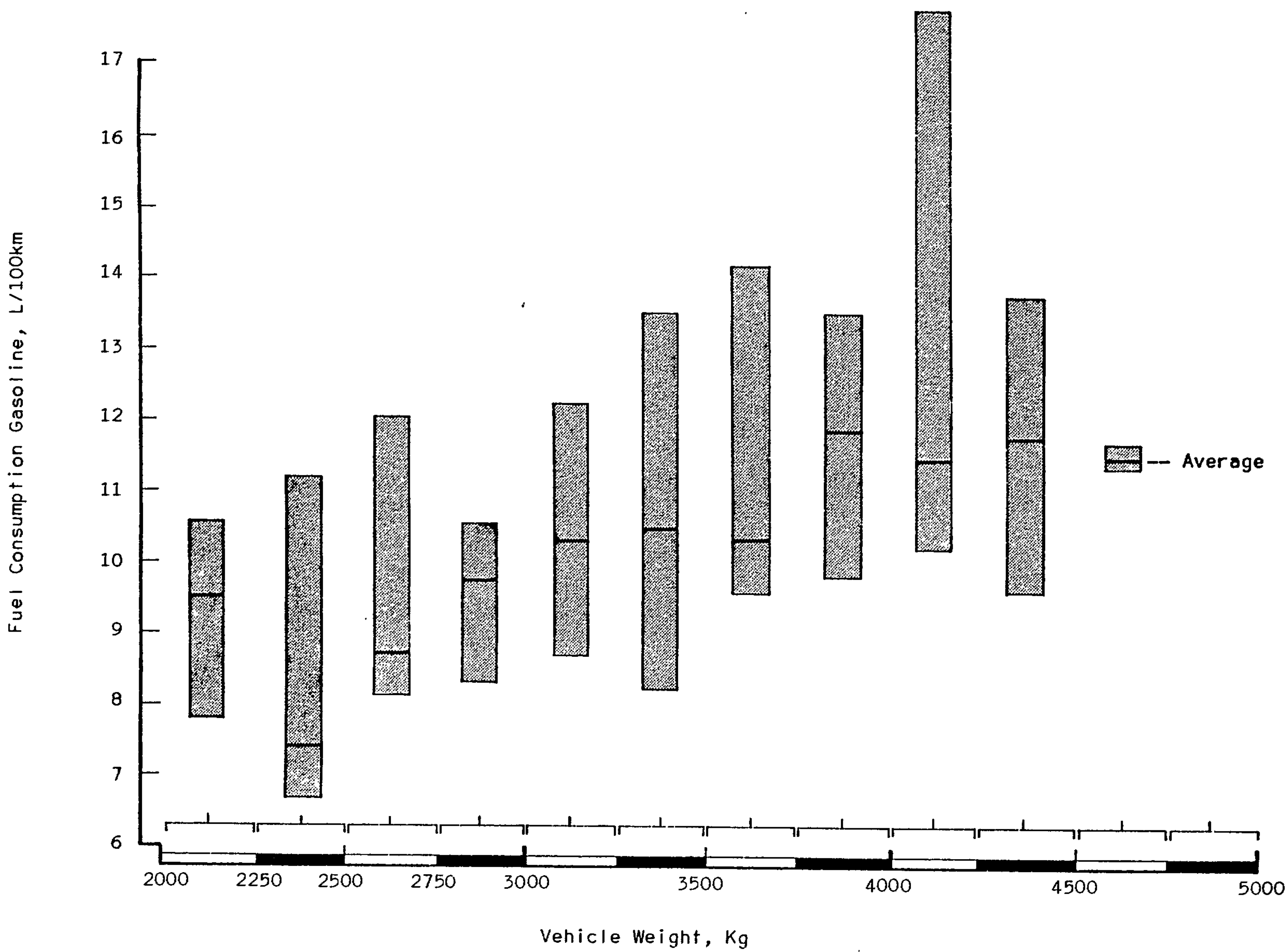
Figure 4.2.2b Light Duty Diesel Engines Fuel Economy Options 1983-1990 and Beyond



Based on: SAE Report P120.

* and accessories

Figure 4.2.2c Fuel Economy Vehicle Weight Relationship (Gasoline Engines)



Source: Brean, D.J.S., The Economics of Gasoline Demand: Implications for Demand Management through Federal Tax Policy, Inst. for Policy Analysis, U. of Toronto, prepd for EMR Transportation Energy Div., Rept. #TE83-18, Feb. 1983.

Table 4.2.2 Intercity Bus - Fuel, Filled Tank Volumes and Weights

BASIS: 600 mile autonomy with all fuels

	FUEL			FUEL & TANK		ENGINE		
	ENERGY (GJ)	VOLUME (l)	WEIGHT (kg)	VOLUME (l)	WEIGHT (kg)	VOLUME (l)	WEIGHT (kg)	TYPE
1. #2 diesel in existing 2-stroke diesel engine 5.5mpg requires 110 gallon (Imp.)	19.4	500	425	550	475	1140	920	GM6V92TH
2. #2 diesel in typical 4-stroke diesel 6mpg requires 100 gallon (Imp.)	17.6	455	385	500	435	1450 1575 1400	1230* 1184* 900	Cummins E350 and similar
3. Methanol with cetane enhancers in existing diesel (4 stroke; similar change for 2 stroke)	18.9	1050	840	1150	930	As in 2. + 15 litres and 10kg		
4. Ethanol with cetane improvers in 4-stroke diesel	18.9	800	635	950	700	As in 3.		
5. Methanol in spark-modified diesel engine (4-stroke)	18.0	1000	800	1100	880	As in 3.		
6. Propane in spark-modified diesel engine (4-stroke)	17.8	750	385	1100	815(2)	As in 3.		
7. Liquid natural gas (LNG) in spark-modified 4-stroke diesel	18.0	850	360	1200(3)	750	As in 3.		
8. CNG (at 3000psig cylinder pressure) NOT PRACTICAL FOR 600 MILE RANGE	18.0	-	-	3200	4100	Not proven yet		

SUMMARY

	VOLUME (l)	WEIGHT (kg)
DIESEL FUEL FOR 2-STROKE	550	475
MAXIMUM FOR METHANOL, ETHANOL, PROPANE OR LNG (ROUNDED)	1150	950

CONCLUSION: ALTERNATIVE FUELS NEED MAXIMUM TWICE VOLUME AND TWICE WEIGHT OF #2 DIESEL IN FUEL SYSTEM

NOTES: (1) Items marked * include accessories

(2) Propane tanks allow for 80% fill. Can be one tank 76.2cm OD x 220cm (including rounded ends) or two smaller tanks.

(3) Reduced by 1986 to 1150 litres.

Source: R.F. Webb Corp.

4.2.3 Gasoline and Diesel Blends with Alternative Fuels

A theoretically attractive way to introduce alternative fuels is to blend them with conventional fuels. In practice such blending is possible only with synthetic gasolines and diesels (which are high cost products compared to those derived from crude oil) and between dry alcohols and gasoline.

Ethyl alcohol-gasoline blends with and without added lead to improve octane levels are available in the U.S. and in the Winnipeg area of Manitoba as gasohol - a composition with 10% dry ethanol in 90% by volume of gasoline. There is some controversy over the interpretation of fleet tests with gasohol due in part to the variety of gasolines used to formulate the gasohol (leaded and unleaded and varying in base gasoline energy content), in part to the small changes in consumption being measured under difficult to control conditions, and in part to the wide variations in engines across the various tests and times of the tests.

Older work often indicated a significant gain in energy efficiency, sometimes even a gain in volumetric efficiency but much of that gain can be traced to the use of an engine set to rich fuel-air ratios (as was the practice in the early 1970's) which could be "leaned/out" (equivalent to added air) by the oxygenated fuel. Engines close to the knock limit would have responded to the octane improvement brought about by the 10% alcohol addition. Modern automobiles are lean burning and do not show energy efficiency gains from the further leaning involved in the use of alcohol. The Otto-engined taxi, standard automobile and light truck examples (Cases 2h, 3m, 8j) show equivalent energy consumption/km of service and a 3.3-3.4% increase in volume of gasohol consumed over gasoline (in both cases leaded gasoline was used). The fuel costs in Ontario in 1983 for all three classes of vehicle were slightly higher for gasohol than gasoline (no road fuel tax paid on the ethanol portion of the blend is offset by higher cost of the blend in

Ontario) and the other variable and fixed costs are unchanged. A 7% reduction in the cost of gasohol is required to break even with gasoline in these Ontario applications: substantial cost reduction or subsidy will be required in the ethyl alcohol portion of the gasohol blend.

Blends of gasoline and methanol need fortification with additives such as butyl alcohol to prevent phase separation of the gasoline blend under practical moist fuel storage conditions (some highly aromatic gasolines are compatible with dry methanol even without the additive but dryness does not prevail in commercial fuel situations).

One formulation investigated in the present study was a refinery produced blend of methanol (4.75% volume) and t-butanol (4.75% volume) in gasoline (90.5% volume), which was adjusted for specification vapour pressure by "backing out" butane to compensate for the increased fuel blend volatility with methanol and then brought to regular grade octane specification by addition of lead tetraethyl (see Appendix C for refinery plant gate cost worksheet on this case).

The cost effect of these formulations is to produce a composition with lower retail cost in Ontario than gasohol ($8.67/GJ compared to $9.01/GJ for gasohol) but still higher than regular leaded gasoline ($8.40/GJ) when the methanol is costed at 18.6¢/litre FOB refinery plant gate (see Appendix E). No cost-saving benefit is available under these circumstances but may be attained if:

1. the blends were to enjoy provincial tax exempt status
2. the blend is to compete as a premium (high octane) unleaded grade of gasoline
3. very low returns on fuel grade methanol were taken by producers with access to very low cost natural gas.

The benefits of methanol blending may be more significant to refiners rather than vehicle users when high volumes of unleaded gasoline are required from the refineries without increasing refinery process severity and oil consumption.

In the cases of low alcohol content gasoline blends the future engine technology developments will be available to gasoline as well and no significant improvement in the relative life cycle costs with the alternative blends is expected in the future to 1990 from this source.

4.2.4 High Level Methanol Blends

Methanol can be used without additives as a fuel for both spark-ignition engines and modified compression ignition engines. The high octane value and high latent heat of vapourization of the fuel explains its well-known use in high compression ratio, high specific power output engines for racing cars where cooling by the vapourization of the methanol in the fuel-rich mixture permits a reduction in the size of the engine and cooling system. These attributes can be advantageously employed in commercial methanol engines equipped with spark ignition, but the fuel-rich operation is replaced by a more economic lean-burn operation to take advantage of another outstanding property of methanol - its ability to ignite at very low fuel-to-air ratios compared to gasoline. With appropriate equipment a methanol engine can be operated with good fuel economy (at high air-to-fuel ratios) at low power (an attribute of diesel engines) and also at high power (an attribute of gasoline engines, since diesels with their constant air and variable fuel intake design inject excess fuel at high power which carbonizes to form unacceptable levels of black smoke, whereas a carburetted gasoline engine or methanol engine ingests air to match the fuel intake). A methanol spark-ignition engine with this fuel quality control and quantity control system has been demonstrated in city buses by Daimler-Benz.

The use of 100% methanol in spark-ignition engines is not convenient since the high heat of vapourization of methanol gives cold start problems. Methanol fuel is therefore formulated with low boiling gasolines to improve the cold start capability – this is the basis of "M90" – 90% volume percent methanol with gasoline or isopentane (10% volume) added. The added hydrocarbon also improves storage safety.

Case 2f (Appendix A) summarizes the life-cycle costs of a 4-cylinder automobile operated on M90. At prices derived for 4th Quarter 1983 in Ontario (20¢/litre for M90 FOB primary terminal) and with the provincial road fuel tax waived on the methanol portion there is a very small annual saving on fuel costs. But the cost of converting the vehicle to methanol by the manufacturer (a larger methanol-resistant fuel tank, some upgrading of plastic fuel lines and gaskets to provide methanol resistance) is passed on and not fully recovered by the waiver of 7% sales tax on the vehicle. The net effect in this case is a relatively insignificant saving in total life-cycle costs from the conversion from regular leaded gasoline to M90. For the average vehicle savings would be increased to the $100/year range if M90 were to replace unleaded regular gasoline, and to the $180-200/year range if the methanol-fuelled vehicle were assembled to compete with one operated on high octane (premium) unleaded gasoline. Costs would be more favourable if vehicles converted to M90 were to receive federal grants ($400, $500) given to propane or CNG conversions.

The case of conversion of a taxi to M90 is complicated by the fact that commercial users of gasoline can claim back the federal excise tax (this 1.5¢/litre tax is not reclaimable by private vehicle users) which reduces the attractiveness of M90. In the 6-cylinder taxi example (Case 3j) with annual fuel use of 16,000 litres, a fuel cost penalty for M90 of $940/year is incurred in the conversion from leaded regular gasolines, and M90 costs are very similar to those for M10, despite the higher road tax saving on the M90 grade.

A reduction in the price of methanol to the M90 blender-refiner is required for M90 to be strongly competitive with regular leaded gasoline, but is not required if M90 has only to compete with unleaded gasolines as a result of lead phase-out legislation or imposition in Canada of exhaust emission standards which dictate the use of catalytic converters and unleaded gasolines.

For the future it is expected that the margin between M90 and gasoline will grow as lead legislation tightens and engine efficiencies are improved through the adoption of high compression ratio engines. M90 has the octane number required to tolerate the higher compression engines. A 3-4% gain by M90 over that achieved by gasoline to the year 1990 is therefore projected in the display "Comparison of Base Fuel Consumptions by Vehicle Type" (in Appendix B). The M90 premium vehicle cost will also be reduced: by 1990 this is expected to reduce the life-cycle cost of a taxi by 6.5% compared to only a 3.5% reduction for gasoline and low alcohol level gasolines (expressed in terms of constant 1983 dollars) gained from improved vehicle technology.

The use of M90 in a city bus with a spark-ignition engine is shown to be uneconomic (see Case 5e) compared to other options, but this is not unexpected since gasoline engines have been almost totally displaced in this application by diesel-fuelled compression ignition engines due to the high fuel consumption, high maintenance cost and short life of the high speed, heavy duty gasoline engine.

An M90-fuelled city bus would have annual costs some $6400-6500 higher than the average $96,200 annual cost of a conventional diesel fuel city bus. Another engine technology is required if M90 is to be used in large heavy duty engines such as those in city buses, intercity buses and heavy duty trucks. The economics of the use of M90 in medium duty urban trucks is similar to the taxi case: there is no cost advantage for M90 compared to leaded regular gasoline, but the $100/year disadvantage in fuel cost (with a methanol plant gate [Alta.] cost of 14.3¢/litre in the M90 blend case) could be reversed, given stringent lead legislation and a phase out of leaded gasoline, engine efficiency improvements through use of the high octane rating of M90 and extension of federal government grants now given to purchasers and convertors of propane and CNG vehicles to include methanol vehicles.

The high cost of ethanol in Canada precludes its use as an alternative alcohol for M90-type applications.

4.2.5 Methanol Fuel

General Motors has demonstrated the use of 100% methanol in a 2-cycle diesel engine modified to include a glow-plug, retention of a portion of the combustion product to increase engine temperature and an increase in the compression ratio - all designed to assist the compression ignition of the methanol-air mixture. The present analysis has assumed that this technology can be extended from its demonstration in a city bus to the 2-cycle engines used in urban and intercity trucks.

Another way of accomplishing methanol ignition in a diesel engine is to add ignition improvers such as cyclo-hexyl nitrate and octyl nitrate. These are already used to improve the ignition quality of diesel fuels but for methanol massive doses of these relatively expensive additives (typically $4/litre cost) must be used. Even if it is assumed that it will be possible to reduce the level of octane extender from currently demonstrated 10-12 volume per cent levels to 5% by volume, a high cost ($21/GJ FOB primary terminal) low density fuel (18.5MJ/litre versus 38.2MJ/litre for diesel) is produced which, even with Ontario road fuel tax remission, more than doubles the fuel cost relative to diesel ($6.9/GJ FOB terminal). Cetane-fortified methanol may therefore be considered as an emergency fuel not as an economic alternative for diesel fuel. A modest improvement in cost may be possible in the future from new additives but cetane-improved methanol fuel is a misapplication of the fuel. Also the use of cetane improvers to effect such a large change in cetane number (30+ cetane units) is an uneconomic use of the improvers. Improver technology is well suited to the upgrading of diesel fuel, for example, to meet winter cold start requirements by improving ignition quality, or to bring specific refinery batches of diesel fuel up to specification. Cetane improvements of 30+ units require new engine as well as new fuel technology.

The use of 100% methanol without the high cost of cetane improvement may be difficult to extend to current 4-stroke diesel engines but can be considered for modified current designs of 2-stroke engines and future 4-stroke engines in which high engine temperatures are maintained (the "adiabatic" diesel engines).

The 2-stroke version in a typical Ontario city bus (Case 5f) would have fuel costs about $2500 higher than for diesel fuel, even after allowing for the road fuel tax rebate: this is only partly ameliorated by the $700/year reduction in fixed costs which arise from the 7% sales tax remission ($11,550) on the $155,000 or so original vehicle cost. A 16% reduction in methanol fuel costs (to a delivered price of 19.7¢/litre) would permit methanol to compete with diesel fuel in this application. Some gain in efficiency of methanol use in compression ignition engines is forecast to 1990 but will not be much greater than the 6% improvement which is seen to lie ahead to 1990 in the conventional diesel fleet. The competition of methanol with diesel as a fuel for compression ignition engines therefore lies in reducing the terminal and refuelling station costs associated with the larger volume of methanol needed compared to diesel (2.1:1 by volume), the higher cost of in-vehicle fuel storage tanks compared to diesel, but most of all from changes in the relative price of methanol and diesel (which can be expected if a future supply shortage of conventional "straight run" diesel fuel occurs: see 4.2.1). In Ontario this implies retention of the road fuel tax exemption on methanol fuel.

The operation of a Class 8 intercity truck with the 100% methanol 2-stroke technology (Case 10c in Appendix A) parallels that of the city bus: methanol at 23.39¢/litre or $12.93/GJ delivered based on 14.3¢/litre methanol at the Alberta plant gate increases annual cost of operation and ownership after allowance is made for the added net capital charges (and after the Ontario tax concessions) from $166,500/year in the diesel case to $172,500, increasing the costs/tonne kilometre of freight carried from 4.5¢ to 4.66¢.

The 3.5-4% annual cost penalty for methanol compared to diesel fuel could be eliminated by a 3.1¢/litre (13%) reduction in the delivered cost of methanol (to about 20¢/litre). The 100% methanol technology is clearly superior to the cetane blending route. In the cases considered an intercity truck operated on the cetane enhanced methanol fuel would cost $42,000/year more than the 100% methanol equivalent, incurring a freight cost penalty of over 1.1¢/tonne-kilometer.

In the case of the Ontario-based small urban truck (see Cases 8a,b,e,f,g,h) the life-cycle cost comparisons are heavily weighted with driver costs and annual fixed costs which obscure the controllable variable costs or those which are subject to some choice in engine and fuel options. The various engine/fuel technologies examined provide the following for the small urban truck:

Technology/Fuel	Annual Fuel Cost	Ratio to Lowest Cost (Diesel)	Life Cycle Cost ($/Tekm)
Diesel in compression ignition engine (CI)	$ 978	1*	3.76
Gasoline in spark engine (SI)	1468	1.51	3.82
Gasoline-methanol-butanol blends (SI)	1527	1.56	3.82
Methanol in 2-stroke (CI)	1576 (1260)*	1.61 (1.28)*	3.88
"M90" (SI)	1688	1.73	3.85
Methanol, cetane improved (CI)	2687	2.74	4.06

* Reference case
** Improved technology

As shown above, if the methanol in the compression ignition engine case reported could be improved to the same energy consumption level as diesel (as achieved by GM with the larger city bus engine) that regime would be lower in fuel cost than the gasoline spark-ignition system and identical in life-cycle cost.

In the case of the (Class 3) urban/interurban truck, the high capital charges for the diesel vehicle compared to the gasoline alternative balance the fuel savings at the low average annual mileage typical for this vehicle class (22,400km/year). A "current technology" compression ignition methanol engine results in about 2% higher annual (i.e. fixed and variable) costs than the diesel equivalent (which is about $42,000/year or $2.57/tonnes kilometer - see Cases 9c and 9f respectively in Appendix A).

Development of an improved technology compression ignition 100% methanol engine with the same energy efficiency as the diesel, together with a modest 20% increase in the price of diesel (relative to untaxed methanol) would make that methanol option competitive.

4.2.6 Propane and Natural Gas

Propane and natural gas (CNG or LNG) are currently used in road transport in systems which convert the stored liquid forms (propane/LNG) and the stored gaseous form (CNG) into low pressure gas. Thereafter there are two principal ways of using the gas:

1. As a monofuel or sole fuel in spark-ignition (Otto cycle) engines (the spark engine may be converted from a gasoline engine or from a diesel engine by addition of a spark system).
2. In dual fuel modes:
   a. where gas is used alternatively with gasoline, i.e. vehicle operates on gas or gasoline but not on both simultaneously and uses a spark ignition engine

b. where gas is inducted into a diesel engine with the gas/air mixture ignited by the injection of diesel fuel (usually a minimum of 20% by volume), which acts as a "pilot" spark source.

Injection of liquid propane or liquid natural gas into spark-ignition engines is being researched, but is not commercially available.

The monofuel systems are capable of being optimized for the gaseous fuel, which explains the recent introduction of diesel engine-derived large propane and gas engines with optimized compression ratios which will extend the use of propane and natural gas from the current small vehicle applications (automobiles, small and medium trucks and school buses) to large buses (city and intercity) and heavy duty trucks.

The dual fuel alternating fuel mode is useful where range on the gaseous fuel (especially CNG) is insufficient or where too few refuelling stations are available in a territory. The dual fuel (concurrent fuelling) system with diesel used as a pilot is rather complex with two fuel injection and storage systems, but is reported to provide the highest fuel combustion efficiency for reasons not yet fully explained. The dual diesel-gas fuel system also does not suffer from the throttle losses associated with carburetted spark-ignition engines.

The conversion of a small commuter vehicle from gasoline to monofuel CNG and propane has been examined (cases 1a,b,c). The lowest annual cost and life-cycle cost is shown by the commuter vehicle equipped to burn natural gas. In Ontario, with the federal grant for conversion and the Ontario remission of road fuel tax and vehicle sales tax, the commuter automobile annual costs are reduced by 3% ($54) compared to the $1770 annual cost of operating the vehicle with regular leaded gasoline. Propane conversion of the small gasoline vehicle cannot be justified at the typical pump prices which prevailed in 4th Quarter 1983 in Ontario (propane 25.9¢/litre, gasoline 47.4¢/litre) since, despite a saving of $41/year on propane fuel, the fixed cost component of annual and life-cycle costs is increased by the conversion to a greater extent.

In the case of the small fuel-efficient automobiles (such as the Honda CRX used in this example) fuel is such a small portion of the life-cycle cost (8.3% with gasoline, 6% with propane, and 4% with CNG) that further technology change to improve fuel efficiency provides only a modest return in life-cycle cost savings, and work to improve the annual costs of alternative fuels is less productive than work to reduce the cost of the basic gasoline-fuelled automobile and the costs of conversion to CNG or propane. These cost considerations mean that even if these commuter vehicles must be converted to premium-priced unleaded gasoline, the 3¢/litre or so cost increase will not persuade owners to convert to CNG or propane. The most significant item here is the promise of the convenience that home fuelling will bring when inexpensive home compressors for gas and improved in-vehicle storage tanks for CNG are available.

The typical 4-cylinder passenger automobile (such as the Ford Fairmont Futura used as an example) provides a more promising opportunity for alternative fuels, since gasoline costs are about 27% of life-cycle costs and fuel consumption at 8.6 litres/100 kilometers is significant. In the average example chosen the annual gasoline fuel cost was about $750; other costs, including maintenance and vehicle financing, would typically increase annual ownership and operating costs to the $2770 range. The fuel economy of a diesel-engined N. American automobile in this class would reduce fuel costs, relative to a gasoline-fuelled vehicle, by about $140/year (a 19% reduction), but the higher initial cost of the vehicle would almost eliminate any annual or life-cycle cost savings.

With 1983 technology and the Ontario fuel cost and tax remission program in place, fuel costs can be substantially reduced by conversion from gasoline to propane, and even more so in the conversion to CNG. In the automobile example given (18,300 km/year) annual CNG costs at $340 would be less than half the cost of gasoline, and that for propane ($540/year) about 72%. The life-cycle costs of automobiles on CNG or propane are also lower than those for the gasoline and diesel automobiles, and the advantage increases rapidly with more intensive vehicle use (increased annual mileage) providing (in the case of CNG) the advantage of the CNG fuel cost is not lost by the need to maintain vehicle range by conversion from a monofuel (all CNG) fuel system to a dual fuel system operated for a significant proportion of mileage on gasoline.

Technical improvements to 1990 are expected to further improve the comparative advantage of the CNG and propane automobiles compared to gasoline. The high fixed cost component of the life-cycle cost (77%) of the CNG automobile, is due in part to the costs of in-vehicle fuel storage cylinders. This is an obvious target for future improvements in life-cycle costs. A further reason for the high fixed cost component of the life-cycle cost is the very low operating cost element.

Vehicles operated on either CNG or propane in Ontario owe much of their life-cycle cost savings to tax incentives: removal of the current incentives would increase the variable cost of the CNG vehicle by 34%; that of the propane automobile by 25%: the life-cycle cost increases would be 13.5% and 12.2% respectively. Without these subsidies the costs for the 1983 CNG automobile example would still have been marginally lower than those for gasoline, but the life-cycle costs for the propane vehicle would have been about 5% higher than for gasoline. With improved technology and a faster increase in gasoline than propane prices, it is expected that propane will eventually be cost-competitive with gasoline, even without subsidies.

LNG, when purchased at retail outlets, would have been much less attractive than CNG or propane at 1983 costs in Ontario; a saving of only $50/year on fuel cost compared to gasoline, but higher initial vehicle cost (even after the rebate of the 7% Ontario sales tax) would have increased annual costs by $290 and operating costs by 1.2¢/passenger kilometer.

Notwithstanding allowances for fuel boil-off losses, annual LNG fuel costs are marginally lower (in the case examined) than those for gasoline, or gasoline-alcohol blends in the range 90-10% alcohol. But the high cost of specially-fabricated cryogenic storage increases initial vehicle and fixed costs to such a degree that the LNG option is found to be the most expensive. The sensitivity analysis and technology forecast (Appendix B) indicate that LNG may remain uncompetitive as a fuel for small to medium-sized automobiles throughout the remainder of the decade. LNG has its place in fleets of large heavy-duty vehicles (such as trucks and buses) fuelled at a central facility.

Large 6-cylinder automobiles used intensively in applications such as taxi service offer excellent opportunities for life-cycle cost savings through conversion to gaseous fuels. In the base case of the gasoline-fuelled taxi with a fuel economy of 13.4 litres/100 kilometers annually operated over 120,000 kilometers, annual fuel costs in Ontario were estimated at $6580 - 11.6% of total annual cost. The lowest fuel costs in this application are incurred when CNG is used as the sole fuel. While on this fuel, annual fuel costs are at the low rate of $3500-4000/year (depending upon the fleet ownership of gas compression and refuelling facilities or purchase of fuel from a public facility). However, the taxi application is not suited yet to a monofuel CNG operation, due to limitations in the vehicle range between refuelling points, and a dual fuel gasoline-CNG system is required to provide for completion of a duty cycle on gasoline and avoidance of service revenue loss through vehicle returns to the fuelling centre and the time loss in the frequent refuelling step. Under these dual fuel circumstances, the vehicle is not operated at optimum efficiency and fuel costs are intermediate between those of CNG ($3500-4000/year) and gasoline ($6580 for a fleet refuelled at a company-owned service station and about $7400 for purchases made at a retail service station).

In the case of the monofuel CNG taxi, the added cost of the fuel tanks and conversion (after the tax concessions and grants) would range from about $2000-4000/vehicle (depending on the ownership of the fleet fuelling facility). Despite the fact that the fuel cost is only 12% or so of the total life-cycle cost, the savings from conversion to CNG are significant when it is realized that most of the non-fuel related costs are fixed (vehicle, garage costs), or semi-variable (driver costs, for example).

In practice, the fuel savings from conversion to CNG cannot all be realized at this time, since present technology for the storage of CNG in the vehicle limits the vehicle range requiring that the capacity for operating on gasoline be retained. Under these circumstances with a 30% gasoline 70% CNG operation, the fuel costs rise not only due to the use of more expensive gasoline but also because, unlike the monfuel CNG case, the combustion chamber cannot be optimized to take advantage of the high octane value of CNG. This dual fuel mode still provides lower costs than a gasoline operation, but the monofuel goal remains as a further cost-reducing step to be accomplished in the future.

A comparison of life-cycle costs and total annual costs for a gasoline, and dual fuel gasoline/CNG taxi in Ontario 1983 are:

Fuel type (outlet)	Case #	Cost/¢ per passenger kilometer	Annual cost (Dollars)
Gasoline			
(retail fleet)	3a, 3b	56.6-55.8	57,500-56,700
Dual Fuel			
(retail fleet)	3e, 3f	55.6-55.7	55,600-55,700

Based on the Ontario 4Q1983 prices and incentives, the annual cost for the use of propane in taxi service is lower than that for the 70/30, CNG/gasoline or gasoline options, and in Ontario was the lowest cost practical option in 1983.

In the case of propane, the highest savings are realized when a propane fuelling facility is installed at a large taxi fleet service centre: the cost of the facility is often borne by the fuel supplier, or passed on in the form of a modest added charge for fuel. In the cases assumed here (see Cases 3g and 3h in Appendix A) the added saving for self-fuelling would be in the range of $200/vehicle per year.

The effect of changes in the tax and grant incentives from the levels prevailing in Ontario in the 4th Quarter of 1983 for a fleet garage-fuelled taxi may be summarized as follows:

CNG/dual fuel taxi. The elimination of the vehicle sales tax rebate and the introduction of an Ontario fuel sales tax at a 20% ad valorem level (same rate as for gasoline) would increase the annual cost of operating and owning a "standard dual fuel CNG/gasoline taxi-cab" by about $850/year and increase the life-cycle cost of operation by 0.9¢/passenger kilometer. Since the use of CNG/gasoline is already less costly than gasoline used alone, the reduced conversion costs and improved technology available in the future for the CNG vehicle are expected to make the tax rebates less necessary.

In contrast, the use of LNG in taxi service was found to be significantly more expensive ($1475/year) than gasoline throughout the period to 1990. However, if the taxi fleet were sufficiently large (very few in fact are) to justify a captive LNG plant (in this study the minimum economic capacity was taken to be 1000GJ/day - see Case 5c) located at the refuelling terminal, then a saving of about 6¢/litre in the pump cost of LNG could be realized. This would result in an operating cost reduction of $1480/year to give a life-cycle cost of

56¢/passenger km, which is almost the same as the gasoline-fuelled case. Fuelling at the equivalent of a retail LNG outlet (Case 3c) would bring about an increase in the cost of LNG fuel; the annual fuel costs for a typical taxi would be $500/year higher than vehicles fuelled with gasoline at a company-owned and operated gasoline pump (Case 3b).

Propane offered the most advantageous life-cycle cost to a taxi owner in Ontario in 1983. For fleet fuelling at a company-owned pump the advantage in fuel costs for propane compared to gasoline is shown to be about $1250/year and the total annual cost advantage, including conversion costs and all taxes and grants available is about $1100/year for each taxi. Elimination of the vehicle cost-related incentives (7% provincial sales tax and $400 federal grant), but not the Ontario fuel tax incentive, would increase the annual cost of operation and ownership by $805 and the life-cycle cost by 0.8¢/passenger kilometer (1.5%). If, in addition, the fuel tax were imposed on propane and maintained on gasoline at the 20% ad valorem rate, the annual increase in ownership and operating costs of $1870, compared to the actual 1983 situation for propane, would make the propane-converted taxi more expensive to own and operate than the gasoline-fuelled taxi. The cost penalty would be reduced but not eliminated by the anticipated improvements in propane vehicle efficiency and conversion costs (factory-fitted vehicle cost) available by 1990. If the propane-fuelled taxi is to compete with the gasoline-fuelled taxi without the benefit of tax concessions and grants, then the price of taxed propane at the fleet pump should not exceed 26.4¢/litre. That is to say, the propane fuel cost before the provincial road tax would need to be 21.1¢/litre – 82% of the published untaxed propane price and 51.5% of the price per litre of leaded regular gasoline. When the taxi must be operated on unleaded gasoline and a penalty of about 2.5¢/litre absorbed, then the breakeven price for propane competing with 43.5¢/litre gasoline would be about 22.4¢/litre for the "average" taxi cab.

As shown in the "Summary of Life-Cycle Costs" (Appendix B), the alcohol-gasoline blends are more expensive options than CNG or propane, but those based on blending methanol with gasoline may be competitive with straight gasoline in taxi service.

In school bus service propane and CNG are attractive alternatives to gasoline (diesel school buses were not included in this investigation), despite the fact that fuel costs in a gasoline-fuelled school bus are only 19% of total annual costs, substitution of propane for gasoline and use of the tax advantages reduces the cost/student kilometer from 4.6¢ to 4.4¢ and annual costs by about $780 (a 3.5% saving) mainly attributed to the $715 or so reduction in annual fuel cost. The monofuel CNG school bus has double the cost savings at $1500/school bus/year, due to the $1415 or so reduction in fuel cost and the vehicle grant and sales tax saving on the vehicle partially offsetting the $2250 vehicle conversion cost for CNG. The monofuel school bus has the lowest life-cycle cost of operation of all options at 4.29¢/student kilometer. In many cases the gasoline operation of the bus will be retained and reduces the CNG cost advantage, but improvements in storage and engine technology by 1990 are expected to reduce fuel costs by 9% compared to gasoline. Conversion costs (see Appendix B "Comparison of Vehicle Conversion Costs") for CNG school buses are projected to decrease from the $2250 level in 1983 to $1625 (in 1983 dollars) by 1995, when factory-fitted fuel tanks and original CNG engines will be available. In 1983 the conversions were not made by the original vehicle manufacturers.

Urban buses have been operated for many years with propane fuel, but until 1983 the engines used for conversion were gasoline-type engines. Recent technology uses a diesel engine block converted to accept "100% propane" (by addition of spark systems) or dual fuel (diesel pilot fuel injected to ignite a propane-air mixture in a compression-ignition engine). These engines provide high propane economy and can be adapted to use CNG and LNG.

The dual fuel diesel/propane system has been reported to have a higher thermal (total fuel energy) economy than diesel or propane fuel used alone, but for the present analysis it is assumed that the energy efficiency is identical to the diesel fuel case. The annual fuel costs in the case (see Case 5b in Appendix A for details) where 80% propane is substituted for diesel is reduced by $2200 compared to the diesel-only cost of $13,526; concessions on the Ontario sales tax and the federal propane conversion grant together more than offset the $3900 vehicle conversion cost (tanks for propane and a propane air mixer - carburetor) giving a total annual cost savings for the dual fuel case of $2200 per year, which is reflected in a reduction in the cost per passenger kilometer from 11.4¢ to 11.2¢. The cost of fuel is reduced in this case from 14% of total cost to 12% by the use of propane.

In the 1983 Ontario case examined, the conversion from diesel to propane used in a spark-ignition system provided an annual saving in fuel costs of about $1300, but total costs were not reduced by the conversion. New technology for the spark-ignition propane engine is now available. This is expected to reduce the 1983-based costs for propane in a spark-ignition converted diesel engine to slightly below the costs for diesel fuel by an improvement in the fuel consumption of the bus on propane from 92.4 litres/100 km to 85.9 litres/100 km (i.e. from a ratio of propane-to-diesel fuel consumption of 1.7 to an improved 1.6 ratio: the theoretical ratio being 1.5 litres of propane to displace each litre of diesel fuel).

It should be noted that propane prices to large fleets may be substantially lower than those taken in the example where aggressive development of this market is undertaken by the propane suppliers.

LNG (see Case 5c in Appendix A) is an option which can provide life-cycle costs very similar to those for propane in large city bus fleets fuelled at a central location. Annual LNG costs at about $12,000 per bus in our typical example are $200 less than propane, but $1500 less than diesel. The high cost of LNG storage vessels and gas loss by evaporation will be reduced in future vehicle designs and the current (1983) modest additional cost for LNG versus diesel (11.5¢/passenger kilometer versus 11.4¢/passenger kilometer for diesel, a difference of about $750/year per bus) is likely to be converted into a cost savings for LNG by 1990, but only if fuel and vehicle tax savings continue for the alternative fuel.

Intercity buses and coaches require a range between fuelling of at least 600 km, and vehicle redesign to accommodate the increased volume of alternative fuel needed, without undue sacrifice of valuable cargo and luggage space. Case 6b examines the substitution of a spark-ignition engine and propane storage for the conventional compression ignition diesel-fuelled engine (the most frequently used 2-stroke engines from General Motors are used in the base diesel Case 6a).

At a cost of propane of 22.06¢/litre and with taxed diesel at 41.64¢/litre, annual kilometers at 160,000 and the demonstrated 1.7 volumetric fuel consumption ratio for propane (spark ignition) to diesel in a compression ignition engine, fuel savings of about $2750/year accrue to propane use, but are lost to increased (+$5400) maintenance charges. The added cost of the propane vehicle is more than offset by the grants and sales tax concessions available in Ontario, but in the example chosen, the net effect is that the annual added cost of owning and operating the propane intercity bus is about $1400 per year (a 6.7% increase).

The cost of diesel fuel would need to increase by only 2.07¢/litre (5%), or the price of propane to decrease by 1.2¢/litre to effect a breakeven between diesel and propane use under 1983 Ontario conditions with intercity coaches. This is likely to occur in the future when the cost advantage of the propane coach could be further improved by engine design to improve propane fuel economy and to reduce the burden of maintenance cost.

Light trucks for urban service (such as the Ford F150 or Dodge pick-up D150 RAM) are excellent candidates for the application of gaseous fuels as an alternative to gasoline and diesel under the tax incentive situation in Ontario. In the examples (Cases 8a,b,c,d given in Appendix A) a low mileage application was taken (19,350 km/year). In these cases CNG and propane conversions are cost-effective compared to the use of gasoline, and even the purchase of a diesel-engined truck. The lowest fuel cost in this set is diesel fuel, which is consumed at a rate only 73% of that of gasoline and provides annual saving of over $500 (33%) compared to gasoline, but despite lower maintenance costs for the diesel engine, all but $200 of the diesel advantage is lost due to the higher initial cost of the diesel-powered truck ($2000 premium). The after-tax and after-grant net cost premium for the propane and CNG vehicles compared to gasoline engined vehicles is only $300 and $450 respectively.

The CNG truck gave annual costs almost indistinguishable from the diesel case and the propane case:

Life-cycle operating cost comparison
(cents/tonne kilometer)

Gasoline (regular)	381.8
Diesel	376.4
Propane	375.0
CNG	375.9

Elimination of the subsidies on CNG or propane systems would increase life-cycle costs (see Appendix B "Sensitivity Analysis") by 2.7 and 2.4% respectively and elminate their cost advantage in comparison with diesel or gasoline vehicles, even if the gasoline used were to bear the premium for the unleaded grade. A 25% increase in annual kilometerage (see "Sensitivity Analysis" in Appendix B) equally favours diesel, CNG and propane affecting a 16.4% reduction in the cost/tonne kilometer (to about 314¢/tonne kilometer).

The large Class 3 truck used in urban and interurban services (exemplified by the International Harvester Loadmaster-type vehicle) is in a state of fast technological evolution, with diesel, CNG and propane conversions rapidly reducing the proportion of gasoline-powered vehicles in new truck sales. Typically (see "Comparison of Reference Vehicle Classes" in Appendix B) these vehicles have 8-cylinder gasoline engines in the 185-200HP range and maximum payload of 1.25 tonnes. The power requirements are similar to those needed to power city buses.

The propane-powered truck compares favourably in cost with the diesel and gasoline versions, even when annual kilometerage is limited, as in this example to 22,400 km (a one shift per day urban truck operation) but the advantage over gasoline increases substantially when the vehicle is used more intensively.

In the low duty 22,400 km/year service, the propane fuel costs are about $600/year (18.5%) lower than for leaded regular gasoline and the total annual advantage about the same, since the net acquisition cost of the propane truck after grants and sales tax remission is only $50 higher than the unconverted gasoline truck.

Under comparable fuelling conditions (company-owned pump) using 1983 tax incentives and fuel prices, the propane truck provides cost savings of about 3.5¢/tonne-kilometer compared to the gasoline truck and the diesel truck. Improved technology is expected to reduce propane fuel consumption by 1990 by 10-12% compared to 1983 levels, which will provide further cost savings of $235/year when propane replaces gasoline. The savings will be increased by a further $160 when the gasoline truck must use unleaded gasoline, achieving about a $1000/year fuel saving in the propane case.

The heavy duty truck fleets are dominated by high horsepower diesel engines which normally operate on #2 diesel fuel, have an empty vehicle weight of 14 tonnes or so, and can hold up to 36 tonnes of freight. On diesel fuel in highway service, they provide fuel economy (52 litres/100 km) about equal to that of the typical city bus and fuel costs are typically about 23% of annual costs. At 1983 costs the typical heavy duty rig would require expenditure on diesel fuel of $38,100 per year out of a total cost of $166,500. In the examples given in Appendix A (Case 10b) we have examined the technology where 80% of the diesel fuel is replaced by propane with retention of the compression ignition system. The annual fuel cost in this dual fuel case is reduced by $6220 or so (16%) over the pure diesel case and the 1983 remission of provincial sales tax on the vehicle is large enough to reduce the total net vehicle acquisition cost by $1505. These two cost-saving factors are only somewhat reduced by the additional maintenance costs involved for the two-fuel truck: the net outcome being that the dual fuel truck provides freight service at a cost of 4.33¢/tonne-kilometer compared to cost of 4.5¢/tonne-kilometer on diesel fuel alone. This dual fuel operation is the lowest cost of the cases examined for the heavy duty truck.

SECTION 5 - INTERMODAL AND INTERFUEL COMPARISONS

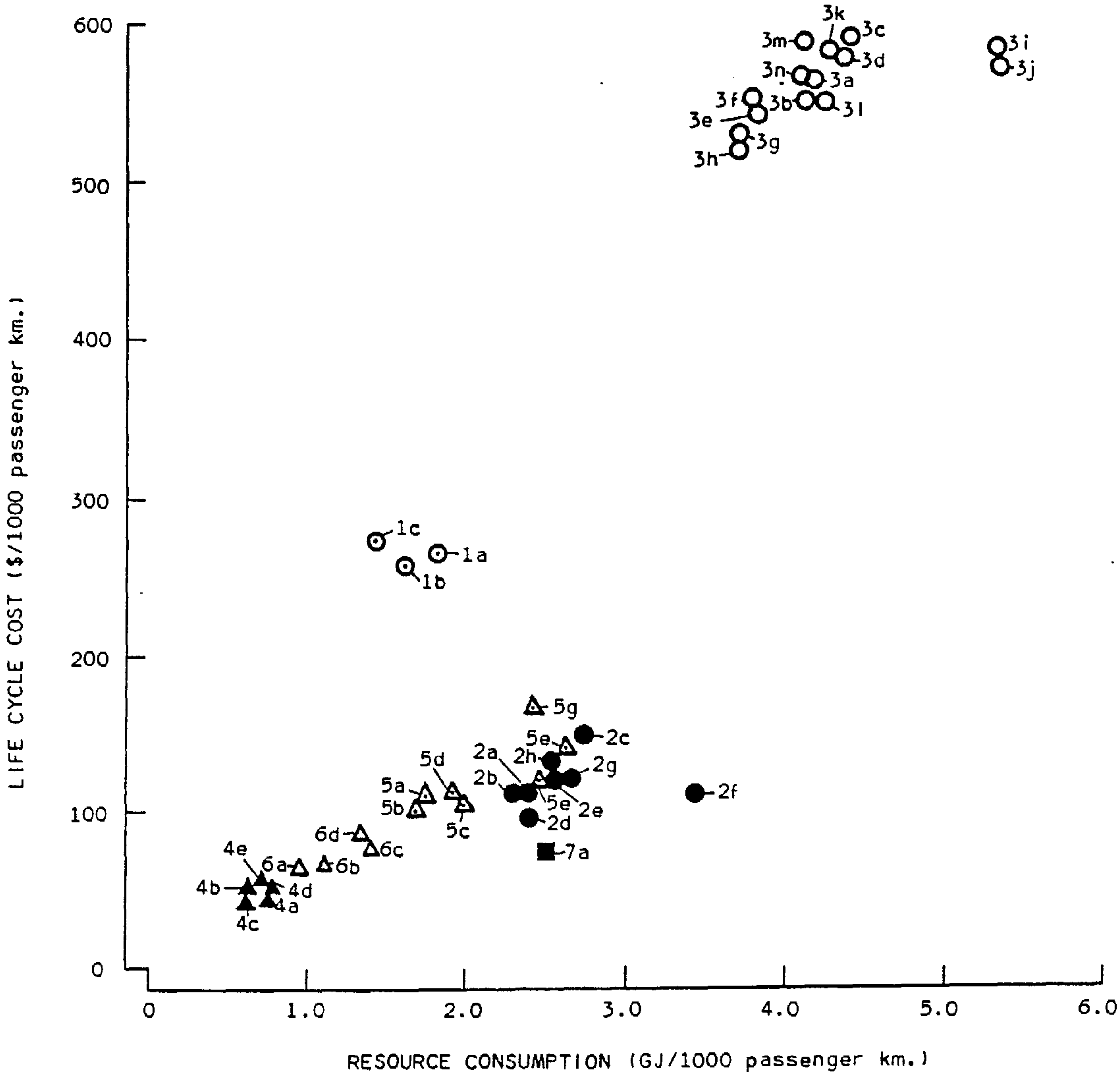
5.1 INTERMODAL COMPARISONS AND INTRAMODAL FUEL COMPARISONS

The discussion of fuel costs and life-cycle costs by vehicle type in Section 4 illustrates the ability of the life-cycle cost methodology to examine the effect of fuel substitutions within a given class of vehicle or service. It also illustrates the wide variation in the contribution the fuel and fuelling system costs make to life-cycle costs. However, even in cases where the fuel cost component is small compared to fixed costs or non fuel-related variable costs, the cost saving opportunity for fuel substitution and fuel economy should not be discounted, since it may be the only cost item that can be attacked. The strength of the life-cycle cost methodology developed in this investigation is that it permits these factors to be explored by providing a generalized framework from which each vehicle owner or fleet manager can develop his or her own cost comparisons.

The extension of the methodology to comparison of life-cycle and even fuel costs between modes is not so rewarding, since much more fine detail is required than can be handled in this exercise to compare, for example, the cost per passenger kilometer of owning and operating an automobile compared to riding a combination of city buses and intercity coaches to achieve the same "mileage". Load factors, the convenience factor, the value of the automobile owner's time and the shared cost of the bus driver and, above all, different subsidies and tax rates mean that even case-by-case investigations are complex, and generalized cases are always incomplete and may be misleading. The wide variation in life-cycle costs calculated here for the different passenger and freight transport modes at average vehicle loadings and average fuel economy are illustrated in Figures 5.1a and 5.1b respectively.

Each value of life-cycle cost can be varied by changing these load and fuel economy factors, financing methods, or by changing driver costs and sales servicing costs. Figures 5.1a and 5.1b are more useful in showing the effect of fuel variations within each class of

Figure 5.1a Summary of Cost/Resource Consumption Factor: Passenger Transport Mode



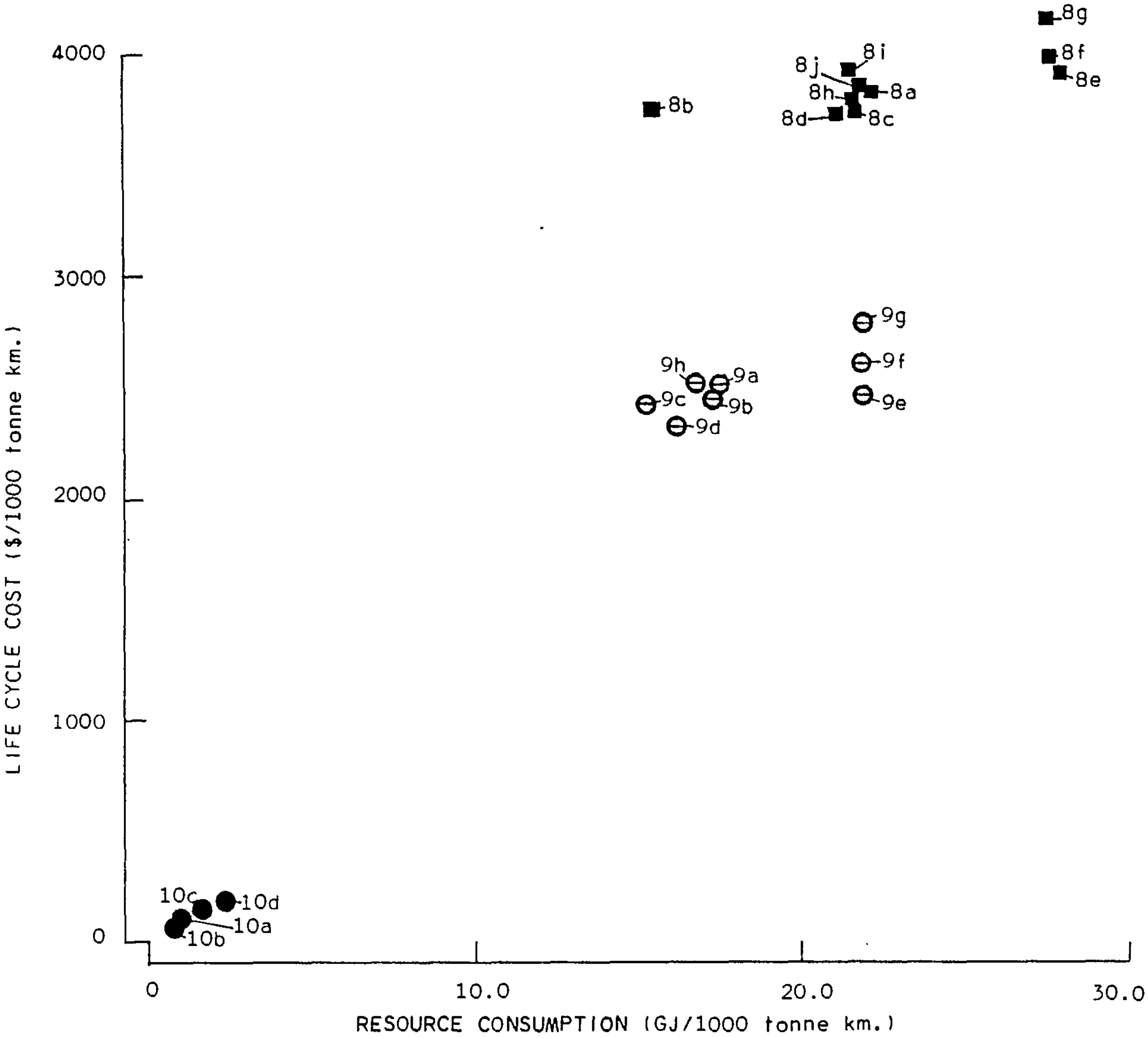
1 ⊙ Commuter Auto   2 ● Standard Auto   3 O Taxi

4 ▲ School Bus   5 △ Urban Bus   6 △ Interurban Bus/Coach

7 ■ Passenger Truck

1. a: Gasoline; b: CNG; c: Propane
2. a: Gasoline; b: Diesel; c: LNG; d: CNG; e: Propane; f: MeOH 90%; g: MeOH Blend; h: EtOH Blend
3. a,b: Gasoline; c,d: LNG; e,f: CNG/Gasoline; g,h: Propane; i,j: MeOH 90%; k,l: MeOH Blend; m,n: EtOH Blend
4. a: Gasoline; b: CNG; c: Propane; d: MeOH Blend; e: EtOH Blend
5: a: Diesel; b: Propane/Diesel; c: LNG; d: Propane; e: MeOH 90%; f: MeOH 100%; g: MeOH + Cetane
6. a: Diesel; b: Propane; c: MeOH 90%; d: MeOH + Cetane
7. a: Gasoline

Figure 5.1b Cost/Resource Consumption Factor: Freight Transport Mode



8 ■ Urban light truck (Class 1,2)

- a: Gasoline (R)
- b: Diesel (R)
- c: CNG (F)
- d: Propane (R)
- e: MeOH 90% (F)
- f: MeOH 100% (F)
- g: MeOH + Cetane (F)
- h: MeOH Blend (F)
- i: EtOH Blend (R)
- j: EtOH Blend (F)

9 ⊖ Interurban/urban truck (Class 3)

- a: Gasoline (R)
- b: Gasoline (F)
- c: Diesel (F)
- d: Propane (F)
- e: MeOH 100% (R)
- f: MeOH 100% (F)
- g: MeOH + Cetane (F)
- h: MeOH Blend (F)

10 ● Interurban truck (Class 8)

- a: Diesel (F)
- b: Diesel/Propane (F)
- c: MeOH 100% (F)
- d: MeOH + Cetane (F)

R = Retail fuelling
F = Fleet fuelling

vehicle-service (intramodal fuel comparison) and in identifying the lowest and highest fuel cost options at a particular location and time: taking the passenger transportation set of Figure 5.1a, for example, we can sort our limited set of fuels examined in each case into those which gave the highest or the lowest cost/passenger km in one type of vehicle and service in Ontario 4Q1983 as follows:

High-Low Passenger Service Cost

	Highest Cost Option Examined	Lowest Cost Option Examined
Commuter automobile	Propane	CNG
Standard automobile	LNG	CNG
Taxi	LNG	Propane
School bus	Gasohol	Propane
Urban bus	Cetane improved methanol	Propane/diesel dual fuel
Interurban bus (coach)	Cetane improved methanol	Diesel

The freight transport set gives the following highest and lowest cost fuel-engine options for 4Q1983 in Ontario:

High-Low Freight Transport Cost

	Highest Cost Option Examined	Lowest Cost Option Examined
Light urban truck	Cetane improved methanol	Propane
Class 3 truck, urban/interurban	Cetane improved methanol	Propane
Class 8 intercity truck	Cetane improved methanol	Propane/diesel dual fuel

Figures 5.1a and 5.1b also illustrate in some examples the effect on life-cycle cost of refuelling at a fleet-owned pump, compared to

retail purchase of fuel. Taxis and trucks frequently use both sources of fuel.

SECTION 6 - RESOURCE UTILIZATION

6.1 LIMITS TO RESOURCE UTILIZATION ANALYSIS

In examining the energy efficiency or resource utilization in a transport system, it is possible to trace energy use or energy losses right through the energy chain starting with the efficiency of recovery of the resource, tracing through the efficiencies of resource transportation, refining to fuels, the efficiency of the fuel transport, storage and dispensing system, until at the vehicle level one examines the vehicle efficiency (combustion efficiency, efficiency of the components such as drive-train, tires and even the energy content involved in the materials used to build the vehicle) and then the end-use efficiency (loading, routing, unproductive movements). While these factors are considered in the cost details of the life-cycle cost, many of them are small contributors to the total energy use. The key factors concerning energy or resource utilization are: the efficiency of producing the fuel from the resource at the refinery or chemical (fuel) plant (the plant conversion efficiency), the fuel consumption of the vehicle (GJ of fuel/kilometer) and the payload factor (passengers or tonnes carried). The equations involved are:

$$\text{Resource Utilization Efficiency (Passenger [or tonne]-kilometer/GJ)} = \frac{\text{Payload}}{\text{Vehicle Fuel Consumption}} \times \text{Refinery (or Plant) Conversion Efficiency}$$

and

$$\text{Resource Consumption Factor (GJ/Passenger [or tonne]-kilometer)} = \frac{1}{\text{Resource Utilization}} = \frac{\text{Vehicle Fuel Consumption}}{\text{Payload} \times \text{Refinery Conversion Efficiency}}$$

Table 6.1 summarizes the resource utilization factors calculated for each fuel/vehicle combination (further detail on each case is given in the cases of Appendix A).

Table 6.1 Summary of Life-Cycle Costs and Resource Utilization Efficiency Factors

REF #	VEHICLE TYPE	FUEL TYPE	FLEET OUTLET R=retail F=fleet	LIFE CYCLE COSTS (cents/ psngr.km)	RESOURCE UTILIZATION EFFICIENCY (Psngr.km/GJ)
1a	Commuter	Gasoline	R	26.7	537
1b	auto	CNG	R	25.9	583
1c	"	Propane	R	26.8	618
2a	Standard	Gasoline	R	11.6	381
2b	auto	Diesel	R	11.5	428
2c	"	LNG	R	12.8	363
2d	"	CNG	R	10.2	412
2e	"	Propane	R	10.9	412
2f	"	MeOH 90%	R	11.5	290
2g	"	MeOH blend	R	11.6	383
2h	"	EtOH blend	R	11.7	385
3a	Taxi	Gasoline	R	56.6	245
3b	"	Gasoline	F	55.8	245
3c	"	LNG	R	58.9	235
3d	"	LNG	F	57.3	240
3e	"	CNG (5)	R	55.6	258
3f	"	CNG (5)	F	55.7	258
3g	"	Propane	R	54.9	264
3h	"	Propane	F	54.7	264
3i	"	MeOH 90%	R	56.5	186
3j	"	MeOH 90%	F	56.7	186
3k	"	MeOH blend	R	56.7	246
3l	"	MeOH blend	F	55.8	246
3m	"	EtOH blend	R	56.9	247
3n	"	EtOH blend	F	56.0	247
4a	School	Gasoline	F	4.60	1247
4b	bus	CNG	F	4.29	1348
4c	"	Propane	F	4.44	1348
4d	"	MeOH blend	F	4.62	1254
4e	"	EtOH blend	F	4.64	1258
5a	Urban	Diesel	F	11.4	585
5b	bus	C3/diesel	F	11.2	619
5c	"	LNG	F	11.5	523
5d	"	Propane	F	11.5	551
5e	"	MeOH 90%	F	12.2	374
5f	"	MeOH 100%	F	11.6	413
5g	"	MeOH + Cet	F	13.5	408
6a	Inter-	Diesel	F	6.84	1019
6b	urban	Propane	F	6.88	958
6c	bus	MeOH 90%	F	7.25	681
6d	"	Meth + Cet	F	7.99	711
7a	Psngr Trk	Gasoline	R	9.30	394

Table 6.1 continued

REF #	VEHICLE TYPE	FUEL TYPE	FLEET OUTLET R=retail F=fleet	LIFE CYCLE COSTS (cents/ psngr.km)	RESOURCE UTILIZATION EFFICIENCY (Psngr.km/GJ)
8a	Urban	Gasoline	R	382	45.7
8b	truck	Diesel	R	376	62.7
8c	"	CNG	F	376	49.4
8d	"	Propane	R	375	50.4
8e	"	MeOH 90%	F	385	34.8
8f	"	MeOH 100%	F	388	35.7
8g	"	MeOH + Cet	F	406	35.7
8h	"	MeOH blend	F	382	46.0
8i	"	EtOH blend	R	381	46.1
8j	"	EtOH blend	F	383	46.1
9a	Inter-	Gasoline	R	258	56.0
9b	urban	Gasoline	F	257	56.0
9c	truck	Diesel	F	257	66.3
9d	class 3	Propane	F	253	61.7
9e	"	MeOH 100%	R	259	43.7
9f	"	MeOH 100%	F	262	43.7
9g	"	Meth + Cet	F	276	43.7
9h	"	MeOH blend	F	258	56.2
10a	Inter-	Diesel	F	4.50	915
10b	urban	C3/diesel	F	4.33	968
10c	truck	MeOH 100%	F	4.66	646
10d	class 8	Meth + Cet	F	5.88	638

Figures 5.1a and 5.1b were previously examined for life-cycle costs but the same figures illustrate the values and variations of the resource consumption factor for each fuel-vehicle combination examined.

6.2 COMPARISONS OF RESOURCE CONSUMPTION FACTOR

6.2.1 Intermodal Comparisons

The spread of resource consumption factors (GJ/1000 passenger km) between different transport service modes is wide, ranging in our examples from less than 1 GJ/1000 passenger km for a school bus or intercity bus to a relatively energy-wasteful (4-5 GJ/1000 passenger km) taxi. The bus cases clearly indicate the impact of multi-passenger vehicle capacity on energy consumption and the low payloads and energy-for-convenience trade-off involved in taxi service and operation of personal automobiles. In Case 7a of Figure 5.1a - the passenger van - efficiency is similar to that of the standard automobile: this vehicle is almost identical with the small urban gasoline-fuelled truck used for freight transport comparisons (Case 8a of Figure 5.1b and Appendix A).

The freight transport cases illustrated in Figure 5.1b show the large differences in resource consumption that exist between the 3 classes of truck investigated, irrespective of the fuel considered. The resource utilization efficiency part of the methodology can be used to obtain new correlations between these classes of vehicle. For example, in the diesel-engined truck series useful comparisons can be made of the empty vehicle weight, the maximum and average load on the one hand and fuel economy and resource utilization on the other.

Using data from both Figure 5.1b and from "Comparison of Reference Vehicle Classes" (Appendix B) we have the following series for comparison:

Diesel Trucks (1983 data)	Class 8 Truck	Class 3 Truck	Class 1 Truck
Average vehicle resource consumption, GJ/1000tonne km	1.1	15.1	16.0
Average diesel fuel economy, litres/100 km	52.0	24.75	10.4
Vehicle weight empty, tonnes	14.0	3.3	2.2
Maximum payload, tonnes	36.0	1.25	0.5
Average payload, tonnes	21.0	0.725	0.29
Vehicle, horsepower	350	205	130

It should be noted that the fuel economy in vehicles is changing rapidly and the data quoted represent the values reported for average fleets in 1983. New vehicles may have substantially better fuel economy but this does not greatly affect the interfuel and intermodal comparisons.

6.2.2 Interfuel Comparisons

Within each vehicle category the fuel type has a second order effect on resource consumption. For all vehicle classes surveyed, resource consumption followed the pattern listed below in order of decreasing consumptions:

MeOH - 90%
MeOH - Cetane
MeOH - 100%
LNG
Gasoline
MeOH blend
EtOH blend
CNG
Propane
Diesel
Propane-Diesel

The resource utilization efficiency data developed using the methodology can be used to select the high or low resource efficiency candidates among the fuels chosen within each vehicle and service class. In the passenger transportation set the fuels with the highest and lowest resource utilization identified in the present examples are:

	Resource Utilization Efficiency	
	Highest Efficiency Fuel	Lowest Efficiency Fuel
Commuter automobile	Propane	Gasoline
Standard automobile	Diesel	Methanol 90% Gasoline 10%
Taxi	Propane	Methanol 90% Gasoline 10%
School bus	Propane	Methanol 90% Gasoline 10%
Urban bus	Propane/Diesel dual fuel	LNG
Interurban bus (coach)	Diesel	Methanol 90% Gasoline 10%

The freight transportation set similarly provides the following high and low resource efficiency examples for comparison:

	Resource Utilization Efficiency	
	Highest Efficiency Fuel	Lowest Efficiency Fuel
Light urban truck	Diesel	Methanol 90% Gasoline 10%
Class 3 truck urban/interurban	Diesel	Methanol
Class 8 intercity truck	Diesel	Methanol with cetane improver

The methanol resource efficiency is low compared to other systems, due to the low efficiency of conversion of natural gas to methanol - 61% process efficiency is typical for modern methanol plants.

Clearly the lowest life-cycle cost examples are not always the most resource-efficient. The coincidence of lowest cost and lowest resource utilization occurs in the present set of examples only with the taxi-propane, school bus-propane and urban bus-propane diesel dual fuel combinations.

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SUMMARY OF APPENDICES

APPENDIX A - LIFE-CYCLE COST (LCC) WORKSHEETS

ALTERNATIVE FUELS LIFE CYCLE COSTS MATRIX

																$$	$$													
CASE #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
REF #	1a	1b	1c	2a	2b	2c	2d	2e	2f	2g	2h	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k	3l	3m	3n	4a	4b	4c	4d	4e
COMMUTER AUTO	x	x	x																											
AUTO				x	x	x	x	x	x	x	x																			
TAXI												x	x	x	x	x	x	x	x	x	x	x	x	x	x					
BUS SCHOOL																										x	x	x	x	x
GASOLINE	x			x								x	x													x				
DIESEL					x																									
LNG						x								x	x															
CNG		x					x									x	x										x			
PROPANE			x					x										x	x									x		
MEOH 90%									x											x	x									
MEOH BLEND										x												x	x						x	
ETOH BLEND											x													x	x					x
SI ENGINE	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CI ENGINE					x																									
RETAIL PUMP	x	x	x	x	x	x	x	x	x	x	x	x		x		x		x		x		x		x						
FLEET PUMP													x		x		x		x		x		x		x	x	x	x	x	x

		##																														##		
CASE #	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
REF #	5a	5b	5c	5d	5e	5f	5g	6a	6b	6c	6d	7a	8a	8b	8c	8d	8e	8f	8g	8h	8i	8j	9a	9b	9c	9d	9e	9f	9g	9h	10a	10b	10c	10d
BUS URBAN	x	x	x	x	x	x	x																											
BUS INT/URBAN								x	x	x	x																							
TRUCK PSNGR												x																						
TRUCK URBAN													x	x	x	x	x	x	x	x	x	x												
TRUCK INT/URB-3																							x	x	x	x	x	x	x	x				
TRUCK INT/URB-8																															x	x	x	x
GASOLINE												x	x										x	x										
DIESEL	x							x						x											x						x			
DIESEL/C3		x																														x		
LNG			x																															
CNG															x																			
PROPANE				x					x							x										x								
MEOH 90%					x					x							x																	
MEOH 100%						x												x									x	x					x	
MEOH+CETANE							x				x								x										x					x
MEOH BLEND																				x										x				
ETOH BLEND																					x	x												
SI ENGINE			x	x	x				x	x		x	x		x	x	x			x	x	x	x	x		x				x				
CI ENGINE	x	x				x	x	x			x			x				x	x						x		x	x	x		x	x	x	x
RETAIL PUMP												x	x	x		x					x		x				x							
FLEET PUMP	x	x	x	x	x	x	x	x	x	x	x				x		x	x	x	x		x		x	x	x		x	x	x	x	x	x	x

NOTES: $$ signifies cases involving dual fuel operation (CNG 70%, Gasoline 30%) and two worksheets are used per case.
signifies cases involving dual fuel operation (Propane 80%, Diesel 20%) and two worksheets are used per case.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)			
MATRIX REF #:	1a	MATRIX CASE#:	1
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	AUTO (COMM)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 40% plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	8.4
Product cost (cents/l)	28.56

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	1.5	7.6
Total fuel tax (c/l & $/GJ)	12.26	3.6
Tot fuel cost (c/l & $/GJ)	47.43	13.95

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	4.7	.001598
Vehicle life (km & yrs)	92400	14
Payload (psngrs & Te)	1	0
Base cost ($) & tax ($)	8156	614
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		8770

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	537	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	626
Annual cost of financing ($/y)	187
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1548

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		147
Misc matls ($/1000km & $/y)	5.3	34
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.1	40
Total variable costs ($/y)		221

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 26.7 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 76-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging. sales and administration, etc. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)			
MATRIX REF #:	1b	MATRIX CASE#:	2
FUEL:	CNG	ENGINE TYPE:	SI
SERVICE:	AUTO (COMM)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.114
Fuel higher heating value (GJ/m3) (5) (7)	6.04

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location (2)	Toronto
Product rate (GJ/d)	(2)
Product name	CNG
Process efficiency (%)	92.8
Resource cost ($/GJ)	4.7
Resource cost (c/l) (7)	2.83

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	0
km from upstrm point	0	0	0
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	0
Total distr cost ($/GJ)	0	0	0
Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:(6)		
Fleet or retail		Retail
Throughput GJ/d & m3/d(7)	50	8.27
Avg inventory (days thrput)		negl
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.11
Incr inv costs ($/d)		60
Incr maint costs ($/d)		8
Incr labour costs ($/d)		0
Incr other costs ($/d)		6
Incr utility costs ($/d)		12
Statn costs ($/GJ & cents/l)	1.71	1.03

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	3.86	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	3.86	6.39

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	26.31	.001589124
Vehicle life (km & yrs)	92400	14
Payload (psngrs & Te)	1	0
Base cost ($) & tax ($)	8156	614
Conversion type & costs ($)	R	1400
Grants & tax concessions ($)	500	614
Total net investment ($)		9056

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	583	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	646
Annual cost of financing ($/y)	193
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1574

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		67
Misc matls ($/1000km & $/y)	5.3	34
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.1	40
Total variable costs ($/y)		141

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 25.9 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154 .
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure.

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CASE DEFINITION (1)			
MATRIX REF #:	1c	MATRIX CASE#:	3
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	AUTO (COMM)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3)(5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d) (6)	46308
Product name	Propane
Process efficiency (%)	98.9
Product cost (2) ($/GJ)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.57
Total distr cost ($/GJ)	.74	.45	.57
Total distr cost (cents/l)	1.89	1.15	1.45

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	6443	300
Throughput (GJ/d) (6)	164876	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	8000
Terminal costs $/GJ	.68	1.46
Terminal costs cents/l	1.74	3.73

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.07
Incr inv costs ($/d)		38
Incr maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		43
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.67	4.27

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	25.08	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	25.89	10.11

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	618	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	6.245	.0015980955
Vehicle life (km & yrs)	92400	14
Payload (psngrs & Te)	1	0
Base cost ($) & tax ($)	8156	614
Conversion type & cost ($)	F	1100
Grants & tax concessions ($)	0	614
Total net investment ($)		9256

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	661
Annual cost of financing ($/y)	198
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1594

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		106
Misc matls ($/1000km & $/y)	5.3	34
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.1	40
Total variable costs ($/y)		180

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 26.8 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 111-118 .

(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).

(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values

(6) Propane only (7) Gathering costs in Alberta are shown as road cost.

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	2a	MATRIX CASE#:	4	% ROI on 4Q83 plant replacement value	20
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL	Fuel density (Te/m3)	.718
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Crude	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	5.88	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate (GJ/d) (6)	78295	$/GJ shipped by pipe	.09	0	0
Product name	Gasoline(RL)	$/GJ shipped by rail	0	0	0
Process efficiency (%)	85.88	$/GJ shipped by road	0	0	.11
Product cost (2) ($/GJ)	8.4	Total distr cost ($/GJ)	.09	0	.11
Product cost (cents/l)	28.56	Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.25	4.25

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.31	3.17
Fed exc/Prov tax (cents/l)	1.5	7.6
Total fuel tax (c/l & $/GJ)	12.27	3.6
Tot fuel cost (c/l & $/GJ)	47.58	13.99
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	381	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	8.6	.002924
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		8150

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	815
Annual cost of financing ($/y)	244
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1794

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		748
Misc matls ($/1000km & $/y)	5.7	105
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		973

AVERAGE VEHTCLE LIFE CYCLE COST OF OPERATION = 11.6 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)

MATRIX REF #:	2b	MATRIX CASE#:	5
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	7.64
Product cost (cents/l)	29.16

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	7195	0
Terminal costs $/GJ	.48	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	395	10.34
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.09	4.16

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.82	3.22
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.82	3.35
Tot fuel cost (c/l & $/GJ)	48.64	12.73

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	428	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	6.82	.002603876
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	8555	645
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		9200

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	920
Annual cost of financing ($/y)	276
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1931

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		606
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.2	113
Total variable costs ($/y)		823

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.5 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-34, 76-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) Diesel only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)

MATRIX REF #:	2c	MATRIX CASE#:	6
FUEL:	LNG	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.425
Fuel higher heating value (GJ/m3)(5)	22.16

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location	Toronto
Product rate (GJ/d)	1000
Product name	LNG
Process efficiency (%)	84.3
Product cost (2) ($/GJ)	10.28
Product cost (cents/l)	22.78

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	Toronto
km from upstrm point	0	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.66
Total distr cost ($/GJ)	0	0	.66
Total distr cost (cents/l)	0	0	1.46

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	2.25
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.14
Increm inv costs ($/d)		76
Incr. maint costs ($/d)		4
Incr labour costs ($/d)		0
Incr other costs ($/d)		8
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.77	3.92

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	28.16	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	28.16	12.7

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	363	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.59	.003011544
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)	FX	3200
Grants & tax concessions ($)	0	570
Total net investment ($)		10780

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	1078
Annual cost of financing ($/y)	323
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	2136

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		699
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		923

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 12.8 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 127, 128, 130, 132-152..
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values

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CASE DEFINITION (1)

MATRIX REF #:	2d	MATRIX CASE#:	7
FUEL:	CNG	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.114
Fuel higher heating value (GJ/m3)(5)(7)	6.04

PLANT GATE COST:

Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location (2)	Toronto
Product rate (GJ/d)	(2)
Product name	CNG
Process efficiency (%)	92.8
Resource cost ($/GJ)	4.7
Resource cost (c/l)(7)	2.83

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	0
km from upstrm point	0	0	0
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	0
Total distr cost ($/GJ)	0	0	0
Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:

Fleet or retail		Retail
Throughput GJ/d & m3/d	50	8.27
Avg inventory (days thrput)		negl
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.11
Increm inv costs ($/d)		60
Incr. maint costs ($/d)		8
Incr labour costs ($/d)		0
Incr other costs ($/d)		6
Incr utility costs ($/d)		12
Statn costs ($/GJ & cents/l)	1.71	1.03

FUEL COST AT PUMP:

Pretax fuel/Fed sal tx (c/l)	3.86	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	3.86	6.39

OVERALL RESOURCE UTILIZATION :

Psngr.km/GJ & Te.km/GJ :	412	0

VEHICLE DATA:

Fuel usage (l/100km & GJ/km)	48.41	.002923964
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)	R	1800
Grants & tax concessions ($)	500	570
Total net investment ($)		8880

VEHICLE ANNUAL FIXED COSTS:

License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	888
Annual cost of financing ($/y)	266
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1889

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):

Total fuel costs ($/y)		341
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		565

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 10.2 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154 .
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure.

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CASE DEFINITION (1)			
MATRIX REF #:	2e	MATRIX CASE#:	8
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.57
Total distr cost ($/GJ)	.74	.45	.57
Total distr cost (cents/l)	1.89	1.15	1.45

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	6443	300
Throughput (GJ/d) (6)	164876	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	8000
Terminal costs $/GJ	.68	1.46
Terminal costs cents/l	1.74	3.73

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.07
Increm inv costs ($/d)		38
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		43
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.67	4.27

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	25.08	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	25.89	10.11

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	11.43	.002924937
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)	R	1400
Grants & tax concessions ($)	400	570
Total net investment ($)		8580

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	412	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	858
Annual cost of financing ($/y)	257
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1850

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		541
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		765

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 10.9 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 111-118 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta and breakout tank/term costs at U.S border are included in road costs as .36 and .08 $/GJ respectively.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	2f	MATRIX CASE#:	9
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

	PLANT GATE COST:		
Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	8.4	8
Prod cents/l	14.3	28.56	15.73

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	3.95	0	1.06

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	25	0
Throughput (GJ/d (7)	491	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investmt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.53	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	2.54
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.075
Increm inv costs ($/d)		41
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	.95	1.86

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	23.97	2.15
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.15	1.09
Tot fuel cost (c/l & $/GJ)	26.12	13.27

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	14.87	.002924929
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)	Rx	800
Grants & tax concessions ($)	0	570
Total net investment ($)		8380

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	290	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	838
Annual cost of financing ($/y)	251
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1824

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		710
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		934

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.5 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.
(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).

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CASE DEFINITION (1)			
MATRIX REF #:	2g	MATRIX CASE#:	10
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.724
Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:	
Primary resources	Crude/MeOH/BuOH
Resrce cost $/GJ (6)	5.88/10.31/12.62
Plant location	S.Ontario
Product rate GJ/d (8)	80185
Product name	Oxinol blend
Process effic.(%) (7)	86.3
Product cost ($/GJ)(2)	8.67
Product cost (cents/l)	28.6

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1098	0
Throughput (GJ/d) (8)	36223	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintenance cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.547	0
Terminal costs cents/l	1.8	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.79
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6		.51
New investment $(10)6		.01
Investment costs ($/d)		284
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.23	4.05

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.11	3.15
Fed exc/Prov tax (cents/l)	1.5	6.88
Total fuel tax (c/l & $/GJ)	11.53	3.49
Tot fuel cost (c/l & $/GJ)	46.64	14.13

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	383	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	8.863	.0029239037
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		8150

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	815
Annual cost of financing ($/y)	244
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1794

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		756
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		980

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.6 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #: 2h		MATRIX CASE#:	11
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	AUTO (STD)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	9.01
Product cost (cents/l)	29.65

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.77	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.81
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.51
New investment $(10)6		.01
Investment costs ($/d)		284
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.23	4.04

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	36.12	3.25
Fed exc/Prov tax (cents/l)	1.5	6.84
Total fuel tax (c/l & $/GJ)	11.59	3.52
Tot fuel cost (c/l & $/GJ)	47.71	14.49

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	385	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	8.88	.002922408
Vehicle life (km & yrs)	183000	10
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	7580	570
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		8150

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	735
Annual cost of investment ($/y)	815
Annual cost of financing ($/y)	244
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	1794

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		774
Misc matls ($/1000km & $/y)	5.7	104
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	6.6	120
Total variable costs ($/y)		998

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.7 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 76-90 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.
(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications. (9) Includes $260000 land cost.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	3a	MATRIX CASE#:	12	% ROI on 4Q83 plant replacement value	20
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TAXI	PUMP STATION:	RETAIL	Fuel density (Te/m3)	.718
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	8.4
Product cost (cents/l)	28.56

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.76	3.16
Tot fuel cost (c/l & $/GJ)	45.93	13.5
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	245	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.4	.004556
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7380
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38480

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56.6 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch , **admin., and vehicle ROI** (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)			
MATRIX REF #:	3b	MATRIX CASE#:	13
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	7.17
Product cost (cents/l)	24.37

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.85	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	4.41
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6	(7)	.125
New investment $(10)6		0
Investment costs ($/d)		68
Maintenance costs ($/d)		3
Labour costs ($/d)		130
Other costs ($/d)		7
Utility costr ($/d)		2
Statn costs ($/GJ & cents/l)	1.39	4.72

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	30.61	2.75
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.35	3.04
Tot fuel cost (c/l & $/GJ)	40.96	12.04

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.4	.004556
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	245	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6582
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		37682

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 55.8 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, **admin., and vehicle** ROI (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Land cost is omitted here but included with garage costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3c	MATRIX CASE#:	14
FUEL:	LNG	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.425
Fuel higher heating value (GJ/m3)(5)	22.16

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location	Toronto
Product rate (GJ/d)	1000
Product name	LNG
Process efficiency (%)	84.3
Product cost (2) (GJ/d)	10.28
Product cost (cents/l)	22.78

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	Toronto
km from upstrm point	0	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.66
Total distr cost ($/GJ)	0	0	.66
Total distr cost (cents/l)	0	0	1.46

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	2.25
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.14
Increm inv costs ($/d)		76
Incr. maint costs ($/d)		4
Incr labour costs ($/d)		0
Incr other costs ($/d)		8
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.77	3.92

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	28.16	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	28.16	12.7

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	235	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	20.97	.004646952
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	3500
Grants & tax concessions ($)	0	770
Total net investment ($)		13730

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6865
Annual cost of financing ($/y)	2059
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	20799

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7081
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38181

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 64 %

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 58.9 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 127, 128, 130, 132-152.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3d	MATRIX CASE#:	15
FUEL:	LNG	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.425
Fuel higher heating value (GJ/m3)(5)	22.16

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location	Toronto
Product rate (GJ/d)	1000
Product name	LNG
Process efficiency (%)	84.3
Product cost (2) (GJ/d)	8.44
Product cost (cents/l)	18.7

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	Toronto
km from upstrm point	0	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.66
Total distr cost ($/GJ)	0	0	.66
Total distr cost (cents/l)	0	0	1.46

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	6.76
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(6)	.11
New investment $(10)6		.29
Increm inv costs ($/d)		219
Incr. maint costs ($/d)		11
Incr labour costs ($/d)		130
Incr other costs ($/d)		22
Incr utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	2.55	5.65

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	25.81	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	25.81	11.64
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	240	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	20.56	.004556096
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	3500
Grants & tax concessions ($)	0	770
Total net investment ($)		13730

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6865
Annual cost of financing ($/y)	2059
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	20799

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6363
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		37463

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 57.3 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 127, 128, 130, 132-152.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch , **admin., and vehicle ROI** (5) All GJ units are higher heating values
(6) Land cost is omitted but included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	3e/1	MATRIX CASE#:	16	% ROI on 4Q83 plant replacement value	20
FUEL:	CNG (8)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TAXI	PUMP STATION:	RETAIL	Fuel density (Te/m3)	.114
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)(7)	6.04

PLANT GATE COST:		TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat. Gas	Facility location	0	0	0
Resource cost ($/GJ)	4.7	km from upstrm point	0	0	0
Plant location (2)	Toronto	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	(2)	$/GJ shipped by pipe	0	0	0
Product name	CNG	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	0	0	0
Resource cost ($/GJ)	4.7	Total distr cost ($/GJ)	0	0	0
Resource cost (c/l)(7)	2.83	Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS (CNG):		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	8.27
Avg inventory (days thrput)		negl
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.11
Increm inv costs ($/d)		60
Incr. maint costs ($/d)		8
Incr labour costs ($/d)		0
Incr other costs ($/d)		6
Incr utility costs ($/d)		12
Statn costs ($/GJ & cents/l)	1.71	1.03

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	3.86	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	3.86	6.39
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	264	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	75.43	.004555972
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	2000
Grants & tax concessions ($)	0	770
Total net investment ($)		12230

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6115
Annual cost of financing ($/y)	1834
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19824

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3493
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		34593

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 64 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 54.4 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154.
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, **admin., and vehicle ROI** (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure. (8) Dual CNG(70%)/Gasoline(30%) fuel. This sheet reflects CNG mode of operation (see page ref# 3e/2 for gasoline mode).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3e/2	MATRIX CASE#:	16
FUEL:	CNG (7)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	8.4
Product cost (cents/l)	28.56

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS (GASOLINE):		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.76	3.16
Tot fuel cost (c/l & $/GJ)	45.93	13.5

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.4	.004556
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	2000
Grants & tax concessions ($)	0	770
Total net investment ($)		12230

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	245	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6115
Annual cost of financing ($/y)	1834
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19824

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7380
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38480

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 64 %

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 58.3 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154.

(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).

(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values

(6) Regular leaded gasoline only. (7) Dual CNG(70%)/Gasoline(30%) fuel. This sheet reflects gasoline mode operation.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3f/1	MATRIX CASE#:	17
FUEL:	CNG (8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.114
Fuel higher heating value (GJ/m3)(5)(7)	6.04

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location (2)	Toronto
Product rate (GJ/d)	(2)
Product name	CNG
Process efficiency (%)	92.8
Resource cost ($/GJ)	4.7
Resource cost (c/l)(7)	2.83

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	0
km from upstrm point	0	0	0
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	0
Total distr cost ($/GJ)	0	0	0
Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS (CNG):		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	24.83
Avg inventory (days thrput)		negl
Construction status (3)		C
Orig invest base stn $(10)6	(9)	.11
New investment $(10)6		.25
Increm inv costs ($/d)		197
Incr. maint costs ($/d)		25
Incr labour costs ($/d)		130
Incr other costs ($/d)		20
Incr utility costs ($/d)		36
Statn costs ($/GJ & cents/l)	2.71	1.63

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	4.46	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	4.46	7.38

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	264	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	75.43	.004555972
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	2000
Grants & tax concessions ($)	0	770
Total net investment ($)		12230

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6115
Annual cost of financing ($/y)	1834
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19824

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		4034
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		35134

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 64 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 54.9 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154.
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure. (8) Dual CNG(70%)/Gasoline(30%) fuel. Sheet reflects CNG mode of operation (see also page ref 3f/2). (9) Land is included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3f/2	MATRIX CASE#:	17
FUEL:	CNG (8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	7.17
Product cost (cents/l)	24.37

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.85	0

REFUELLING STATION COSTS (GASOLINE):		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	4.41
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (7)		.11
New investment $(10)6		0
Investment costs ($/d)		60
Maintenance costs ($/d)		3
Labour costs ($/d)		130
Other costs ($/d)		6
Utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	1.33	4.52

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	30.41	2.73
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.33	3.03
Tot fuel cost (c/l & $/GJ)	40.74	11.98

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	245	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.4	.004556
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	R	2000
Grants & tax concessions ($)	0	770
Total net investment ($)		12230

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	6115
Annual cost of financing ($/y)	1834
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19824

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6549
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		37649

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 64 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 57.4 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 129-131, 133, 135-141, 143-154.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Land cost is omitted here but included with garage costs (see note 4).
(8) Dual CNG(70%)/Gasoline(30%) fuel. This sheet reflects gasoline mode of operation (see also page ref# 3f/1).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	3g	MATRIX CASE#:	18
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:

Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.57
Total distr cost ($/GJ)	.74	.45	.57
Total distr cost (cents/l)	1.89	1.15	1.45

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	6443	300
Throughput (GJ/d) (6)	164876	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	8000
Terminal costs $/GJ	.68	1.46
Terminal costs cents/l	1.74	3.73

REFUELLING STATION COSTS:

Fleet or retail		Retail
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.07
Increm inv costs ($/d)		38
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		43
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.67	4.27

FUEL COST AT PUMP:

Pretax fuel/Fed sal tx (c/l)	25.08	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	25.89	10.11

OVERALL RESOURCE UTILIZATION :

Psngr.km/GJ & Te.km/GJ :	264	0

VEHICLE DATA:

Fuel usage (l/100km & GJ/km)	17.8	.00455502
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	F	1400
Grants & tax concessions ($)	400	770
Total net investment ($)		11230

VEHICLE ANNUAL FIXED COSTS:

License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5615
Annual cost of financing ($/y)	1684
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19174

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):

Total fuel costs ($/y)		5526
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		36626

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 54.9 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 111-118.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost
in road costs as .36 and .08 $/GJ respectively.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)			
MATRIX REF #:	3h	MATRIX CASE#:	19
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.38
Total distr cost ($/GJ)	.74	.45	.38
Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	6443	300
Throughput (GJ/d) (6)	164876	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.68	.94
Terminal costs cents/l	1.74	2.4

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	5.86
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(8)	.11
New investment $(10)6		.16
Increm inv costs ($/d)		147
Incr. maint costs ($/d)		7
Incr labour costs ($/d)		130
Incr other costs ($/d)		15
Incr utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	2	5.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	24.11	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	24.92	9.73

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	264	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	17.8	.00455502
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type cost ($)	F	1400
Grants & tax concessions ($)	400	770
Total net investment ($)		11230

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5615
Annual cost of financing ($/y)	1684
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19174

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		5318
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		36418

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 54.7 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1-10, 12-34, 76-90, 111-118.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost
in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3i	MATRIX CASE#:	20
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

PLANT GATE COST:			
Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	8.4	8
Prod cents/l	14.3	28.56	15.73

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	4.28	0	1.06

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	25	0
Throughput (GJ/d (7)	491	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investmt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.53	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	2.54
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.075
Increm inv costs ($/d)		41
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	.95	1.86

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	23.97	2.15
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.15	1.09
Tot fuel cost (c/l & $/GJ)	26.12	13.27

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	186	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	23.16	.004555572
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	Rx	800
Grants & tax concessions ($)	0	770
Total net investment ($)		11030

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5515
Annual cost of financing ($/y)	1654
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19044

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7254
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38354

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56.5 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.
(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)

MATRIX REF #:	3j	MATRIX CASE#:	21
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

PLANT GATE COST:

Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	7.17	7.78
Prod cents/l	14.3	24.37	15.31

TOTAL DISTRIBUION COSTS:

	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	4.28	0	1.06

TERMINAL COSTS

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	25	0
Throughput (GJ/d (7)	491	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.53	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:

Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	7.62
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.11
New investment $(10)6		.066
Increm inv costs ($/d)		96
Incr. maint costs ($/d)		5
Incr labour costs ($/d)		130
Incr other costs ($/d)		10
Utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	1.61	3.16

FUEL COST AT PUMP:

Pretax fuel/Fed sal tx (c/l)	24.85	2.23
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.23	1.13
Tot fuel cost (c/l & $/GJ)	27.08	13.76

OVERALL RESOURCE UTILIZATION :

Psngr.km/GJ & Te.km/GJ :	186	0

VEHICLE DATA:

Fuel usage (l/100km & GJ/km)	23.16	.004555572
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)	Rx	800
Grants & tax concessions ($)	0	770
Total net investment ($)		11030

VEHICLE ANNUAL FIXED COSTS:

License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5515
Annual cost of financing ($/y)	1654
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19044

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):

Total fuel costs ($/y)		7522
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38622

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56.7 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.
(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).
(9) Land included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	3k	MATRIX CASE#:	22	% ROI on 4083 plant replacement value	20
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TAXI	PUMP STATION:	RETAIL	Fuel density (Te/m3) (8)	.724
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resources	Crude/MeOH/BuOH	Facility location	Toronto	0	Toronto
Resrce cost $/GJ (6)	5.88/10.31/12.62	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate GJ/d (8)	80185	$/GJ shipped by pipe	0	0	0
Product name	Oxinol blend	$/GJ shipped by rail	0	0	0
Process effic.(%) (7)	86.3	$/GJ shipped by road	.093	0	.11
Product cost ($/GJ)(2)	8.67	Total distr cost ($/GJ)	.093	0	.11
Product cost (cents/l)	28.6	Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1098	0
Throughput (GJ/d) (8)	36223	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintenance cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.547	0
Terminal costs cents/l	1.8	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.79
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6		.51
New investment $(10)6		.01
Investment costs ($/d)		284
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.23	4.05

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.11	3.15
Fed exc/Prov tax (cents/l)	0	6.88
Total fuel tax (c/l & $/GJ)	10.03	3.04
Tot fuel cost (c/l & $/GJ)	45.14	13.68
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	246	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.81	.004555919
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & costs ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7478
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38578

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56.7 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch , admin., and vehicle ROI (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

CASE DEFINITION (1)

MATRIX REF #:	31	MATRIX CASE#:	23
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.724
Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:	
Primary resources	Crude/MeOH/BuOH
Resrce cost $/GJ (6)	5.88/10.31/12.62
Plant location	S.Ontario
Product rate GJ/d (8)	80185
Product name (8)	Oxinol blend
Process effic.(%) (7)	86.3
Product cost ($/GJ)(2)	7.42
Product cost (cents/l)	24.47

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1098	0
Throughput (GJ/d) (8)	36223	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintenance cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.252	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	4.54
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.11
New investment $(10)6		.006
Investment costs ($/d)		63
Maintenance costs ($/d)		3
Labour costs ($/d)		130
Other costs ($/d)		6
Utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	1.35	4.45

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	30.41	2.73
Fed exc/Prov tax (cents/l)	0	6.88
Total fuel tax (c/l & $/GJ)	9.61	2.91
Tot fuel cost (c/l & $/GJ)	40.02	12.13
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	246	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.81	.004555919
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6631
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		37731

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 55.8 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 37-47, 49-59, 61-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	3m	MATRIX CASE#:	24
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	9.01
Product cost (cents/l)	29.65

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.77	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.81
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6		.51
New investment $(10)6		.01
Investment costs ($/d)		284
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.23	4.04

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	36.12	3.25
Fed exc/Prov tax (cents/l)	0	6.84
Total fuel tax (c/l & $/GJ)	10.09	3.06
Tot fuel cost (c/l & $/GJ)	46.21	14.04

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.84	.004554744
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	247	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		7673
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		38773

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56.9 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 38, 41, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 76-90.

(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).

(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values

(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.

(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications.

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CASE DEFINITION (1)

MATRIX REF #:	3n	MATRIX CASE#:	25
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	TAXI	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	7.73
Product cost (cents/l)	25.43

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.82	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	150	4.55
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.11
New investment $(10)6		.006
Investment costs ($/d)		63
Maintenance costs ($/d)		3
Labour costs ($/d)		130
Other costs ($/d)		6
Utility costs ($/d)		2
Statn costs ($/GJ & cents/l)	1.35	4.44

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	31.35	2.82
Fed exc/Prov tax (cents/l)	0	6.84
Total fuel tax (c/l & $/GJ)	9.66	2.93
Tot fuel cost (c/l & $/GJ)	41.01	12.46

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	247	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	13.84	.004554744
Vehicle life (km & yrs)	240000	2
Payload (psngrs & Te)	1.3	0
Base cost ($) & tax ($)	10230	770
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		11000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	3375
Annual cost of investment ($/y)	5500
Annual cost of financing ($/y)	1650
Other fixed costs ($/y) (4)	8500
Total fixed costs ($/y)	19025

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6810
Misc matls ($/1000km & $/y)	26	3120
Driver costs incl ovhd ($/y)		24500
Maint cost ($/1000km & $/y)	29	3480
Total variable costs ($/y)		37910

AVERAGE VEHICLE IN-REVENUE-SERVICE FACTOR = 65 %
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 56 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1-10, 12-34, 38, 41, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 76-90.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch, admin., and vehicle ROI (5) All GJ units are higher heating values
(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.
(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included in garaging costs (see note 4).

CASE DEFINITION (1)

MATRIX REF #:	4a	MATRIX CASE#:	26
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	SCHL BUS	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:		TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Crude	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	5.88	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate (GJ/d) (6)	78295	$/GJ shipped by pipe	.09	0	0
Product name	Gasoline(RL)	$/GJ shipped by rail	0	0	0
Process efficiency (%)	85.88	$/GJ shipped by road	0	0	.11
Product cost (2) ($/GJ)	7.17	Total distr cost ($/GJ)	.09	0	.11
Product cost (cents/l)	24.37	Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.85	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6	(7)	.06
New investment $(10)6		0
Investment costs ($/d)		32
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		3
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.15	7.31

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	33.2	2.98
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.58	3.11
Tot fuel cost (c/l & $/GJ)	43.78	12.87
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	1247	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	50.6	.017204
Vehicle life (km & yrs)	192000	10
Payload (psngrs & Te)	25	0
Base cost ($) & tax ($)	31155	2345
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		33500

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	730
Annual cost of investment ($/y)	3350
Annual cost of financing ($/y)	1005
Other fixed costs ($/y) (4)	4665
Total fixed costs ($/y)	9750

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		4251
Misc matls ($/1000km & $/y)	34	652
Driver costs incl ovhd ($/y)		4990
Maint cost ($/1000km & $/y)	129	2476
Total variable costs ($/y)		12369

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.6 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-10, 12-17, 19-36, 91, 94, 96, 98, 99.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration, etc. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Land cost is omitted here but included with garage costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	4b	MATRIX CASE#:	27	% ROI on 4083 plant replacement value	20
FUEL:	CNG (8)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	SCHL BUS	PUMP STATION:	FLEET	Fuel density (Te/m3)	.114
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)(7)	6.04

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat. Gas	Facility location	0	0	0
Resource cost ($/GJ)	4.7	km from upstrm point	0	0	0
Plant location (2)	Toronto	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	(2)	$/GJ shipped by pipe	0	0	0
Product name	CNG	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	0	0	0
Resource cost ($/GJ)	4.7	Total distr cost ($/GJ)	0	0	0
Resource cost (c/l)(7)	2.83	Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	8.27
Avg inventory (days thrput)		negl
Construction status (3)		C
Orig invest base stn $(10)6	(9)	.06
New investment $(10)6		.11
Increm inv costs ($/d)		93
Incr. maint costs ($/d)		12
Incr labour costs ($/d)		70
Incr other costs ($/d)		9
Incr utility costs ($/d)		12
Statn costs ($/GJ & cents/l)	3.91	2.36

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	5.19	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	5.19	8.59
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	1348	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	284.8	.01720192
Vehicle life (km & yrs)	192000	10
Payload (psngrs & Te)	25	0
Base cost ($) & tax ($)	31155	2345
Conversion type & cost ($)	R	2250
Grants & tax concessions ($)	500	2345
Total net investment ($)		32905

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	730
Annual cost of investment ($/y)	3290
Annual cost of financing ($/y)	987
Other fixed costs ($/y) (4)	4665
Total fixed costs ($/y)	9672

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		2837
Misc matls ($/1000km & $/y)	34	652
Driver costs incl ovhd ($/y)		4990
Maint cost ($/1000km & $/y)	129	2476
Total variable costs ($/y)		10955

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.29 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-10, 12-17, 19-36, 91, 94, 96, 98, 99, 129-131, 133, 135-141, 143-154.
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging and administration. (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure. (8) Monofuel
(9) Land is included in garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	4c	MATRIX CASE#:	28	% ROI on 4Q83 plant replacement value	20
FUEL:	PROPANE	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	SCHL BUS	PUMP STATION:	FLEET	Fuel density (Te/m3)	.508
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Raw nat gas	Facility location	Sarnia (7)	Toronto	Toronto
Resource cost ($/GJ)	2	km from upstrm point	3095	245	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)(6)	46308	$/GJ shipped by pipe	.3	0	0
Product name	Propane	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	.44	.45	.38
Product cost ($/GJ)(2)	4.24	Total distr cost ($/GJ)	.74	.45	.38
Product cost (cents/l)	10.85	Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	7269	300
Throughput (GJ/d) (6)	186013	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.61	.94
Terminal costs cents/l	1.56	2.4

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(8)	.06
New investment $(10)6		.07
Increm inv costs ($/d)		71
Incr. maint costs ($/d)		4
Incr labour costs ($/d)		70
Incr other costs ($/d)		7
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	3.05	7.8

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	26.62	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	27.43	10.71
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	1348	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	67.23	.017204157
Vehicle life (km & yrs)	192000	10
Payload (psngrs & Te)	25	0
Base cost ($) & tax ($)	31155	2345
Conversion type & cost ($)	F	2200
Grants & tax concessions ($)	400	2345
Total net investment ($)		32955

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	730
Annual cost of investment ($/y)	3295
Annual cost of financing ($/y)	988
Other fixed costs ($/y) (4)	4665
Total fixed costs ($/y)	9678

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3537
Misc matls ($/1000km & $/y)	34	652
Driver costs incl ovhd ($/y)		4990
Maint cost ($/1000km & $/y)	129	2476
Total variable costs ($/y)		11655

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.44 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-10, 12-17, 19-47, 49-59, 61-75, 91, 94, 96, 98, 99, 111-118.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging and administration. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26/84

CASE DEFINITION (1)

MATRIX REF #:	4d	MATRIX CASE#:	29
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	SCHL BUS	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.724
Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:

Primary resources	Crude/MeOH/BuOH
Resrce cost $/GJ (6)	5.88/10.31/12.62
Plant location	S.Ontario
Product rate GJ/d (8)	80185
Product name (8)	Oxinol blend
Process effic.(%) (7)	86.3
Product cost ($/GJ)(2)	7.42
Product cost (cents/l)	24.47

TOTAL DISTRIBUTION COSTS:

	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS

	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1098	0
Throughput (GJ/d) (8)	36223	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintenance cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.252	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:

Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.51
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.06
New investment $(10)6		.005
Investment costs ($/d)		35
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.23	7.35

FUEL COST AT PUMP:

Pretax fuel/Fed sal tx (c/l)	33.31	2.99
Fed exc/Prov tax (cents/l)	0	6.88
Total fuel tax (c/l & $/GJ)	9.87	2.99
Tot fuel cost (c/l & $/GJ)	43.18	13.08

OVERALL RESOURCE UTILIZATION :

Psngr.km/GJ & Te.km/GJ :	1254	0

VEHICLE DATA:

Fuel usage (l/100km & GJ/km)	52.15	.017204285
Vehicle life (km & yrs)	192000	10
Payload (psngrs & Te)	25	0
Base cost ($) & tax ($)	31155	2345
Vehicle retrofit cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		33500

VEHICLE ANNUAL FIXED COSTS:

License & Insurance cost ($/y)	730
Annual cost of investment ($/y)	3350
Annual cost of financing ($/y)	1005
Other fixed costs ($/y) (4)	4665
Total fixed costs ($/y)	9750

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):

Total fuel costs ($/y)		4320
Misc matls ($/1000km & $/y)	34	652
Driver costs incl ovhd ($/y)		4990
Maint cost ($/1000km & $/y)	129	2476
Total variable costs ($/y)		12438

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.62 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-10, 12-17, 19-47, 49-59, 61-90, 91, 94, 96, 98, 99.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26/84

CASE DEFINITION (1)			
MATRIX REF #:	4e	MATRIX CASE#:	30
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	SCHL BUS	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	7.73
Product cost (cents/l)	25.43

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.82	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.51
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.06
New investment $(10)6		.005
Investment costs ($/d)		35
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.23	7.33

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	34.24	3.08
Fed exc/Prov tax (cents/l)	0	6.84
Total fuel tax (c/l & $/GJ)	9.92	3.01
Tot fuel cost (c/l & $/GJ)	44.16	13.41

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	1258	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	52.28	.017205348
Vehicle life (km & yrs)	192000	10
Payload (psngrs & Te)	25	0
Base cost ($) & tax ($)	31155	2345
Conversion type & costs ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		33500

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	730
Annual cost of investment ($/y)	3350
Annual cost of financing ($/y)	1005
Other fixed costs ($/y) (4)	4665
Total fixed costs ($/y)	9750

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		4429
Misc matls ($/1000km & $/y)	34	652
Driver costs incl ovhd ($/y)		4990
Maint cost ($/1000km & $/y)	129	2476
Total variable costs ($/y)		12547

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.64 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-10, 12-17, 19-36, 38, 41, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 91, 94, 96, 98, 99.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values
(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.
(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)			
MATRIX REF #:	5a	MATRIX CASE#:	31
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	86.51
Product cost (2) ($/GJ)	6.79
Product cost (cents/l)	25.92

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.22	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	18.33
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		0
Investment costs ($/d)		202
Maintenance costs ($/d)		10
Labour costs ($/d)		130
Other costs ($/d)		20
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.52	1.98

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	29.4	2.64
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.24	3.2
Tot fuel cost (c/l & $/GJ)	41.64	10.9
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	585	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	54.17	.020682106
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		165000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	9166
Annual cost of financing ($/y)	2749
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27795

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		13526
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	244	14640
Total variable costs ($/y)		68421

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.4 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 91-97, 99-109 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging and administration. (5) All GJ units are higher heating values
(6) Diesel only. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)

MATRIX REF #:	5b/1	MATRIX CASE#:	32
FUEL:	C3/DIESEL(9)	ENGINE TYPE:	CI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (6)	.508
Fuel higher heating value (GJ/m3) (5) (6)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.38
Total distr cost ($/GJ)	.74	.45	.38
Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	7269	300
Throughput (GJ/d) (6)	186013	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.61	.94
Terminal costs cents/l	1.56	2.4

REFUELLING STATION COSTS (PROPANE):		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	560	21.88
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6 (8)		0
New investment $(10)6		.41
Increm inv costs ($/d)		224
Incr. maint costs ($/d)		11
Incr labour costs ($/d)		130
Incr other costs ($/d)		22
Incr utility costs ($/d)		6
Statn costs ($/GJ & cents/l)	.7	1.79

PROPANE COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	20.61	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	21.42	8.37
DIESEL COST (c/l & $/GJ)	46.38	12.14
DUAL FUEL COST (c/l & $/GJ)	24.99	9.12
PSNGR.KM/GJ & Te.KM/GJ	619	0

VEHICLE DATA: (dual fuel basis)		
Fuel usage (l/100km & GJ/km)	75.48	.02068152
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type cost ($)	Rx	3900
Grants & tax concessions ($)	400	11550
Total net investment ($)		156950

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	8719
Annual cost of financing ($/y)	2615
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27214

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		11316
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	254	15240
Total variable costs ($/y)		66811

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.19 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-17, 91-97, 99-109.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost
in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).
(9) Dual Propane(80%)/Diesel(20%) fuel. This sheet incorporates diesel pump cost from sheet Ref# 5b/2.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

Mar 26 / 1984

CASE DEFINITION (1)			
MATRIX REF #:	5b/2	MATRIX CASE#:	32
FUEL:	C3/DIESEL(8)	ENGINE TYPE:	CI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	86.51
Product cost (2) ($/GJ)	6.79
Product cost (cents/l)	25.92

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.22	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS (DIESEL):		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	140	3.66
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		0
Investment costs ($/d)		202
Maintenance costs ($/d)		10
Labour costs ($/d)		0
Other costs ($/d)		20
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.66	6.33

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	33.75	3.03
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.63	3.3
Tot fuel cost (c/l & $/GJ)	46.38	12.14

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	0	0
Vehicle life (km & yrs)	0	0
Payload (psngrs & Te)	0	0
Base cost ($) & tax ($)	0	0
Conversion type & cost ($)	0	0
Grants & tax concessions ($)	0	0
Total net investment ($)	0	0

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	0
Annual cost of investment ($/y)	0
Annual cost of financing ($/y)	0
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	0

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		0
Misc matls ($/1000km & $/y)	0	0
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	0	0
Total variable costs ($/y)		0

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 91-97, 99-109.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging and administration. (5) All GJ units are higher heating values
(6) Diesel only. (7) Land is included with garaging costs (see note 4). This refuelling outlet was originally built to dispense 700 GJ/d diesel fuel.
(8) Dual Propane(80%)/Diesel(20%) fuel. This sheet is used to obtain diesel pump price to be used on sheets ref# 5b/1 & 10b.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

CASE DEFINITION (1)

MATRIX REF #:	5c	MATRIX CASE#:	33
FUEL:	LNG	ENGINE TYPE:	SI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.425
Fuel higher heating value (GJ/m3)(5)	22.16

PLANT GATE COST:	
Primary resource	Nat. Gas
Resource cost ($/GJ)	4.7
Plant location	Toronto
Product rate (GJ/d)	1000
Product name	LNG
Process efficiency (%)	84.3
Product cost (2) (GJ/d)	8.44
Product cost (cents/l)	18.7

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	0	0	Toronto
km from upstrm point	0	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	0
Total distr cost ($/GJ)	0	0	0
Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	1000	45.12
Avg inventory (days thrput) (7)		0
Construction status (3)		C
Orig invest base stn $(10)6 (6)		.37
New investment $(10)6		.1
Increm inv costs ($/d)		257
Incr. maint costs ($/d)		13
Incr labour costs ($/d)		130
Incr other costs ($/d)		26
Incr utility costs ($/d)		10
Statn costs ($/GJ & cents/l)	.43	.95

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	19.65	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	19.65	8.86

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	523	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	101.7	.02253672
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)	R	9800
Grants & tax concessions ($)	500	11550
Total net investment ($)		162750

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	9041
Annual cost of financing ($/y)	2712
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27633

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		11980
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	285	17100
Total variable costs ($/y)		69335

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.54 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-17, 19-36, 91, 92, 94-97, 99-102, 127, 128, 130, 132-152.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values
(6) Land cost is omitted but included in garaging costs (see note 4). (7) LNG plant is adjacent to garage/refuelling stn.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	5d	MATRIX CASE#:	34
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.38
Total distr cost ($/GJ)	.74	.45	.38
Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	7269	300
Throughput (GJ/d) (6)	186013	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.61	.94
Terminal costs cents/l	1.56	2.4

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	27.35
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(8)	.37
New investment $(10)6		.475
Increm inv costs ($/d)		463
Incr. maint costs ($/d)		23
Incr labour costs ($/d)		130
Incr other costs ($/d)		46
Incr utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.95	2.43

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	21.25	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	22.06	8.62

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	551	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	92.14	.023578626
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)	Fx	2900
Grants & tax concessions ($)	400	11550
Total net investment ($)		155950

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	8663
Annual cost of financing ($/y)	2598
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27141

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		12194
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	285	17100
Total variable costs ($/y)		69549

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.5 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-17, 19-36, 91, 92, 94-97, 99-109, 111-118.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta and breakout tank/term costs at U.S border are included in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	5e	MATRIX CASE#:	35
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

PLANT GATE COST:			
Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	7.17	7.78
Prod cents/l	14.3	24.37	15.31

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	4.28	0	1.06

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4917	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investmt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.28	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	35.58
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6 (9)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.41

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	22.61	2.03
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.03	1.03
Tot fuel cost (c/l & $/GJ)	24.64	12.52

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	374	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	124.1	.02441047
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)	Fx	1900
Grants & tax concessions ($)	0	11550
Total net investment ($)		155350

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	8630
Annual cost of financing ($/y)	2589
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27099

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		18337
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	285	17100
Total variable costs ($/y)		75692

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 12.23 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-47, 49-59, 61-75, 91, 92, 94-97, 99-102.

(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).

(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values

(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.

(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).

(9) Land included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	5f	MATRIX CASE#:	36
FUEL:	MEOH(100%)	ENGINE TYPE:	CI
SERVICE:	BUS(URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.796
Fuel higher heating value (GJ/m3)	18.08

PLANT GATE COST:	
Primary resource	Nat Gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)	45414
Product name	Methanol
Process Efficiency (%)	61.1
Product cost ($/GJ)(2)	7.909
Product cost (cents/l)	14.3

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	2.4	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.4	0	.54
Total distr cost (cents/l)	4.33	0	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	250	0
Throughput (GJ/d) (6)	4520	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.31	0
Terminal costs cents/l	.56	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	38.71
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.3

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	21.46	1.93
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	1.93	1.06
Tot fuel cost (c/l & $/GJ)	23.39	12.93

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	413	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	114.4	.02068352
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)	R	1800
Grants & tax concessions ($)	0	11550
Total net investment ($)		155250

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	8625
Annual cost of financing ($/y)	2587
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27092

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		16046
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	244	14640
Total variable costs ($/y)		70941

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 11.6 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-47, 49-59, 61-75, 91, 92, 94-97, 99-102.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with fleet garaging, sales and administration, etc. (5) All GJ units are higher heating values
(6) 100% methanol. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	5g	MATRIX CASE#:	37
FUEL:	MEOH+CET(8)	ENGINE TYPE:	CI
SERVICE:	BUS (URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.804
Fuel higher heating value (GJ/m3)(8)(5)	18.52

PLANT GATE COST:

Prim resrce	Nat gas		-
Resrce $/GJ	2		-
Location	Edmonton	Toronto	-
Prod GJ/d	45414		-
Prod name	Methanol	DII-3	Blend(8)
Proc Eff %	61.1	60	61
Prod $/GJ (2)	7.909	160	18.93
Prod cents/l	14.3	429	35.05

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail (6)	2.29	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.29	0	.54
Total distr cost (cents/l)	4.24	0	1

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4630	0
Avg inventory (days thrput)	26	0
Construction status (3)	C	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.3	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	37.79
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.33

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	42.17	3.79
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	3.79	2.04
Tot fuel cost (c/l & $/GJ)	45.96	24.81

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	408	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	112.8	.02089056
Vehicle life (km & yrs)	1080000	18
Payload (psngrs & Te)	14	0
Base cost ($) & tax ($)	153450	11550
Conversion type & cost ($)	R	900
Grants & tax concessions ($)	0	11550
Total net investment ($)		154350

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2480
Annual cost of investment ($/y)	8575
Annual cost of financing ($/y)	2572
Other fixed costs ($/y) (4)	13400
Total fixed costs ($/y)	27027

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		31097
Misc matls ($/1000km & $/y)	60	3600
Driver costs incl ovhd ($/y)		36655
Maint cost ($/1000km & $/y)	244	14640
Total variable costs ($/y)		85992

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 13.45 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-47, 49-59, 61-75, 91, 92, 94-97, 99-102.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, dispatch & admin., etc. (5) All GJ units are higher heating values
(6) 95% of methanol rail tariff from Edmonton. Plant gate cost of DII-3 includes 13cents/l truck cost fr. S. Carolina.
(8) Blend of 95v% methanol and 5v% DII-3 cetane enhancer (blended in conventional fuels terminal)
(9) Land included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	6a	MATRIX CASE#:	38
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	BUS(INT/URB)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	86.51
Product cost (2) ($/GJ)	6.79
Product cost (cents/l)	25.92

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.22	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	18.33
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		0
Investment costs ($/d)		202
Maintenance costs ($/d)		10
Labour costs ($/d)		130
Other costs ($/d)		20
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.52	1.98

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	29.4	2.64
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.24	3.2
Tot fuel cost (c/l & $/GJ)	41.64	10.9

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	1019	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	41.58	.015875244
Vehicle life (km & yrs)	1770000	11
Payload (psngrs & Te)	18.7	0
Base cost ($) & tax ($)	188325	14175
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		202500

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2735
Annual cost of investment ($/y)	18409
Annual cost of financing ($/y)	5522
Other fixed costs ($/y) (4)	65000
Total fixed costs ($/y)	91666

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		27843
Misc matls ($/1000km & $/y)	19	3057
Driver costs incl ovhd ($/y)		50830
Maint cost ($/1000km & $/y)	202	32503
Total variable costs ($/y)		114233

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 6.84 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-36, 91, 92, 94-97, 99-102.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Diesel only. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	6b	MATRIX CASE#:	39
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	BUS(INT/URB)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.38
Total distr cost ($/GJ)	.74	.45	.38
Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	7269	300
Throughput (GJ/d) (6)	186013	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.61	.94
Terminal costs cents/l	1.56	2.4

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	27.35
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(8)	.37
New investment $(10)6		.475
Increm inv costs ($/d)		463
Incr. maint costs ($/d)		23
Incr labour costs ($/d)		130
Incr other costs ($/d)		46
Incr utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.95	2.43

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	21.25	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	22.06	8.62

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	70.72	.018097248
Vehicle life (km & yrs)	1770000	11
Payload (psngrs & Te)	18.7	0
Base cost ($) & tax ($)	188325	14175
Conversion type & cost ($)	Fx	3200
Grants & tax concessions ($)	400	14175
Total net investment ($)		191125

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	958	0

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2735
Annual cost of investment ($/y)	17375
Annual cost of financing ($/y)	5212
Other fixed costs ($/y) (4)	65000
Total fixed costs ($/y)	90322

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		25101
Misc matls ($/1000km & $/y)	19	3057
Driver costs incl ovhd ($/y)		50830
Maint cost ($/1000km & $/y)	236	37974
Total variable costs ($/y)		116962

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 6.88 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. sources: 1, 3-17, 19-36, 91, 92, 94-97, 99-102, 111-118.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost
in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).

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CASE DEFINITION (1)

MATRIX REF #:	6c	MATRIX CASE#:	40
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	BUS(INT/URB)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

	PLANT GATE COST:		
Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	7.17	7.78
Prod cents/l	14.3	24.37	15.31

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	4.28	0	1.06

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4917	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.28	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	35.58
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6 (9)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.41

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	22.61	2.03
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.03	1.03
Tot fuel cost (c/l & $/GJ)	24.64	12.52

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	681	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	91.2	.01793904
Vehicle life (km & yrs)	1770000	11
Payload (psngrs & Te)	18.7	0
Base cost ($) & tax ($)	188325	14175
Conversion type & cost ($)	Fx	2190
Grants & tax concessions ($)	0	14175
Total net investment ($)		190515

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2735
Annual cost of investment ($/y)	17319
Annual cost of financing ($/y)	5195
Other fixed costs ($/y) (4)	65000
Total fixed costs ($/y)	90249

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		36139
Misc matls ($/1000km & $/y)	19	3057
Driver costs incl ovhd ($/y)		50830
Maint cost ($/1000km & $/y)	236	37974
Total variable costs ($/y)		128000

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 7.25 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-47, 49-59, 61-75, 91, 92, 94-97, 99-102.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.
(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).
(9) Land included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	6d	MATRIX CASE#:	41	% ROI on 4083 plant replacement value	20
FUEL:	MEOH+CET(8)	ENGINE TYPE:	CI	% int. on 80% vehicle investment	15
SERVICE:	BUS(INT/URB)	PUMP STATION:	FLEET	Fuel density (Te/m3) (8)	.804
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(8)(5)	18.52

PLANT GATE COST:				TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Prim resrce	Nat gas		-	Facility location	Toronto	0	Toronto
Resrce $/GJ	2		-	km from upstrm point	2850	0	20
Location	Edmonton	Toronto	-	$/GJ shipped by barge	0	0	0
Prod GJ/d	45414		-	$/GJ shipped by pipe	0	0	0
Prod name	Methanol	DII-3	Blend(8)	$/GJ shipped by rail (6)	2.29	0	0
Proc Eff %	61.1	60	61	$/GJ shipped by road	0	0	.54
Prod $/GJ (2)	7.909	160	18.93	Total distr cost ($/GJ)	2.29	0	.54
Prod cents/l	14.3	429	35.05	Total distr cost (cents/l)	4.24	0	1

TERMINAL COSTS	PRIMARY	SECONDARY	REFUELLING STATION COSTS:		
Throughput (m3/d) (7)	250	0			
Throughput (GJ/d (7)	4630	0	Fleet or retail		Fleet
Avg inventory (days thrput)	26	0	Throughput GJ/d & m3/d	700	37.79
Construction status (3)	C	0	Avg inventory (days thrput)		4
Incr investnt $(10)6	2	0	Construction status (3)		C
Incr invst cost $/d	1095	0	Orig invest base stn $(10)6 (9)		.37
Incr util cost $/d	14	0	New investment $(10)6		.222
Incr maint cost $/d	14	0	Increm inv costs ($/d)		324
Incr labor cost $/d	220	0	Incr. maint costs ($/d)		16
Incr other costs $/d	60	0	Incr labour costs ($/d)		130
Incr mktg costs $/d	0	0	Incr other costs ($/d)		32
Terminal costs $/GJ	.3	0	Utility costs ($/d)		7
Terminal costs cents/l	.55	0	Statn costs ($/GJ & cents/l)	.72	1.33

FUEL COST AT PUMP:			VEHICLE DATA:		
Pretax fuel/Fed sal tx (c/l)	42.17	3.79	Fuel usage (l/100km & GJ/km)	86.58	.016034616
Fed exc/Prov tax (cents/l)	0	0	Vehicle life (km & yrs)	1770000	11
Total fuel tax (c/l & $/GJ)	3.79	2.04	Payload (psngrs & Te)	18.7	0
Tot fuel cost (c/l & $/GJ)	45.96	24.81	Base cost ($) & tax ($)	188325	14175
			Conversion type & cost ($)	R	900
OVERALL RESOURCE UTILIZATION :			Grants & tax concessions ($)	0	14175
Psngr.km/GJ & Te.km/GJ :	711	0	Total net investment ($)		189225

VEHICLE ANNUAL FIXED COSTS:		VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
License & Insurance cost ($/y)	2735	Total fuel costs ($/y)		64012
Annual cost of investment ($/y)	17202	Misc matls ($/1000km & $/y)	19	3057
Annual cost of financing ($/y)	5160	Driver costs incl ovhd ($/y)		50830
Other fixed costs ($/y) (4)	65000	Maint cost ($/1000km & $/y)	202	32503
Total fixed costs ($/y)	90097	Total variable costs ($/y)		150402

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 7.99 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 1, 3-17, 19-47, 49-59, 61-75, 91-97, 99-102 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) 95% of methanol rail tariff from Edmonton. Plant gate cost of DII-3 includes 13cents/l truck cost fr. S. Carolina.
(8) Blend of 95v% methanol and 5v% DII-3 cetane enhancer (blended in conventional fuels terminal)
(9) Land included with garaging costs (see note 4).

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CASE DEFINITION (1)			
MATRIX REF #:	7a	MATRIX CASE#:	42
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	TRUCK(PSNGR)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	8.4
Product cost (cents/l)	28.56

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	1.5	7.6
Total fuel tax (c/l & $/GJ)	12.26	3.6
Tot fuel cost (c/l & $/GJ)	47.43	13.95

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	394	0

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	16	.00544
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	2.5	0
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		10000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	760
Annual cost of investment ($/y)	1250
Annual cost of financing ($/y)	375
Other fixed costs ($/y) (4)	0
Total fixed costs ($/y)	2385

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1468
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		0
Maint cost ($/1000km & $/y)	25	483
Total variable costs ($/y)		2119

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 9.3 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/Te.km

(1) Ref. source: 3-35, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging and administration. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)			
MATRIX REF #:	8a	MATRIX CASE#:	43
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	8.4
Product cost (cents/l)	28.56

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	1.5	7.6
Total fuel tax (c/l & $/GJ)	12.26	3.6
Tot fuel cost (c/l & $/GJ)	47.43	13.95

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	45.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	16	.00544
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		10000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1250
Annual cost of financing ($/y)	375
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6920

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1468
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14506

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 381.8 cents/Te.km

(1) Ref. source: 3-35, 155-173 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)

MATRIX REF #:	8b	MATRIX CASE#:	44
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	7.64
Product cost (cents/l)	29.16

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	7195	0
Terminal costs $/GJ	.48	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	395	10.34
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.09	4.16

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.82	3.22
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.82	3.35
Tot fuel cost (c/l & $/GJ)	48.64	12.73

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	62.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	10.4	.00397072
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	11160	840
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		12000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1500
Annual cost of financing ($/y)	450
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	7245

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		978
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	38	735
Total variable costs ($/y)		13881

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 376.4 cents/Te.km

(1) Ref. source: 3-35, 155-173 .
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Diesel only. (7) Includes $260000 land cost.

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	8c	MATRIX CASE#:	45	% ROI on 4083 plant replacement value	20
FUEL:	CNG	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET	Fuel density (Te/m3)	.114
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)(7)	6.04

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat. Gas	Facility location	0	0	0
Resource cost ($/GJ)	4.7	km from upstrm point	0	0	0
Plant location (2)	Toronto	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	(2)	$/GJ shipped by pipe	0	0	0
Product name	CNG	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	0	0	0
Resource cost ($/GJ)	4.7	Total distr cost ($/GJ)	0	0	0
Resource cost (c/l)(7)	2.83	Total distr cost (cents/l)	0	0	0

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d)	0	0
Throughput (GJ/d)	0	0
Storage capacity (days)	0	0
Construction status (3)	0	0
Investment $(10)6	0	0
Investment cost $/d	0	0
Utility cost $/d	0	0
Maintnce cost $/d	0	0
Labour cost $/d	0	0
Other costs $/d	0	0
Marketing costs $/d	0	0
Terminal costs $/GJ	0	0
Terminal costs cents/l	0	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	30	4.96
Avg inventory (days thrput)		negl
Construction status (3)		C
Orig invest base stn $(10)6	(9)	.04
New investment $(10)6		.09
Increm inv costs ($/d)		71
Incr. maint costs ($/d)		9
Incr labour costs ($/d)		70
Incr other costs ($/d)		7
Incr utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	5.46	3.29

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	6.12	0
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	0	0
Tot fuel cost (c/l & $/GJ)	6.12	10.13
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	49.4

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	90.07	.005440228
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)	R	1650
Grants & tax concessions ($)	500	700
Total net investment ($)		10450

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1306
Annual cost of financing ($/y)	391
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6992

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1066
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14104

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 375.9 cents/Te.km

(1) Ref. source: 3-35, 89, 129-131, 133, 135-141, 143-173 .
(2) Plant is located at retail outlet. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Excluding NG feed cost. (7) At 16.5 MPa fuel tank pressure. (8) Land is included in garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	8d	MATRIX CASE#:	46	% ROI on 4083 plant replacement value	20
FUEL:	PROPANE	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(URBAN)	PUMP STATION:	RETAIL	Fuel density (Te/m3)	.508
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Raw nat gas	Facility location	Sarnia (7)	Toronto	Toronto
Resource cost ($/GJ)	2	km from upstrm point	3095	245	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)(6)	46308	$/GJ shipped by pipe	.3	0	0
Product name	Propane	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	.44	.45	.57
Product cost ($/GJ)(2)	4.24	Total distr cost ($/GJ)	.74	.45	.57
Product cost (cents/l)	10.85	Total distr cost (cents/l)	1.89	1.15	1.45

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	6443	300
Throughput (GJ/d) (6)	164876	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	8000
Terminal costs $/GJ	.68	1.46
Terminal costs cents/l	1.74	3.73

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.07
Increm inv costs ($/d)		38
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		43
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	1.67	4.27

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	25.08	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	25.89	10.11
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	50.4

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	20.83	.005330397
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)	R or F	1400
Grants & tax concessions ($)	400	700
Total net investment ($)		10300

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1287
Annual cost of financing ($/y)	386
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6968

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1042
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14080

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 375 cents/Te.km

(1) Ref. source: 3-35, 111-118, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost
in road costs as .36 and .08 $/GJ respectively.

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CASE DEFINITION (1)			
MATRIX REF #:	8e	MATRIX CASE#:	47
FUEL:	MEOH(90%)(8)	ENGINE TYPE:	SI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.788
Fuel higher heating value (GJ/m3)(8)(5)	19.67

PLANT GATE COST:			
Prim resrce	Nat gas	Crude	-
Resrce $/GJ	2	5.88	-
Location	Edmonton	S. Ont.	-
Prod GJ/d	45414	83741	-
Prod name	Methanol	Gasoline(RL)	Blend(8)
Proc Eff %	61.1	85.88	65.38
Prod $/GJ (2)	7.909	7.17	7.78
Prod cents/l	14.3	24.37	15.31

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850 & 150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe (6)	.01	0	0
$/GJ shipped by rail (6)	2.17	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.18	0	.54
Total distr cost (cents/l)	4.28	0	1.06

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	25	0
Throughput (GJ/d (7)	491	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.53	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	30	1.52
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.04
New investment $(10)6		.024
Increm inv costs ($/d)		35
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		70
Incr other costs ($/d)		4
Utility costs ($/d)		.3
Statn costs ($/GJ & cents/l)	3.7	7.27

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	28.96	2.6
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.6	1.32
Tot fuel cost (c/l & $/GJ)	31.56	16.04
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	34.8

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	27.66	.005440722
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)	R	600
Grants & tax concessions ($)	0	700
Total net investment ($)		9900

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1237
Annual cost of financing ($/y)	371
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6903

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1688
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14726

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 385 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) 10% gasoline pipeline tariff (.31c/l) & 90% MeOH rail tariff (4.35c/l). (7) 90% MeOH blend w/gasoline.
(8) Cold start formulation of 90v% Methanol, 10v% gasoline (latter blended at conventional fuels terminal).
(9) Land included with garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	8f	MATRIX CASE#:	48	% ROI on 4083 plant replacement value	20
FUEL:	MEOH(100%)	ENGINE TYPE:	CI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET	Fuel density (Te/m3)	.796
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)	18.08

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat Gas	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	2	km from upstrm point	2850	0	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	45414	$/GJ shipped by pipe	0	0	0
Product name	Methanol	$/GJ shipped by rail	2.4	0	0
Process Efficiency (%)	61.1	$/GJ shipped by road	0	0	.54
Product cost ($/GJ)(2)	7.909	Total distr cost ($/GJ)	2.4	0	.54
Product cost (cents/l)	14.3	Total distr cost (cents/l)	4.33	0	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	25	0
Throughput (GJ/d) (6)	452	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.58	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	30	1.65
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (7)		.04
New investment $(10)6		.024
Increm inv costs ($/d)		35
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		70
Incr other costs ($/d)		4
Utility costs ($/d)		.3
Statn costs ($/GJ & cents/l)	3.7	6.68

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	27.32	2.45
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.45	1.35
Tot fuel cost (c/l & $/GJ)	29.77	16.46
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	35.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	27.38	.004950304
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	11160	840
Conversion type & cost ($)	F	1200
Grants & tax concessions ($)	0	840
Total net investment ($)		12360

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1545
Annual cost of financing ($/y)	463
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	7303

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1576
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	38	735
Total variable costs ($/y)		14479

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 388 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 100% methanol. (7) Land included with garaging costs (see note 4).

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CASE DEFINITION (1)			
MATRIX REF #:	8g	MATRIX CASE#:	49
FUEL:	MEOH+CET(8)	ENGINE TYPE:	CI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.804
Fuel higher heating value (GJ/m3)(8)(5)	18.52

	PLANT GATE COST:		
Prim resrce	Nat gas		-
Resrce $/GJ	2		-
Location	Edmonton	Toronto	-
Prod GJ/d	45414		-
Prod name	Methanol	DII-3	Blend(8)
Proc Eff %	61.1	60	61
Prod $/GJ (2)	7.909	160	18.93
Prod cents/l	14.3	429	35.05

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail (6)	2.29	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.29	0	.54
Total distr cost (cents/l)	4.24	0	1

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4630	0
Avg inventory (days thrput)	26	0
Construction status (3)	C	0
Incr investmt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.3	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	30	1.61
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.04
New investment $(10)6		.024
Increm inv costs ($/d)		35
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		70
Incr other costs ($/d)		4
Utility costs ($/d)		.3
Statn costs ($/GJ & cents/l)	3.7	6.85

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	47.69	4.29
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	4.29	2.31
Tot fuel cost (c/l & $/GJ)	51.98	28.06
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	35.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	26.73	.004950396
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	11160	840
Conversion type & cost ($)	F	560
Grants & tax concessions ($)	0	840
Total net investment ($)		11720

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1465
Annual cost of financing ($/y)	439
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	7199

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		2687
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	38	735
Total variable costs ($/y)		15590

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 406 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) 95% of methanol rail tariff from Edmonton. Plant gate cost of DII-3 includes 13cents/l truck cost fr. S. Carolina.
(8) Blend of 95v% methanol and 5v% DII-3 cetane enhancer (blended in conventional fuels terminal)
(9) Land included with garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	8h	MATRIX CASE#:	50	% ROI on 4083 plant replacement value	20
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET	Fuel density (Te/m3) (8)	.724
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resources	Crude/MeOH/BuOH	Facility location	Toronto	0	Toronto
Resrce cost $/GJ (6)	5.88/10.31/12.62	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate GJ/d (8)	80185	$/GJ shipped by pipe	0	0	0
Product name (8)	Oxinol blend	$/GJ shipped by rail	0	0	0
Process effic.(%) (7)	86.3	$/GJ shipped by road	.093	0	.11
Product cost ($/GJ)(2)	7.42	Total distr cost ($/GJ)	.093	0	.11
Product cost (cents/l)	24.47	Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY	REFUELLING STATION COSTS:		
Throughput (m3/d) (8)	1098	0	Fleet or retail		Fleet
Throughput (GJ/d) (8)	36223	0	Throughput GJ/d & m3/d	30	.9
Avg inventory (days thrput)	20	0	Avg inventory (days thrput)		7
Construction status (3)	C	0	Construction status (3)		C
Investment $(10)6	12.3	0	Orig invest base stn $(10)6 (9)		.04
Investment cost $/d	6739	0	New investment $(10)6		.004
Utility cost $/d	110	0	Investment costs ($/d)		24
Maintenance cost $/d	110	0	Maintenance costs ($/d)		1
Labour cost $/d	1706	0	Labour costs ($/d)		70
Other costs $/d	484	0	Other costs ($/d)		2
Marketing costs $/d	10672	0	Utility costs ($/d)		.3
Terminal costs $/GJ	.547	0	Statn costs ($/GJ & cents/l)	3.24	10.68
Terminal costs cents/l	1.8	0			

FUEL COST AT PUMP:			VEHICLE DATA:		
Pretax fuel/Fed sal tx (c/l)	37.61	3.38	Fuel usage (l/100km & GJ/km)	16.49	.005440051
Fed exc/Prov tax (cents/l)	0	6.88	Vehicle life (km & yrs)	154800	8
Total fuel tax (c/l & $/GJ)	10.26	3.11	Payload (psngrs & Te)	0	.29
Tot fuel cost (c/l & $/GJ)	47.87	14.51	Base cost ($) & tax ($)	9300	700
			Conversion type & cost ($)		0
OVERALL RESOURCE UTILIZATION :			Grants & tax concessions ($)	0	0
Psngr.km/GJ & Te.km/GJ :	0	46	Total net investment ($)		10000

VEHICLE ANNUAL FIXED COSTS:		VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
License & Insurance cost ($/y)	1295	Total fuel costs ($/y)		1527
Annual cost of investment ($/y)	1250	Misc matls ($/1000km & $/y)	8.7	168
Annual cost of financing ($/y)	375	Driver costs incl ovhd ($/y)		12000
Other fixed costs ($/y) (4)	4000	Maint cost ($/1000km & $/y)	45	870
Total fixed costs ($/y)	6920	Total variable costs ($/y)		14565

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 382 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included with garaging costs (see note 4).

CASE DEFINITION (1)

MATRIX REF #:	8i	MATRIX CASE#:	51
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	9.01
Product cost (cents/l)	29.65

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.77	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.81
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6		.51
New investment $(10)6		.01
Investment costs ($/d)		284
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.23	4.04

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	36.12	3.25
Fed exc/Prov tax (cents/l)	0	6.84
Total fuel tax (c/l & $/GJ)	10.09	3.06
Tot fuel cost (c/l & $/GJ)	46.21	14.04
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	46.1

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	16.53	.005440023
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		10000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1250
Annual cost of financing ($/y)	375
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6920

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1477
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14515

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 381 cents/Te.km

(1) Ref. source: 3-35, 38, 41, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values
(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.
(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications.

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CASE DEFINITION (1)

MATRIX REF #:	8j	MATRIX CASE#:	52
FUEL:	ETOH BLEND (8)	ENGINE TYPE:	SI
SERVICE:	TRUCK(URBAN)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.725
Fuel higher heating value (GJ/m3)(8)(5)	32.91

PLANT GATE COST:	
Primary resources	Crude/Ethanol
Resrce cost $/GJ (6)	5.88/20.32
Plant location	S.Ontario
Product rate GJ/d (8)	75844
Product name	Gasohol
Process effic.(%) (7)	86.63
Product cost ($/GJ)(2)	7.73
Product cost (cents/l)	25.43

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.093	0	.11
Total distr cost ($/GJ)	.093	0	.11
Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1103	0
Throughput (GJ/d) (8)	36299	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility costs $/d	110	0
Maintenance cost $/d	110	0
Labour costs $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.77	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	30	.91
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6	(9)	.04
New investment $(10)6		.004
Investment costs ($/d)		24
Maintenance costs ($/d)		1
Labour costs ($/d)		70
Other costs ($/d)		2
Utility costs ($/d)		.3
Statn costs ($/GJ & cents/l)	3.24	10.66

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	38.52	3.46
Fed exc/Prov tax (cents/l)	0	6.84
Total fuel tax (c/l & $/GJ)	10.3	3.12
Tot fuel cost (c/l & $/GJ)	48.82	14.83
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	46.1

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	16.53	.005440023
Vehicle life (km & yrs)	154800	8
Payload (psngrs & Te)	0	.29
Base cost ($) & tax ($)	9300	700
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		10000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	1295
Annual cost of investment ($/y)	1250
Annual cost of financing ($/y)	375
Other fixed costs ($/y) (4)	4000
Total fixed costs ($/y)	6920

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		1561
Misc matls ($/1000km & $/y)	8.7	168
Driver costs incl ovhd ($/y)		12000
Maint cost ($/1000km & $/y)	45	870
Total variable costs ($/y)		14599

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 383 cents/Te.km

(1) Ref. source: 3-35, 38, 41, 42, 44, 46-48, 51, 56, 57, 60-68, 70, 72, 73, 155-173.

(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).

(4) Associated with garaging, admin., and vehicle ROI. (5) All GJ units are higher heating values

(6) EtOH cost is Edmonton plant gate(18.49/GJ) + $1.83/GJ rail tariff to refinery. (7) 87%(refinery), 59%(EtOH prod'n) @ %GJ.

(8) 10v% ethanol & 90v% leaded gasoline blended at refinery to leaded regular specifications.

(9) Land is included in garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	9a	MATRIX CASE#:	53	% ROI on 4083 plant replacement value	20
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	RETAIL	Fuel density (Te/m3)	.718
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Crude	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	5.88	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate (GJ/d) (6)	78295	$/GJ shipped by pipe	.09	0	0
Product name	Gasoline(RL)	$/GJ shipped by rail	0	0	0
Process efficiency (%)	85.88	$/GJ shipped by road	0	0	.11
Product cost (2) ($/GJ)	8.4	Total distr cost ($/GJ)	.09	0	.11
Product cost (cents/l)	28.56	Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.54	0
Terminal costs cents/l	1.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	356	10.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.51
New investment $(10)6		0
Investment costs ($/d)		279
Maintenance costs ($/d)		7
Labour costs ($/d)		130
Other costs ($/d)		14
Utility costs ($/d)		4
Statn costs ($/GJ & cents/l)	1.21	4.11

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.17	3.16
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.76	3.16
Tot fuel cost (c/l & $/GJ)	45.93	13.5

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	56

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	32.7	.011118
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	13950	1050
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		15000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	2500
Annual cost of financing ($/y)	750
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	18880

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3362
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	149	3337
Total variable costs ($/y)		23083

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 258.3 cents/Te.km

(1) Ref. source: 3-35, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Includes $260000 land cost.

CASE DEFINITION (1)			
MATRIX REF #: 9b		MATRIX CASE#:	54
FUEL:	GASOLINE(RL)	ENGINE TYPE:	SI
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.718
Fuel higher heating value (GJ/m3)(5)	34

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	78295
Product name	Gasoline(RL)
Process efficiency (%)	85.88
Product cost (2) ($/GJ)	7.17
Product cost (cents/l)	24.37

TOTAL DISTRIBUTION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.09	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.11
Total distr cost ($/GJ)	.09	0	.11
Total distr cost (cents/l)	.3	0	.37

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	1068	0
Throughput (GJ/d) (6)	36312	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintnce cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.25	0
Terminal costs cents/l	.85	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.47
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6	(7)	.06
New investment $(10)6		0
Investment costs ($/d)		32
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		3
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.15	7.31

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	33.2	2.98
Fed exc/Prov tax (cents/l)	0	7.6
Total fuel tax (c/l & $/GJ)	10.58	3.11
Tot fuel cost (c/l & $/GJ)	43.78	12.87

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	56

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	32.7	.011118
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	13950	1050
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		15000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	2500
Annual cost of financing ($/y)	750
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	18880

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3205
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	149	3337
Total variable costs ($/y)		22926

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 256.7 cents/Te.km

(1) Ref. source: 3-35, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Regular leaded gasoline only. (7) Land cost is omitted here but included with garage costs (see note 4).

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CASE DEFINITION (1)

MATRIX REF #:	9c	MATRIX CASE#:	55
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	86.51
Product cost (2) ($/GJ)	6.79
Product cost (cents/l)	25.92

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.22	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.3
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.06
New investment $(10)6		0
Investment costs ($/d)		32
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		3
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.15	8.2

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	35.62	3.2
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.8	3.35
Tot fuel cost (c/l & $/GJ)	48.42	12.68
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	66.3

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	24.75	.00944955
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	17670	1330
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		19000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	3166
Annual cost of financing ($/y)	949
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	19745

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		2683
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	134	3001
Total variable costs ($/y)		22068

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 256.7 cents/Te.km

(1) Ref. source: 3-35, 103-109, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Diesel only. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)

MATRIX REF #:	9d	MATRIX CASE#:	56
FUEL:	PROPANE	ENGINE TYPE:	SI
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES

% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.508
Fuel higher heating value (GJ/m3) (5)	25.59

PLANT GATE COST:	
Primary resource	Raw nat gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)(6)	46308
Product name	Propane
Process efficiency (%)	92.8
Product cost ($/GJ)(2)	4.24
Product cost (cents/l)	10.85

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Sarnia (7)	Toronto	Toronto
km from upstrm point	3095	245	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.3	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	.44	.45	.38
Total distr cost ($/GJ)	.74	.45	.38
Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	7269	300
Throughput (GJ/d) (6)	186013	7677
Storage capacity (days)	20	10
Construction status (3)	SA	SA
Investment $(10)6	30	4
Investment cost $/d	16438	2191
Utility cost $/d	20700	100
Maintnce cost $/d	1644	219
Labour cost $/d	2730	500
Other costs $/d	1644	219
Marketing costs $/d	70600	4000
Terminal costs $/GJ	.61	.94
Terminal costs cents/l	1.56	2.4

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.95
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6	(8)	.06
New investment $(10)6		.07
Increm inv costs ($/d)		71
Incr. maint costs ($/d)		4
Incr labour costs ($/d)		70
Incr other costs ($/d)		7
Incr utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	3.05	7.8

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	26.62	.07
Fed exc/Prov tax (cents/l)	.74	0
Total fuel tax (c/l & $/GJ)	.81	.31
Tot fuel cost (c/l & $/GJ)	27.43	10.71

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	61.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	42.58	.010896222
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	13950	1050
Conversion type & cost ($)	F	1500
Grants & tax concessions ($)	400	1050
Total net investment ($)		15050

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	2510
Annual cost of financing ($/y)	753
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	18893

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		2614
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	149	3337
Total variable costs ($/y)		22335

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 253.2 cents/Te.km

(1) Ref. source: 3-35, 111-118, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road cost in road costs as .36 and .08 $/GJ respectively. (8) Land included in garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #: 9e		MATRIX CASE#:	57
FUEL:	MEOH(100%)	ENGINE TYPE:	CI
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	RETAIL
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4Q83 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.796
Fuel higher heating value (GJ/m3)	18.08

PLANT GATE COST:	
Primary resource	Nat Gas
Resource cost ($/GJ)	2
Plant location	Edmonton
Product rate (GJ/d)	45414
Product name	Methanol
Process Efficiency (%)	61.1
Product cost ($/GJ)(2)	7.909
Product cost (cents/l)	14.3

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail	2.4	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.4	0	.54
Total distr cost (cents/l)	4.33	0	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	25	0
Throughput (GJ/d) (6)	452	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investmt $(10)6	.2	0
Incr invst cost $/d	109	0
Incr util cost $/d	0	0
Incr maint cost $/d	5	0
Incr labor cost $/d	0	0
Incr other costs $/d	11	0
Incr mktg costs $/d	140	0
Terminal costs $/GJ	.58	0
Terminal costs cents/l	1.04	0

REFUELLING STATION COSTS:		
Fleet or retail		Retail
Throughput GJ/d & m3/d	50	2.76
Avg inventory (days thrput)		4
Construction status (3)		AO
Orig invest base stn $(10)6		0
New investment $(10)6		.08
Increm inv costs ($/d)		43
Incr. maint costs ($/d)		2
Incr labour costs ($/d)		0
Incr other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	.99	1.78

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	22.42	2.01
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	2.01	1.11
Tot fuel cost (c/l & $/GJ)	24.43	13.51
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	43.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	55.96	.010117568
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	17670	1330
Conversion type & cost ($)	F	1400
Grants & tax concessions ($)	0	1330
Total net investment ($)		19070

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	3178
Annual cost of financing ($/y)	953
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	19761

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3061
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	134	3001
Total variable costs ($/y)		22446

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 259.1 cents/Te.km

(1) Ref. source: 3-47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 100% methanol.

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	9f	MATRIX CASE#:	58	% ROI on 4083 plant replacement value	20
FUEL:	MEOH(100%)	ENGINE TYPE:	CI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET	Fuel density (Te/m3)	.796
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)	18.08

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat Gas	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	2	km from upstrm point	2850	0	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	45414	$/GJ shipped by pipe	0	0	0
Product name	Methanol	$/GJ shipped by rail	2.4	0	0
Process Efficiency (%)	61.1	$/GJ shipped by road	0	0	.54
Product cost ($/GJ)(2)	7.909	Total distr cost ($/GJ)	2.4	0	.54
Product cost (cents/l)	14.3	Total distr cost (cents/l)	4.33	0	.97

TERMINAL COSTS	PRIMARY	SECONDARY	REFUELLING STATION COSTS:		
Throughput (m3/d) (6)	25	0	Fleet or retail		Fleet
Throughput (GJ/d) (6)	452	0	Throughput GJ/d & m3/d	50	2.76
Avg inventory (days thrput)	26	0	Avg inventory (days thrput)		4
Construction status (3)	AO	0	Construction status (3)		C
Incr investnt $(10)6	.2	0	Orig invest base stn $(10)6 (7)		.06
Incr invst cost $/d	109	0	New investment $(10)6		.036
Incr util cost $/d	0	0	Increm inv costs ($/d)		52
Incr maint cost $/d	5	0	Incr. maint costs ($/d)		3
Incr labor cost $/d	0	0	Incr labour costs ($/d)		70
Incr other costs $/d	11	0	Incr other costs ($/d)		5
Incr mktg costs $/d	140	0	Utility costs ($/d)		1
Terminal costs $/GJ	.58	0			
Terminal costs cents/l	1.04	0	Statn costs ($/GJ & cents/l)	2.61	4.71

FUEL COST AT PUMP:			VEHICLE DATA:		
Pretax fuel/Fed sal tx (c/l)	25.35	2.28	Fuel usage (l/100km & GJ/km)	55.96	.010117568
Fed exc/Prov tax (cents/l)	0	0	Vehicle life (km & yrs)	134400	6
Total fuel tax (c/l & $/GJ)	2.28	1.26	Payload (psngrs & Te)	0	.725
Tot fuel cost (c/l & $/GJ)	27.63	15.28	Base cost ($) & tax ($)	17670	1330
			Conversion type & costs ($)	F	1400
OVERALL RESOURCE UTILIZATION :			Grants & tax concessions ($)	0	1330
Psngr.km/GJ & Te.km/GJ :	0	43.7	Total net investment ($)		19070

VEHICLE ANNUAL FIXED COSTS:		VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
License & Insurance cost ($/y)	2030	Total fuel costs ($/y)		3462
Annual cost of investment ($/y)	3178	Misc matls ($/1000km & $/y)	35	784
Annual cost of financing ($/y)	953	Driver costs incl ovhd ($/y)		15600
Other fixed costs ($/y) (4)	13600	Maint cost ($/1000km & $/y)	134	3001
Total fixed costs ($/y)	19761	Total variable costs ($/y)		22847

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 261.6 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 100% methanol. (7) Land is included with garaging costs (see note 4).

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CASE DEFINITION (1)			
MATRIX REF #:	9g	MATRIX CASE#:	59
FUEL:	MEOH+CET(8)	ENGINE TYPE:	CI
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.804
Fuel higher heating value (GJ/m3)(8)(5)	18.52

PLANT GATE COST:			
Prim resrce	Nat gas		-
Resrce $/GJ	2		-
Location	Edmonton	Toronto	-
Prod GJ/d	45414		-
Prod name	Methanol	DII-3	Blend(8)
Proc Eff %	61.1	60	61
Prod $/GJ (2)	7.909	160	18.93
Prod cents/l	14.3	429	35.05

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail (6)	2.29	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.29	0	.54
Total distr cost (cents/l)	4.24	0	1

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4630	0
Avg inventory (days thrput)	26	0
Construction status (3)	C	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.3	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	2.69
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.06
New investment $(10)6		.036
Increm inv costs ($/d)		52
Incr. maint costs ($/d)		3
Incr labour costs ($/d)		70
Incr other costs ($/d)		5
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.61	4.83

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	45.67	4.11
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	4.11	2.21
Tot fuel cost (c/l & $/GJ)	49.78	26.87
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	43.7

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	54.63	.010117476
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	17670	1330
Conversion type & cost ($)	F	800
Grants & tax concessions ($)	0	1330
Total net investment ($)		18470

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	3080
Annual cost of financing ($/y)	609
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	19319

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		6089
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	134	3001
Total variable costs ($/y)		25474

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 275.6 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 95% of methanol rail tariff from Edmonton. Plant gate cost of DII-3 includes 13cents/l truck cost fr. S. Carolina.
(8) Blend of 95v% methanol and 5v% DII-3 cetane enhancer (blended in conventional fuels terminal)
(9) Land included with garaging costs (see note 4).

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	9h	MATRIX CASE#:	60	% ROI on 4083 plant replacement value	20
FUEL:	MEOH BLEND (8)	ENGINE TYPE:	SI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(INT/URB/3)	PUMP STATION:	FLEET	Fuel density (Te/m3) (8)	.724
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(8)(5)	32.99

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resources	Crude/MeOH/BuOH	Facility location	Toronto	0	Toronto
Resrce cost $/GJ (6)	5.88/10.31/12.62	km from upstrm point	150	0	20
Plant location	S.Ontario	$/GJ shipped by barge	0	0	0
Product rate GJ/d (8)	80185	$/GJ shipped by pipe	0	0	0
Product name (8)	Oxinol blend	$/GJ shipped by rail	0	0	0
Process effic.(%) (7)	86.3	$/GJ shipped by road	.093	0	.11
Product cost ($/GJ)(2)	7.42	Total distr cost ($/GJ)	.093	0	.11
Product cost (cents/l)	24.47	Total distr cost (cents/l)	.3	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (8)	1098	0
Throughput (GJ/d) (8)	36223	0
Avg inventory (days thrput)	20	0
Construction status (3)	C	0
Investment $(10)6	12.3	0
Investment cost $/d	6739	0
Utility cost $/d	110	0
Maintenance cost $/d	110	0
Labour cost $/d	1706	0
Other costs $/d	484	0
Marketing costs $/d	10672	0
Terminal costs $/GJ	.547	0
Terminal costs cents/l	1.8	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	50	1.51
Avg inventory (days thrput)		7
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.06
New investment $(10)6		.005
Investment costs ($/d)		35
Maintenance costs ($/d)		2
Labour costs ($/d)		70
Other costs ($/d)		4
Utility costs ($/d)		1
Statn costs ($/GJ & cents/l)	2.23	7.35

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	34.28	3.08
Fed exc/Prov tax (cents/l)	0	6.88
Total fuel tax (c/l & $/GJ)	9.96	3.01
Tot fuel cost (c/l & $/GJ)	44.24	13.41
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	56.2

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	33.7	.01111763
Vehicle life (km & yrs)	134400	6
Payload (psngrs & Te)	0	.725
Base cost ($) & tax ($)	13950	1050
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		15000

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	2030
Annual cost of investment ($/y)	2500
Annual cost of financing ($/y)	750
Other fixed costs ($/y) (4)	13600
Total fixed costs ($/y)	18880

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		3339
Misc matls ($/1000km & $/y)	35	784
Driver costs incl ovhd ($/y)		15600
Maint cost ($/1000km & $/y)	149	3337
Total variable costs ($/y)		23060

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 257.5 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) MeOH cost is Edmonton plant gate($7.91/GJ) + $2.40/GJ rail tariff to refinery. (7) 87%(refinery), 61%(alc. prod'n) @ %GJ.
(8) 4.75v% methanol, 4.75v% t butanol & 90.5v% leaded gasoline blended at refinery to leaded regular specifications.
(9) Land is included with garaging costs (see note 4).

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CASE DEFINITION (1)			
MATRIX REF #:	10a	MATRIX CASE#:	61
FUEL:	DIESEL	ENGINE TYPE:	CI
SERVICE:	TRUCK(INT/URB/8)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3)	.829
Fuel higher heating value (GJ/m3)(5)	38.18

PLANT GATE COST:	
Primary resource	Crude
Resource cost ($/GJ)	5.88
Plant location	S.Ontario
Product rate (GJ/d) (6)	61074
Product name	Diesel
Process efficiency (%)	86.51
Product cost (2) ($/GJ)	6.79
Product cost (cents/l)	25.92

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	150	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	.083	0	0
$/GJ shipped by rail	0	0	0
$/GJ shipped by road	0	0	.095
Total distr cost ($/GJ)	.083	0	.095
Total distr cost (cents/l)	.31	0	.36

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	720	0
Throughput (GJ/d) (6)	27489	0
Storage capacity (days)	20	0
Construction status (3)	SA	0
Investment $(10)6	8.3	0
Investment cost $/d	4547	0
Utility cost $/d	74	0
Maintnce cost $/d	74	0
Labour cost $/d	1150	0
Other costs $/d	326	0
Marketing costs $/d	0	0
Terminal costs $/GJ	.22	0
Terminal costs cents/l	.83	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	18.33
Avg inventory (days thrput)		7
Construction status (3)		SA
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		0
Investment costs ($/d)		202
Maintenance costs ($/d)		10
Labour costs ($/d)		130
Other costs ($/d)		20
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.52	1.98

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	29.4	2.64
Fed exc/Prov tax (cents/l)	0	9.6
Total fuel tax (c/l & $/GJ)	12.24	3.2
Tot fuel cost (c/l & $/GJ)	41.64	10.9

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	915

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	52	.0198536
Vehicle life (km & yrs)	880000	5
Payload (psngrs & Te)	0	21
Base cost ($) & tax ($)	85095	6405
Conversion type & cost ($)		0
Grants & tax concessions ($)	0	0
Total net investment ($)		91500

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	7094
Annual cost of investment ($/y)	18300
Annual cost of financing ($/y)	5490
Other fixed costs ($/y) (4)	46000
Total fixed costs ($/y)	76884

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		38087
Misc matls ($/1000km & $/y)	32	5632
Driver costs incl ovhd ($/y)		35000
Maint cost ($/1000km & $/y)	62	10912
Total variable costs ($/y)		89631

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.5 cents/Te.km

(1) Ref. source: 3-35, 103-109, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Diesel only. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	10b	MATRIX CASE#:	62	% ROI on 4083 plant replacement value	20
FUEL:	C3/DIESEL(9)	ENGINE TYPE:	CI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(INT/URB/B)	PUMP STATION:	FLEET	Fuel density (Te/m3) (6)	.508
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)(5)(6)	25.59

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Raw nat gas	Facility location	Sarnia (7)	Toronto	Toronto
Resource cost ($/GJ)	2	km from upstrm point	3095	245	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)(6)	46308	$/GJ shipped by pipe	.3	0	0
Product name	Propane	$/GJ shipped by rail	0	0	0
Process efficiency (%)	92.8	$/GJ shipped by road	.44	.45	.38
Product cost ($/GJ)(2)	4.24	Total distr cost ($/GJ)	.74	.45	.38
Product cost (cents/l)	10.85	Total distr cost (cents/l)	1.89	1.15	.97

TERMINAL COSTS	PRIMARY	SECONDARY	REFUELLING STATION COSTS (Propane):		
Throughput (m3/d) (6)	7269	300	Fleet or retail		Fleet
Throughput (GJ/d) (6)	186013	7677	Throughput GJ/d & m3/d	560	21.88
Storage capacity (days)	20	10	Avg inventory (days thrput)		4
Construction status (3)	SA	SA	Construction status (3)		AO
Investment $(10)6	30	4	Orig invest base stn $(10)6	(8)	0
Investment cost $/d	16438	2191	New investment $(10)6		.41
Utility cost $/d	20700	100	Increm inv costs ($/d)		224
Maintnce cost $/d	1644	219	Incr. maint costs ($/d)		11
Labour cost $/d	2730	500	Incr labour costs ($/d)		130
Other costs $/d	1644	219	Incr other costs ($/d)		22
Marketing costs $/d	70600	4000	Incr utility costs ($/d)		6
Terminal costs $/GJ	.61	.94	Statn costs ($/GJ & cents/l)	.7	1.79
Terminal costs cents/l	1.56	2.4			

PROPANE COST AT PUMP:			VEHICLE DATA: (dual fuel basis)		
Pretax fuel/Fed sal tx (c/l)	20.61	.07	Fuel usage (l/100km & GJ/km)	72.46	.01985404
Fed exc/Prov tax (cents/l)	.74	0	Vehicle life (km & yrs)	880000	5
Total fuel tax (c/l & $/GJ)	.81	.31	Payload (psngrs & Te)	0	21
Tot fuel cost (c/l & $/GJ)	21.42	8.37	Base cost ($) & tax ($)	85095	6405
DIESEL COST (c/l & $/GJ)	46.38	12.14	Conversion type & cost ($)	R	4900
DUAL FUEL COST (c/l & $/GJ)	24.99	9.12	Grants & tax concessions ($)	0	6405
PSNGR.KM/GJ & Te.KM/GJ	0	968	Total net investment ($)		89995

VEHICLE ANNUAL FIXED COSTS:		VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
License & Insurance cost ($/y)	7094	Total fuel costs ($/y)		31868
Annual cost of investment ($/y)	17999	Misc matls ($/1000km & $/y)	32	5632
Annual cost of financing ($/y)	5399	Driver costs incl ovhd ($/y)		35000
Other fixed costs ($/y) (4)	46000	Maint cost ($/1000km & $/y)	64	11264
Total fixed costs ($/y)	76492	Total variable costs ($/y)		83764

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.33 cents/Te.km

(1) Ref. source: 3-35, 103-109, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) Propane only. (7) Gathering costs in Alberta are shown as road costs.
(8) Land included in garaging costs (see note 4).
(9) Dual Propane(80%)/Diesel(20%) fuel. This sheet incorporates diesel pump cost from sheet Ref# 5b/2.

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)				ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	10c	MATRIX CASE#:	63	% ROI on 4Q83 plant replacement value	20
FUEL:	MEOH(100%)	ENGINE TYPE:	CI	% int. on 80% vehicle investment	15
SERVICE:	TRUCK(INT/URB/8)	PUMP STATION:	FLEET	Fuel density (Te/m3)	.796
LOCATION:	TORONTO	TIME FRAME:	4Q 1983	Fuel higher heating value (GJ/m3)	18.08

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource	Nat Gas	Facility location	Toronto	0	Toronto
Resource cost ($/GJ)	2	km from upstrm point	2850	0	20
Plant location	Edmonton	$/GJ shipped by barge	0	0	0
Product rate (GJ/d)	45414	$/GJ shipped by pipe	0	0	0
Product name	Methanol	$/GJ shipped by rail	2.4	0	0
Process Efficiency (%)	61.1	$/GJ shipped by road	0	0	.54
Product cost ($/GJ)(2)	7.909	Total distr cost ($/GJ)	2.4	0	.54
Product cost (cents/l)	14.3	Total distr cost (cents/l)	4.33	0	.97

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (6)	250	0
Throughput (GJ/d) (6)	4520	0
Avg inventory (days thrput)	26	0
Construction status (3)	AO	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.31	0
Terminal costs cents/l	.56	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	38.71
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (7)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.3

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	21.46	1.93
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	1.93	1.06
Tot fuel cost (c/l & $/GJ)	23.39	12.93
OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	646.3

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	109.8	.01985184
Vehicle life (km & yrs)	880000	5
Payload (psngrs & Te)	0	21
Base cost ($) & tax ($)	85095	6405
Conversion type & cost ($)	Fx	2200
Grants & tax concessions ($)	0	6405
Total net investment ($)		87295

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	7094
Annual cost of investment ($/y)	17459
Annual cost of financing ($/y)	5237
Other fixed costs ($/y) (4)	46000
Total fixed costs ($/y)	75790

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		45176
Misc matls ($/1000km & $/y)	32	5632
Driver costs incl ovhd ($/y)		35000
Maint cost ($/1000km & $/y)	62	10912
Total variable costs ($/y)		96720

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 4.66 cents/Te.km

(1) Ref. source: 3-35, 103-109, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 100% methanol. (7) Land is included with garaging costs (see note 4).

ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

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CASE DEFINITION (1)			
MATRIX REF #:	10d	MATRIX CASE#:	64
FUEL:	MEOH+CET(8)	ENGINE TYPE:	CI
SERVICE:	TRUCK(INT/URB/8)	PUMP STATION:	FLEET
LOCATION:	TORONTO	TIME FRAME:	4Q 1983

ECONOMIC CRITERIA & FUEL PROPERTIES	
% ROI on 4083 plant replacement value	20
% int. on 80% vehicle investment	15
Fuel density (Te/m3) (8)	.804
Fuel higher heating value (GJ/m3)(8)(5)	18.52

	PLANT GATE COST:		
Prim resrce	Nat gas		-
Resrce $/GJ	2		-
Location	Edmonton	Toronto	-
Prod GJ/d	45414		-
Prod name	Methanol	DII-3	Blend(8)
Proc Eff %	61.1	60	61
Prod $/GJ (2)	7.909	160	18.93
Prod cents/l	14.3	429	35.05

TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Facility location	Toronto	0	Toronto
km from upstrm point	2850	0	20
$/GJ shipped by barge	0	0	0
$/GJ shipped by pipe	0	0	0
$/GJ shipped by rail (6)	2.29	0	0
$/GJ shipped by road	0	0	.54
Total distr cost ($/GJ)	2.29	0	.54
Total distr cost (cents/l)	4.24	0	1

TERMINAL COSTS	PRIMARY	SECONDARY
Throughput (m3/d) (7)	250	0
Throughput (GJ/d (7)	4630	0
Avg inventory (days thrput)	26	0
Construction status (3)	C	0
Incr investnt $(10)6	2	0
Incr invst cost $/d	1095	0
Incr util cost $/d	14	0
Incr maint cost $/d	14	0
Incr labor cost $/d	220	0
Incr other costs $/d	60	0
Incr mktg costs $/d	0	0
Terminal costs $/GJ	.3	0
Terminal costs cents/l	.55	0

REFUELLING STATION COSTS:		
Fleet or retail		Fleet
Throughput GJ/d & m3/d	700	37.79
Avg inventory (days thrput)		4
Construction status (3)		C
Orig invest base stn $(10)6 (9)		.37
New investment $(10)6		.222
Increm inv costs ($/d)		324
Incr. maint costs ($/d)		16
Incr labour costs ($/d)		130
Incr other costs ($/d)		32
Utility costs ($/d)		7
Statn costs ($/GJ & cents/l)	.72	1.33

FUEL COST AT PUMP:		
Pretax fuel/Fed sal tx (c/l)	42.17	3.79
Fed exc/Prov tax (cents/l)	0	0
Total fuel tax (c/l & $/GJ)	3.79	2.04
Tot fuel cost (c/l & $/GJ)	45.96	24.81

OVERALL RESOURCE UTILIZATION :		
Psngr.km/GJ & Te.km/GJ :	0	638

VEHICLE DATA:		
Fuel usage (l/100km & GJ/km)	108.3	.02005716
Vehicle life (km & yrs)	880000	5
Payload (psngrs & Te)	0	21
Base cost ($) & tax ($)	85095	6405
Conversion type & cost ($)	F	1400
Grants & tax concessions ($)	0	6405
Total net investment ($)		86495

VEHICLE ANNUAL FIXED COSTS:	
License & Insurance cost ($/y)	7094
Annual cost of investment ($/y)	17299
Annual cost of financing ($/y)	5189
Other fixed costs ($/y) (4)	46000
Total fixed costs ($/y)	75582

VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
Total fuel costs ($/y)		87580
Misc matls ($/1000km & $/y)	32	5632
Driver costs incl ovhd ($/y)		35000
Maint cost ($/1000km & $/y)	62	10912
Total variable costs ($/y)		139124

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 0 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = 5.8 cents/Te.km

(1) Ref. source: 3-35, 47, 49-59, 61-75, 155-173.
(2) See AFEM printout for details. (3) Converted (C), Add-on (AO) or Stand-alone (SA).
(4) Associated with garaging, administration and vehicle ROI. (5) All GJ units are higher heating values
(6) 95% of methanol rail tariff from Edmonton. Plant gate cost of DII-3 includes 13cents/l truck cost fr. S. Carolina.
(8) Blend of 95v% methanol and 5v% DII-3 cetane enhancer (blended in conventional fuels terminal)
(9) Land included with garaging costs (see note 4).

APPENDIX B - NOTES ON LCC WORKSHEETS

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COMPARISON OF REFERENCE VEHICLE CLASSES

	AUTO COMMUTER	AUTO STANDARD	TAXI	SCHOOL BUS	URBAN BUS	INTER-URBAN BUS	LIGHT PASSENGER TRUCK	LIGHT FREIGHT TRUCK	MEDIUM FREIGHT TRUCK	HEAVY FREIGHT TRUCK
EXAMPLE USED	Honda CRX	Ford Fairmont Futura	Pontiac Parisienne	Interntl Harvestr	GM 6V71	Prevost Marathon +GM6V92TA	Dodge Pickup D150RAM	Ford F150	Interntl Harvestr Loadmstr	Ford + Cummins Engine
DESCRIPTION	5 Speed Manual	4 Speed Manual	4 Speed Auto	4 Speed Auto	2 Stroke nat asp.	2 Stroke turbochg	Class 1 2 whl dr	Class 1 2 whl dr	Class 3 2 axle	Class 8 4 stroke 3 axle
SERVICE	Urban	Urban 55% Hiway 45%	Urban	Urban	Urban	Highway	Urban Commuter	Urban	Urban + Highway	Highway
REFERENCE FUEL	Leaded Gasoline	Leaded Gasoline	Leaded Gasoline	Leaded Gasoline	#1Diesel	#2Diesel	Leaded Gasoline	Leaded Gasoline	Leaded Gasoline	#2Diesel
ENGINE CAPACITY(1) / POWER(BHP)	4 cyl 1.3/56	4 cyl 2.3/100	6 cyl 2.8/135	V8 6.4/185	7/180	9/335	8 cyl 5.8/130	8 cyl 6.4/150	8 cyl 8.8/205	6 cyl 14/350
VEHICLE WEIGHT EMPTY (Te)	0.9	1.33	1.66	1.2	11.2	14.1	2.15	2.2	3.3	14.0
VEHICLE MAX PAY-LOAD (# Psngr or Te)	2P	4P	6P	66P	51P	43P	6P	0.5 Te	1.25 Te	36 Te
AVERAGE PAYLOAD (# Psngrs or Te)	1P	1.3P	1+1.3P	25P(1)	14P	18.7P	2.5P	.29 Te	.725 Te	21 Te

NOTES:
(1) Reflects average occupancy in service; higher value for total number of passengers reaching destination per trip.

COMPARISON OF BASE CASE FUEL CONSUMPTIONS BY VEHICLE TYPE (1)

(Difference between alternative fuel consumption and reference fuel as % ref fuel

GASOLINE REFERENCE		GJ/km(2)	Diesel	Propane/ Diesel	LNG	CNG	Propane	Methanol 90%	Methanol 100%	Methanol + Cetane	Methanol Blend	Ethanol Blend
AUTO	Base Case	.0016				0	0					
(com)	1990 Case	.00152				-10.5	-4					
AUTO	Base Case	.00294	-11		3	0	0	0			0	0
(std)	1990 Case	.00259	-5		-4	-3	-2	-3			0	0
TAXI	Base case	.00456			2	0	0	0			0	0
	1990 Case	.00401			-5	-4	-2	-3			0	0
BUS	Base case	.0172				0	0				0	0
(schl)	1990 Case	.0151				-9	-6				0	0
TRUCK	Base Case	.00544										
(psngr)	1990 Case	.00479										
TRUCK	Base Case	.00544	-27			0	-2	0	-9	-9	0	0
(urb)	1990 Case	.00479	-17			-5	-3	-4	-15	3	0	0
TRUCK	Base case	.0111	-15				-2		-9	-9	0	
(int/urb/3)	1990 Case	.00977	-5				-6		-4	3	0	

DIESEL REFERENCE		GJ/km(2)	Diesel	Propane/ Diesel	LNG	CNG	Propane	Methanol 90%	Methanol 100%	Methanol + Cetane	Methanol Blend	Ethanol Blend
BUS	Base Case	.0207		0	9		14	18	0	1		
(urb)	1990 Case	.0195		1	10.5		16.5	17	-2	3		
BUS	Base case	.0159					14	13		1		
(int/urb)	1990 Case	.0149					15	15		3		
TRUCK	Base case	.0199		0					0	1		
(int/urb/8)	1990 Case	.0187		1					-2	3		

NOTES:

(1) Base Case consumptions of LNG, CNG, propane, 90% methanol, methanol and ethanol blends are consistent with current S/I engine conversions (either field or factory) without changes to basic engine compression ratio. Base Case consumptions of propane/diesel, 100% methanol and methanol + cetane enhancer fuels are consistent with technology presently under development using C/I (or glow plug ignition) engines.

(2) Future (1990) reference fuel consumptions are based on anticipated improvements to base vehicle/engine design. 12% and 6% reductions have been assumed for gasoline and diesel consumption respectively (except 5% for commuter auto and 9% for inter-urban gasoline truck).

(3) Reference sources:

COMPARISON OF VEHICLE CONVERSION COSTS (IN CONSTANT 1983 $)

	Fuel Type	Base(1) Vehicle Cost	Base Case Conversion (current practice) Type(2)	Cost	% Base	Future Conversions (series production) Type(2)	1990 Cost	1990 % Base	1995 Cost	1995 % Base
AUTO (Commuter)	Gasoline	8770		0	0		0	0	0	0
	CNG	8770	R	1400	15.9	F	1200	13.6	1020	11.6
	Propane	8770	F	1100	13.67	F	900	10.2	765	8.7
AUTO (Standard)	Gasoline	8150		0	0		0	0		0
	LNG	8150	F*	3200	39.2	F	2560	31.4	2175	26.6
	CNG	8150	R	1800	22	F	1500	18.4	1250	15.3
	Propane	8150	R	1400	17.1	F	1150	14.1	940	11.5
	90% MeOH	8150	R*	800	9.8	F	200	2.4	80	.9
TAXI	Gasoline	11000		0	0		0	0		0
	LNG	11000	R	3500	31.8	F	2925	26.5	2500	22.7
	CNG	11000	R	2000	18.1	F	1700	15.4	1445	13.1
	Propane	11000	F	1400	12.7	F	1140	10.3	1010	9.1
	90% MeOH	11000	R*	800	7.2	F	250	2.2	100	.9
BUS (School)	Gasoline	33500		0	0			0		0
	CNG	33500	R	2250	6.7	F	1900	5.6	1625	4.8
	Propane	33500	F	2200	6.5	F	1870	5.5	1590	4.7
BUS (Urban)	Diesel	165000		0	0			0		0
	C3/Diesel	165000	R*	3900	2.3	F	3300	2	2800	1.6
	LNG	165000	R	9800	5.9	F	5800	3.5	5000	3
	Propane	165000	F*	2900	1.7	F	1700	1	1445	.8
	90% MeOH	165000	F*	1900	1.1	F	1600	.9	1375	.8
	100% MeOH	165000	R	1800	1	F	1530	.9	1300	.7
	MeOH+Cet.	165000	R	900	.5	F	765	.4	650	.3
BUS (Int-Urban)	Diesel	202500		0	0			0		0
	Propane	202500	F*	3200	1.5	F	2700	1.3	2300	1.1
	90% MeOH	202500	F*	2190	1	F	1775	.8	1510	.7
	MeOH+Cet.	202500	R	900	.4	F	765	.3	650	.3
TRUCK (Passenger)	Gasoline	10000		0	0			0		0
TRUCK (Urban)	Gasoline	10000		0	0			0		0
	CNG	10000	R	1650	16.5	F	1400	14	1200	12
	Propane	10000	R or F	1400	14	F	1190	11.9	1010	10.1
	90% MeOH	10000	R	600	6	F	510	5.1	435	4.3
	100% MeOH	12000	F	1200	10	F	1020	8.5	870	7.2
	MeOH+Cet.	12000	F	560	4.6	F	475	3.9	405	3.3
TRUCK (Int-Urb Class 3)	Gasoline	15000		0	0		0	0		0
	Propane	15000	F	1500	10	F	1275	8.5	1085	7.2
	100% MeOH	19000	F	1400	7.3	F	1050	5.5	890	4.6
	MeOH+Cet.	19000	F	800	4.2	F	680	3.5	580	3
TRUCK (Int-Urb Class 8)	Diesel	91500		0	0		0	0		0
	C3/Diesel	91500	R	4900	5.3	F	4165	4.5	3550	3.8
	100% MeOH	91500	F*	2200	2.4	F	1870	2	1600	1.7
	MeOH+Cet.	91500	F	1400	1.5	F	1200	1.3	1010	1.1

(1) Base cost includes Provincial tax. (2) F = Factory , R = Field retrofit.
* signifies conversion is not yet commercially available (ie. demo installations only at present).

COMPARISON OF MISCELLANEOUS MATERIALS & MAINTENANCE COSTS (1)

(All units in $/1000 km)

		Gasoline (Ld Reg)	Diesel	Propane /Diesel	LNG	CNG	Propane	Methanol 90%	Methanol 100% (2)	Methanol + CI(2)	Methanol Blend	Ethanol Blend
AUTO	Materials	5.3				5.3	5.3					
(com)	Maintnce	6.1				6.1	6.1					
AUTO	Materials	5.7	5.7		5.7	5.7	5.7	5.7			5.74	5.74
(std)	Maintnce	6.6	6.2		6.6	6.6	6.6	6.6			6.56	6.56
TAXI	Materials	26			26	26	26	26			26	26
	Maintnce	29			29	29	29	29			29	29
BUS	Materials	34				34	34				34	34
(schl)	Maintnce	129				129	129				129	129
BUS	Materials		60	60	60		60	60	60	60		
(urb)	Maintnce		244	254	285		285	285	244	244		
BUS	Materials		19				19	19		19		
(int/urb)	Maintnce		202				236	236		202		
TRUCK	Materials	8.7										
(psngr)	Maintnce	25										
TRUCK	Materials	8.7	8.7			8.7	8.7	8.7	8.7	8.7	8.7	8.7
(int/urb/1)	Maintnce	45	38			45	45	45	38	38	45	45
TRUCK	Materials	35	35				35		35	35	35	
(int/urb/3)	Maintnce	149	134				149		134	134	149	
TRUCK	Materials		32	32					32	32		
(int/urb/8)	Maintnce		62	64					62	62		

NOTES: (1) All cases represent current (4Q/1983) technology except where noted.
(2) These cases represent future commercial application.

COMPARISON OF FLEET ANNUAL GARAGE/TERMINAL COSTS PER VEHICLE (1)

	Reference Fuel	Total Fleet Size	Total Opertg days/yr	Fleet fuel stn capacity in GJ/ Opertg day	Fleet fuel stn capacity in GJ/ Calndr day	Fleet ROI $/y/veh (3)	Other Costs $/y/veh (4)	Total Cost $/y/veh
TAXI	Gasoline	100	300	183	150	1400	7100	8500
BUS (schl)	Gasoline	55	200	91	50	865	3800	4665
BUS (urb)	Diesel	200	265	964	700	(2)	13400	13400
BUS (int/urb)	Diesel	100	300	852	700	26000	39000	65000
TRUCK (urb)	Gasoline	100	250	44	30	1300	2700	4000
TRUCK (int/urb/3)	Gasoline	75	300	61	50	2000	11600	13600
TRUCK (int/urb/8)	Diesel	75	300	852	700	11900	34100	46000

NOTES:

(1) Costs of operating fleet garage/terminal using reference fuels (excludes refuelling facilities, vehicle maintenance, driver and fuel costs but includes vehicle return on investment (ROI)).
(2) Operated as public utility and therefore not required to give return on investment.
(3) Based on 13% pretax return on investment (typical for private fleet operators in 1983).
(4) Includes following cost items:
- ROI and/or rent on garages, equipment, offices, terminals, land, etc.
- Management & labour costs associated with fleet admin. & sales but excluding vehicle maintenance, driver and refuelling costs.
- Maintenance of property excluding vehicles.
- Miscellaneous road tolls & property taxes.

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COMPARISON OF LICENSE & INSURANCE COSTS

(All costs in 1983 $ per vehicle)

Reference Vehicle type	Fuel Type	Km per Year	Base Vehicle Cost(2)	License Cost	Insurance Cost	Insurance % Base Cost	Total L&I Cost
AUTO (Commuter)	Gasoline	6600	8770	45	690	7.8	735
AUTO (Standard)	Gasoline	18300	8150	45	690	8.4	735
TAXI	Gasoline	120000	11000	145	3230	29.3	3375
BUS (School) (1)	Gasoline	19200	33500	210	520	1.5	730
BUS (Urban) (1)	Diesel	60000	165000	325	2155	1.3	2480
BUS (Int-Urban) (1)	Diesel	106910	202500	785	1950	.9	2735
TRUCK (Passenger)	Gasoline	19350	10000	45	715	7.1	760
TRUCK (Urban)	Gasoline	19350	10000	45	1250	12.5	1295
TRUCK (Int-Urb-Class 3)	Gasoline	22400	15000	325	1705	11.3	2030
TRUCK (Int-Urb-Class 8)	Diesel	176000	91500	1644	5450	5.9	7094

NOTES:

(1) In view of low insurance cost reported it is likely that bus companies may assume part of insurance liability. About 5-7% of vehicle cost per annum would be full insurance cost. Difference is included in garage/terminal cost and maintenance costs.

(2) Base cost includes Provincial sales tax.

(3) Reference sources:

SUMMARY OF LIFE CYCLE COSTS

REF #	VEHICLE TYPE	FUEL TYPE R=retail F=fleet	REF CASE VARIABLE/ LIFE CYCLE COSTS
1a	Commuter	Gasoline R	221/26.7
1b	auto	CNG R	141/25.9
1c	"	Propane R	180/26.8
2a	Standard	Gasoline R	973/11.6
2b	auto	Diesel R	823/11.5
2c	"	LNG R	923/12.8
2d	"	CNG R	565/10.2
2e	"	Propane R	765/10.9
2f	"	MeOH 90% R	934/11.5
2g	"	MeOH blend R	980/11.6
2h	"	EtOH blend R	998/11.7
3a	Taxi	Gasoline R	39480/56.6
3b	"	Gasoline F	37682/55.8
3c	"	LNG R	38181/58.9
3d	"	LNG F	37463/57.3
3e	"	CNG (1) R	35759/55.6
3f	"	CNG (1) F	35598/55.7
3g	"	Propane R	36626/54.9
3h	"	Propane F	36418/54.7
3i	"	MeOH 90% R	33354/56.5
3j	"	MeOH 90% F	38622/56.7
3k	"	MeOH 90% R	38578/56.7
3l	"	MeOH 90% F	37731/55.8
3m	"	EtOH 90% R	38773/56.9
3n	"	EtOH 90% F	37910/56.0
4a	School	Gasoline F	12369/4.60
4b	bus	CNG F	10955/4.29
4c	"	Propane F	11655/4.44
4d	"	MeOH blend F	12438/4.62
4e	"	EtOH blend F	12547/4.64

REF #	VEHICLE TYPE	FUEL TYPE R=retail F=fleet	REF CASE VARIABLE/ LIFE CYCLE COSTS
5a	Urban	Diesel F	65421/11.4
5b	bus	C3/diesel F	66011/11.2
5c	"	LNG F	39325/11.5
5d	"	Propane F	69549/11.5
5e	"	MeOH 90% F	75692/12.2
5f	"	MeOH 100% F	70941/11.6
5g	"	MeOH + Cet F	63772/13.5
6a	Inter-	Diesel F	114133/6.84
6b	urban	Propane F	116762/6.83
6c	bus	MeOH 90% F	120000/7.25
6d	"	Meth + Cet F	150402/7.99
7a	Psngr Trk	Gasoline R	2119/9.3
8a	Urban	Gasoline R	14506/382
8b	truck	Diesel R	13681/376
8c	"	CNG F	14104/376
8d	"	Propane R	14080/375
8e	"	MeOH 90% F	14726/385
8f	"	MeOH 100% F	14479/388
8g	"	MeOH + Cet F	15590/406
8h	"	MeOH blend F	14565/382
8i	"	EtOH blend R	14515/381
8j	"	EtOH blend F	14599/383
9a	Inter-	Gasoline R	23093/258
9b	urban	Gasoline F	22926/257
9c	truck	Diesel F	22068/257
9d	class 3	Propane F	22335/254
9e	"	MeOH 100% R	22446/259
9f	"	MeOH 100% F	22847/262
9g	"	Meth + Cet F	25474/277
9h	"	MeOH blend F	23060/258
10a	Inter-	Diesel F	89631/4.50
10b	urban	C3/diesel F	83764/4.33 (2)
10c	truck	MeOH 100% F	96720/4.66
10d	class 8	Meth + Cet F	139124/5.80

(1) Separate duel fuel system using CNG 70%, gasoline 30%.

(2) Concurrent propane 80%, diesel 20%, dual fuel system.

METHODOLOGY USED IN ALTERNATIVE FUELS LIFE CYCLE COSTS SUMMARY SHEET

CASE DEFINITION		ECONOMIC CRITERIA & FUEL PROPERTIES	
MATRIX REF #:	MATRIX CASE#:	% ROI on 40083 plant replacement value	X1
FUEL:	ENGINE TYPE:	% int. on 80% vehicle investment	Y1
SERVICE:	PUMP STATION:	Fuel density (Te/m3)	
LOCATION:	TIME FRAME:	Fuel higher heating value (GJ/m3)	Z1

PLANT GATE COST:		TOTAL DISTRIBUION COSTS:	PRI TERMINAL	SEC TERMINAL	REF STATION
Primary resource		Facility location			
Resource cost ($/GJ)		km from upstrm point			
Plant location		$/GJ shipped by barge	C1	"	"
Product rate (GJ/d)		$/GJ shipped by pipe	D1	"	"
Product name		$/GJ shipped by rail	E1	"	"
Process efficiency (%)	A1	$/GJ shipped by road	F1	"	"
Product cost ($/GJ)	B1	Total distr cost ($/GJ)	G1=C1+D1+E1+F1	H1	I1
Product cost (cents/l)	= B1*Z1*.1	Total distr cost (cents/l)	= G1*Z1*.1		

TERMINAL COSTS	PRIMARY	SECONDARY	REFUELLING STATION COSTS:	
Throughput (m3/d)			Fleet or retail	
Throughput (GJ/d)	J1	"	Throughput (GJ/d)	T1
Storage capacity (days)			Avg inventory (days thrput)	
Construction status			Construction status (3)	
Investment $(10)6	K1	"	Orig invest base stn $(10)6	U1
Investment cost $/d	L1=K1*X1/.0365	"	New investment $(10)6	V1
Utility cost $/d	N1	"	Investment costs ($/d)	W1=(U1+V1)*X1/.0365
Maintnce cost $/d	M1	"	Maintenance costs ($/d)	A2
Labour cost $/d	O1	"	Labour costs ($/d)	B2
Other costs $/d	P1	"	Other costs ($/d)	C2
Marketing costs $/d	Q1	"	Utility costs ($/d)	D2
Terminal costs $/GJ	R1=SUM(L1,Q1)/J1	S1	Statn costs ($/GJ)	E2=(W1+A2+B2+C2+D2)/T1
Terminal costs cents/l	= R1*Z1*.1			

FUEL COST AT PUMP:			VEHICLE DATA:		
Pretax fuel/Fed sal tx (c/l)	F2(see note)	G2	Fuel usage (l/100km & GJ/km)	M2	N2=M2*Z1*10E-5
Fed exc/Prov tax (cents/l)	H2	I2	Vehicle life (km & yrs)	O2	P2
Total fuel tax (c/l)	J2=G2+H2+I2		Payload (psngrs & Te)	Q2	R2
Tot fuel cost (c/l & $/GJ)	K2=F2+J2	L2=K2*10/Z1	Base cost ($) & tax ($)	S2	T2
			Conversion type & cost ($) (SEE NOTE)		U2
OVERALL RESOURCE UTILIZATION :			Grants & tax concessions ($)	V2	W2
Psngr.km/GJ & Te.km/GJ :	X2=A1*Q2/N2	Y2=A1*R2/N2	Total net investment ($)		X2=S2+T2+U2-V2-W2

VEHICLE ANNUAL FIXED COSTS:		VEHICLE ANNUAL VARIABLE COSTS (AVERAGE):		
License & Insurance cost ($/y)	Z2	Total fuel costs ($/y)		E3=O2*N2*L2/P2
Annual cost of investment ($/y)	A3=X2/P2	Misc matls ($/1000km & $/y)	F3	G3=F3*O2*.001/P2
Annual cost of financing ($/y)	B3=A3*.3	Driver costs incl ovhd ($/y)		H3
Other fixed costs ($/y) (4)	C3	Maint cost ($/1000km & $/y)	I3	J3=I3*O2*.001/P2
Total fixed costs ($/y)	D3=A3+B3+C3	Total variable costs ($/y)		K3=E3+G3+H3+J3

AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = L3=(D3+K3)*100*P2/O2/Q2 cents/psngr.km
AVERAGE VEHICLE LIFE CYCLE COST OF OPERATION = M3=(D3+K3)*100*P2/O2/R2 cents/Te.km

* NOTE: F2 = (B1+G1+H1+I1+R1+S1+E2)*Z1*.1

R=retrofit, F=factory, *=Demo only

SENSITIVITY ANALYSIS OF VEHICLE ANNUAL VARIABLE COSTS (VC) AND LIFE CYCLE COSTS (LCC)

REF #	VEHICLE TYPE	FUEL TYPE R=retail F=fleet	REF CASE VARIABLE / LCC COSTS(5)	EFFECT ON REFERENCE CASE VARIABLE COSTS / LIFE CYCLE COSTS (AS % OF REF COST) OF ..... 10% reduction in fuel used	25% increase in km/yr (1)	0% ROI for fuels plant(2)	Subsidy(3) deletion	1990 (4) projection
1a	Commuter	Gasoline R	221/26.7	-6.7 / -.8	+25 / -8.2	-4.5 / -.7	n/a	-3.6 / -.5
1b	auto	CNG R	141/25.9	-5.0 / -.4	+25 / -8.5	n/a	+26.2 / +8.1	-7.1 / -1.5
1c	"	Propane R	180/26.8	-6.1 / -.6	+25 / -8.2	-1.1 / -.1	+21.7 / +5.2	-5.0 / -1.9
2a	Standard	Gasoline R	973/11.6	-8.0 / -2.8	+25 / -6.0	-5.2 / -1.8	n/a	-9.0 / -3.2
2b	auto	Diesel R	823/11.5	-7.4 / -2.2	+25 / -5.2	-3.6 / -1.1	n/a	-0.4 / -0.1
2c	"	LNG R	923/12.8	-7.6 / -2.3	+25 / -4.8	-21.9 / -6.6	+21.6 / +8.9	-13.2 / -6.7
2d	"	CNG R	565/10.2	-6.0 / -1.4	+25 / -5.9	n/a	+34.2 / +13.5	-8.5 / -3.5
2e	"	Propane R	765/10.9	-7.1 / -2.1	+25 / -5.7	-1.6 / -0.5	+25.0 / +12.2	-9.4 / -4.0
2f	"	MeOH 90% R	934/11.5	-7.6 / -2.6	+25 / -5.4	-13.0 / -4.4	+14.5 / +7.6	-10.7 / -6.5
2g	"	MeOH blend R	980/11.6	-7.8 / -2.7	+25 / -5.3	-5.4 / -1.9	+1.1 / + 0.4	-8.9 / -3.1
2h	"	EtOH blend R	998/11.7	-7.7 / -2.8	+25 / -5.3	-6.1 / -2.2	+1.3 / +0.5	-8.8 / -3.2
5a	Urban	Diesel F	68421/11.4	-2.0 / -1.4	+11.6 / -10.9	+0.5 / +0.4	n/a	-1.1 / -0.8
5b	bus	C3/diesel F	66811/11.2	-1.7 / -1.2	+11.3 / -11.0	-0.2 / -0.2	+4.9 / +4.4	-0.8 / -0.6
5c	"	LNG F	39335/11.5	-1.7 / -1.2	+11.8 / -10.8	-3.6 / -2.6	+7.0 / +5.9	-0.8 / -0.8
5d	"	Propane F	69549/11.5	-1.8 / -1.3	+11.8 / -10.9	-0.5 / -0.3	+6.7 / +5.6	-0.6 / -0.5
5e	"	MeOH 90% F	75692/12.2	-2.4 / -2.6	+12.9 / -10.2	-3.9 / -2.9	+5.0 / +4.5	-1.6 / -1.2
5f	"	MeOH 100% F	70941/11.6	-2.3 / -1.6	+12.1 / -11.6	-4.5 / -3.2	+4.4 / +4.1	-1.7 / -1.3
5g	"	MeOH + Cet F	85992/13.5	-3.6 / -2.8	+14.3 / -9.3	-8.9 / -6.8	+2.3 / +2.5	-1.4 / -1.1
8a	Urban	Gasoline R	14506/382	-1.0 / -0.7	+4.3 / -16.2	-0.6 / -0.4	n/a	-1.2 / -0.8
8b	truck	Diesel R	13881/376	-0.7 / -0.5	+3.4 / -16.4	-0.4 / -0.2	n/a	0.0 / 0.0
8c	"	CNG F	14104/376	-0.8 / -0.5	+3.7 / -16.4	n/a	+2.7 / +2.7	-1.2 / -1.0
8d	"	Propane R	14080/375	-0.7 / -0.5	+3.7 / -16.4	-0.2 / -0.1	+2.2 / +2.4	-1.0 / -0.8
8e	"	MeOH 90% F	14726/385	-1.1 / -0.8	+4.6 / -16.1	-1.5 / -1.0	+1.6 / +1.6	-1.8 / -1.3
8f	"	MeOH 100% F	14479/388	-1.1 / -0.8	+4.3 / -16.0	-1.7 / -1.3	+1.5 / +1.5	-1.9 / -1.5
8g	"	MeOH + Cet F	15590/406	-1.7 / -1.2	+5.8 / -15.3	-3.7 / -2.7	+0.8 / +1.0	-0.1 / -0.1
8h	"	MeOH blend F	14565/382	-1.1 / -0.7	+4.4 / -16.0	+0.3 / +0.2	+0.4 / +0.2	-1.3 / -0.8
8i	"	EtOH blend R	14515/381	-1.0 / -0.7	+4.3 / -16.0	-1.0 / -0.7	+0.4 / +0.3	-1.2 / -0.8
8j	"	EtOH blend F	14599/383	-1.1 / -0.8	+4.5 / -16.2	+0.2 / +0.1	+0.3 / +0.2	-1.3 / -0.9

NOTES: (1) 25% increase in km/yr at constant total lifetime km.

(2) Plant gate costs (PGC) of fuels (derived from EMR AFEM program) are as follows:

FUEL DESCRIPTION	PLANT NAME	PLANT LOCATION	RETAIL CASE %ROI/PGC($/GJ)	WHOLESALE CASE %ROI/PGC($/GJ)	PGC @ 0% ROI($/GJ)
LR Gasoline	Refinery	S. Ontario	14.7 / 8.40	-7.0 / 7.17	7.59
Diesel	"	"	14.7 / 7.64	-7.0 / 6.79	7.05
9.5v% Oxinol	"	"	14.7 / 8.67	-7.0 / 7.42	7.76
10v% Ethanol	"	"	14.7 / 9.01	-7.0 / 7.73	7.96
100% Methanol	MeOH-NG	Edmonton	n/a	10 / 7.91	5.57
100% Ethanol	EtOH-C2H4	"	n/a	20 / 18.49	14.87
Propane	Straddle	"	n/a	20 / 4.24	4.02
LNG	LNG	Toronto	20 / 10.28	10 / 8.44	6.60

(3) Subsidy deletion implies zero federal/provincial grants or tax concessions on vehicle purchase and the same total fuel tax as for LR gasoline at the retail pump, namely $3.6/GJ.

(4) Projected changes in fuel consumption and vehicle conversion costs only are included (basis: constant $1983).

(5) Annual variable costs in $/yr and life cycle costs (LCC) in cents/psngr.km or cents/Te.km.

APPENDIX C - FUEL PLANT GATE COST WORKSHEETS

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REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & 14.7% ROI (RETAILING CASE) (BASE CASE)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =		300	30	5	=	335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329 / day				=	140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years				=	60
START UP COST MM$	2 % of total plant cost				=	6
TOTAL INVESTMENT MM$						541

ANNUAL COST OF INVESTMENT @ 14.7 % SIMPLE RET ON INVESTMENT = 79 $MM

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	58476	5.803	.838	36	2105	730	6.20	5.88	22.70
NAT GAS FUEL FOEB	695	6.4		26.62	18	6	4.16	3.94	16.78
REF GAS FUEL FOEB	2367	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	238			32.1	8	3			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1604	4.185	.563	35.6	57	20	8.51	8.06	22.45
N BUTANE BBL	606	4.035	.584	35.6	22	7	8.82	8.36	22.45
TEL(100%) Kg	1508			4.8	7	3			
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS					2308	802			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	2367	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	1090	3.85	.508	26.5	28.89	10.02	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					29.35	10.18			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	48.18	73	25	8.62	8.17	30.38
MIXED OLEFINS BBL	800	4.14	.562	48.18	39	13	11.64	11.03	30.38
LEADED REG GASOL BBL	15322	5.11	.718	45.29	694	241	8.86	8.40	28.56
UNLEADED REG GAS BBL	15569	5.17	.729	48.18	750	260	9.32	8.83	30.38
AVIATION GASOLIN BBL	68	4.93	.686	48.18	3	1	9.77	9.26	30.38
JET FUEL "A" BBL	3180	5.6	.805	45.77	146	50	8.17	7.75	28.86
JET FUEL "B" BBL	262	5.32	.756	45.77	12	4	8.60	8.15	28.86
DIESEL (ALL) BBL	10640	5.74	.829	46.26	492	171	8.06	7.64	29.16
LIGHT FUEL OIL BBL	4640	5.95	.882	45.77	212	74	7.69	7.29	28.86
HEAVY FUEL OIL BBL	3070	6.49	1.04	29.58	91	31	4.56	4.32	18.65
TOTAL PRODUCT CREDIT	56165				2512	871			

TOTAL ANNUAL CREDIT: 10.18 $MM + 871.14 $MM = 881.32 $MM TOTAL FUEL & POWER = 6.47 V% CRUDE
TOTAL ANNUAL DEBIT: 79.49 $MM + 801.83 $MM = 881.32 $MM ENERGY IN - OUT = 15.41 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 85.88 %

Mar 26 / 1984

REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & -7% ROI (WHOLESALING CASE) (BASE CASE)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =	300	30	5		=	335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329			/ day	=	140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years				=	60
START UP COST MM$	2 % of total plant cost				=	6
TOTAL INVESTMENT MM$						541
ANNUAL COST OF INVESTMENT @	-7 % SIMPLE RET ON INVESTMENT =		-38 $MM			

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	58476	5.803	.838	36	2105	730	6.20	5.88	22.70
NAT GAS FUEL FOEB	695	6.4		26.62	18	6	4.16	3.94	16.78
REF GAS FUEL FOEB	2367	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	238			32.1	8	3			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1604	4.185	.563	35.6	57	20	8.51	8.06	22.45
N BUTANE BBL	606	4.035	.584	35.6	22	7	8.82	8.36	22.45
TEL(100%) Kg	1508			4.8	7	3			
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS					2308	802			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	2367	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	1090	3.85	.508	26.5	28.89	10.02	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					29.35	10.18			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	41.10	63	22	7.35	6.97	25.91
MIXED OLEFINS BBL	800	4.14	.562	41.10	33	11	9.93	9.41	25.91
LEADED REG GASOL BBL	15322	5.11	.718	38.63	592	205	7.56	7.17	24.36
UNLEADED REG GAS BBL	15569	5.17	.729	41.10	640	222	7.95	7.53	25.91
AVIATION GASOLIN BBL	68	4.93	.686	41.10	3	1	8.34	7.90	25.91
JET FUEL "A" BBL	3180	5.6	.805	39.05	124	43	6.97	6.61	24.62
JET FUEL "B" BBL	262	5.32	.756	39.05	10	4	7.34	6.96	24.62
DIESEL (ALL) BBL	10640	5.74	.829	41.10	437	152	7.16	6.79	25.91
LIGHT FUEL OIL BBL	4640	5.95	.882	39.05	181	63	6.56	6.22	24.62
HEAVY FUEL OIL BBL	3070	6.49	1.04	29.59	91	32	4.56	4.32	18.66
TOTAL PRODUCT CREDIT	56165				2174	754			

TOTAL ANNUAL CREDIT: 10.18 $MM + 753.80 $MM = 763.98 $MM TOTAL FUEL & POWER = 6.47 V% CRUDE
TOTAL ANNUAL DEBIT: -37.85 $MM + 801.83 $MM = 763.98 $MM ENERGY IN - OUT = 15.41 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 85.88 %

Mar 26 / 1984

REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & 14.7% ROI (RETAILING CASE) (BASE CASE + 9.5v% OXINOL + .4g Pb/1)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =	300 30 5	= 335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329 / day	= 140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years	= 60
START UP COST MM$	2 % of total plant cost	= 6
TOTAL INVESTMENT MM$		541

ANNUAL COST OF INVESTMENT @ 14.7 % SIMPLE RET ON INVESTMENT = 79 $MM

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	55522	5.803	.838	36	1999	693	6.20	5.88	22.70
NAT GAS FUEL FOEB	728	6.4		26.62	19	7	4.16	3.94	16.78
REF GAS FUEL FOEB	1692	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	226			32.1	7	3			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1379	4.185	.563	35.6	49	17	8.51	8.06	22.45
N BUTANE BBL	197	4.035	.584	35.6	7	2	8.82	8.36	22.45
TEL(100%) Kg	1508			4.8	7	3			
OXINOL BBL	2935	3.67	.795	43	126	44	11.72	11.10	27.11
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS	62453				2306	801			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	1692	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	864	3.85	.508	26.5	22.90	7.94	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					23.36	8.10			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	48.26	74	26	8.63	8.18	30.43
MIXED OLEFINS BBL	800	4.14	.562	48.26	39	13	11.66	11.05	30.43
LEADED REG GASOL BBL	15322	4.96	.724	45.36	695	241	9.15	8.67	28.60
UNLEADED REG GAS BBL	15569	5.01	.731	48.26	751	261	9.63	9.13	30.43
AVIATION GASOLIN BBL	68	4.93	.686	48.26	3	1	9.79	9.28	30.43
JET FUEL "A" BBL	3180	5.6	.805	45.84	146	51	8.19	7.76	28.90
JET FUEL "B" BBL	262	5.27	.748	45.84	12	4	8.70	8.24	28.90
DIESEL (ALL) BBL	10640	5.75	.832	46.33	493	171	8.06	7.64	29.21
LIGHT FUEL OIL BBL	4640	5.96	.884	45.84	213	74	7.69	7.29	28.90
HEAVY FUEL OIL BBL	3070	6.49	1.04	29.63	91	32	4.57	4.33	18.68
TOTAL PRODUCT CREDIT	55939				2516	872			

TOTAL ANNUAL CREDIT: 8.10 $MM + 872.45 $MM = 880.55 $MM TOTAL FUEL & POWER = 5.51 V% CRUDE
TOTAL ANNUAL DEBIT: 79.49 $MM + 801.06 $MM = 880.55 $MM ENERGY IN - OUT = 15.20 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 86.30 %

Mar 26 / 1984

REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & -7% ROI (WHOLESALING CASE) (BASE CASE + 9.5v% OXINOL + .4g Pb/l)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =	300	30	5		=	335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329			/ day	=	140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years				=	60
START UP COST MM$	2 % of total plant cost				=	6
TOTAL INVESTMENT MM$						541

ANNUAL COST OF INVESTMENT @ -7 % SIMPLE RET ON INVESTMENT = -38 $MM

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	55522	5.803	.838	36	1999	693	6.20	5.88	22.70
NAT GAS FUEL FOEB	728	6.4		26.62	19	7	4.16	3.94	16.78
REF GAS FUEL FOEB	1692	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	226			32.1	7	3			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1379	4.185	.563	35.6	49	17	8.51	8.06	22.45
N BUTANE BBL	197	4.035	.584	35.6	7	2	8.82	8.36	22.45
TEL(100%) Kg	1508			4.8	7	3			
OXINOL BBL	2935	3.67	.795	43	126	44	11.72	11.10	27.11
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS	62453				2306	801			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	1692	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	864	3.85	.508	26.5	22.90	7.94	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					23.36	8.10			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	41.32	63	22	7.39	7.01	26.05
MIXED OLEFINS BBL	800	4.14	.562	41.32	33	11	9.98	9.46	26.05
LEADED REG GASOL BBL	15322	4.96	.724	38.84	595	206	7.83	7.42	24.49
UNLEADED REG GAS BBL	15569	5.01	.731	41.32	643	223	8.25	7.82	26.05
AVIATION GASOLIN BBL	68	4.93	.686	41.32	3	1	8.38	7.94	26.05
JET FUEL "A" BBL	3180	5.6	.805	39.26	125	43	7.01	6.64	24.75
JET FUEL "B" BBL	262	5.27	.748	39.26	10	4	7.45	7.06	24.75
DIESEL (ALL) BBL	10640	5.75	.832	39.67	422	146	6.90	6.54	25.01
LIGHT FUEL OIL BBL	4640	5.96	.884	41.32	192	66	6.93	6.57	26.05
HEAVY FUEL OIL BBL	3070	6.49	1.04	29.75	91	32	4.58	4.35	18.76
TOTAL PRODUCT CREDIT	55939				2178	755			

TOTAL ANNUAL CREDIT: 8.10 $MM + 755.11 $MM = 763.21 $MM   TOTAL FUEL & POWER = 5.51 V% CRUDE
TOTAL ANNUAL DEBIT: -37.85 $MM + 801.06 $MM = 763.21 $MM   ENERGY IN - OUT = 15.20 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 86.30 %

REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & 14.7% ROI (RETAILING CASE) (BASE CASE + 10v% ETHANOL) (1)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =	300	30	5	=	335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329 / day			=	140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years			=	60
START UP COST MM$	2 % of total plant cost			=	6
TOTAL INVESTMENT MM$					541

ANNUAL COST OF INVESTMENT @ 14.7 % SIMPLE RET ON INVESTMENT = 79 $MM

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	54493	5.803	.838	36	1962	680	6.20	5.88	22.70
NAT GAS FUEL FOEB	793	6.4		26.62	21	7	4.16	3.94	16.78
REF GAS FUEL FOEB	1416	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	221			32.1	7	2			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1194	4.185	.563	35.6	43	15	8.51	8.06	22.45
N BUTANE BBL	957	4.035	.584	35.6	34	12	8.82	8.36	22.45
TEL(100%) Kg	1034			4.8	5	2			
ETHANOL BBL	3089	3.56	.795	76.3	236	82	21.43	20.31	48.11
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS	61942				2398	833			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	1416	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	790	3.85	.508	26.5	20.94	7.26	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					21.40	7.42			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	50.06	76	26	8.96	8.49	31.56
MIXED OLEFINS BBL	800	4.14	.562	50.06	40	14	12.09	11.46	31.56
LEADED REG GASOL BBL	15322	4.95	.725	47.06	721	250	9.51	9.01	29.67
UNLEADED REG GAS BBL	15569	4.95	.723	50.06	779	270	10.11	9.59	31.56
AVIATION GASOLIN BBL	68	4.93	.686	50.06	3	1	10.15	9.62	31.56
JET FUEL "A" BBL	3180	5.62	.808	47.56	151	52	8.46	8.02	29.99
JET FUEL "B" BBL	262	5.33	.755	47.56	12	4	8.92	8.46	29.99
DIESEL (ALL) BBL	10640	5.78	.838	48.06	511	177	8.31	7.88	30.30
LIGHT FUEL OIL BBL	4640	5.97	.887	47.56	221	77	7.97	7.55	29.99
HEAVY FUEL OIL BBL	3070	6.49	1.04	30.74	94	33	4.74	4.49	19.38
TOTAL PRODUCT CREDIT	55865				2610	905			

TOTAL ANNUAL CREDIT: 7.42 $MM + 905.11 $MM = 912.53 $MM TOTAL FUEL & POWER = 5.17 V% CRUDE
TOTAL ANNUAL DEBIT: 79.49 $MM + 833.05 $MM = 912.53 $MM ENERGY IN - OUT = 14.80 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 86.72 %

(1) Gasolines contain zero reformate and leaded gasoline TEL usage is less than allowable (.27 vs .4g Pb/l).

Mar 26 / 1984

REFINERY CASE: TYPICAL ONTARIO FUELS REFINERY WITH 3Q/1983 PROD SLATE & -7% ROI (WHOLESALING CASE) (BASE CASE + 10v% ETHANOL) (1)

PLANT CAPACITY / STREAM FACTOR 85000 .95
DATE / LOCATION : 4Q 1983 / TORONTO AREA

INVESTMENT DATA :

PLANT COST = FIELD, ENGINEERING & CAT/CHEM COSTS =	300	30	5	=	335
WORKING CAPITAL MM$	60 days operating expenses @ $M 2329 / day			=	140
INT BFR STRT UP MM$	15 % interest on 40% of total plant cost over 3 years			=	60
START UP COST MM$	2 % of total plant cost			=	6
TOTAL INVESTMENT MM$					541

ANNUAL COST OF INVESTMENT @ -7 % SIMPLE RET ON INVESTMENT = -38 $MM

	QUANTITY PER DAY	HHV MMBTU/B	SG	UNIT COST $	STRM DAY COST M$	ANNUAL COST MM$	$/MMBTU (HHV)	$/GJ (HHV)	CENTS/L
OPERATING EXPENSES:									
CRUDE FEED BBL	54493	5.803	.838	36	1962	680	6.20	5.88	22.70
NAT GAS FUEL FOEB	793	6.4		26.62	21	7	4.16	3.94	16.78
REF GAS FUEL FOEB	1416	6.4		0	0	0	0.00	0.00	0.00
POWER MWH	221			32.1	7	2			
CAT & CHEMICALS					7	2			
ISOBUTANE BBL	1194	4.185	.563	35.6	43	15	8.51	8.06	22.45
N BUTANE BBL	957	4.035	.584	35.6	34	12	8.82	8.36	22.45
TEL(100%) Kg	1034			4.8	5	2			
ETHANOL BBL	3089	3.56	.795	76.3	236	82	21.43	20.31	48.11
MAINT MAT&CONT LAB					17	6			
MAINT LAB&SUP MEN	150			30700	20	7			
OPER LAB&SUP MEN	150			30700	20	7			
ADM & SUPRT LAB					8	3			
OTHER EXPENSES					20	7			
TOTALS	61942				2398	833			
BY-PRODUCT CREDITS:									
SULPHUR TONS	6	7.97		77	0.46	0.16	9.66	9.16	48.55
REF FUEL GAS FOEB	1416	6.4		0	0.00	0.00	0.00	0.00	0.00
PROPANE BBL	790	3.85	.508	26.5	20.94	7.26	6.88	6.52	16.71
BUTANES BBL	0	4.035	.584	35.6	0.00	0.00	8.82	8.36	22.45
TOTAL BY-PROD CREDIT					21.40	7.42			
PRODUCT CREDITS:									
NAPHTHA SPECIALS BBL	1524	5.59	.827	42.95	65	23	7.68	7.28	27.08
MIXED OLEFINS BBL	800	4.14	.562	42.95	34	12	10.38	9.83	27.08
LEADED REG GASOL BBL	15322	4.95	.725	40.38	619	215	8.16	7.73	25.46
UNLEADED REG GAS BBL	15569	4.95	.723	42.95	669	232	8.68	8.22	27.08
AVIATION GASOLIN BBL	68	4.93	.686	42.95	3	1	8.71	8.26	27.08
JET FUEL "A" BBL	3180	5.62	.808	40.81	130	45	7.26	6.88	25.73
JET FUEL "B" BBL	262	5.33	.755	40.81	11	4	7.66	7.26	25.73
DIESEL (ALL) BBL	10640	5.78	.838	42.95	457	158	7.43	7.04	27.08
LIGHT FUEL OIL BBL	4640	5.97	.887	40.81	189	66	6.84	6.48	25.73
HEAVY FUEL OIL BBL	3070	6.49	1.04	30.93	95	33	4.77	4.52	19.50
TOTAL PRODUCT CREDIT	55865				2272	788			

TOTAL ANNUAL CREDIT: 7.42 $MM + 787.77 $MM = 795.19 $MM TOTAL FUEL & POWER = 5.17 V% CRUDE
TOTAL ANNUAL DEBIT: -37.85 $MM + 833.05 $MM = 795.19 $MM ENERGY IN - OUT = 14.80 V% CRUDE
OVERALL REFINERY PROCESS EFFICIENCY (HHV BASIS) ENERGY IN PRODUCTS / ENERGY IN FEED & FUEL STREAMS = 86.72 %

(1) Gasolines contain zero reformate and leaded gasoline TEL usage is less than allowable (.27 vs .4g Pb/1).

DETAILED SUMMARY OF PROCESS & ECONOMIC DATA FOR CASE# 1

CASE STUDY TITLE :
CASE DESCRIPTION : straddle plant in edmonton

PROCESS NAME : PROPANE (STRADDLE) PROCESS CODE : 32

CAPACITY, TE/D :	919	ON-STREAM FACTOR :	0.959
CAPACITY, GJ/D	46308.4	THERMAL EFFICIENCY :	98.9 %
LOCATION :	EDMONTON	STARTUP DATE :	4Q 1983

INVESTMENT:		*** BASIS ***
TOTAL FIELD COST (TFC), MM$	251.33	
LAND COST, MM$	0.06	(10.0 ACRES @ 6333 $/ACRE)
HOME OFFICE COST (HOC), MM$	25.13	(10.0% OF TFC)
CAT & CHEM INVENTORY, MM$	0.00	
UNCERTAINTY CONTRIBUTION, MM$	11.06	(UNCERTAINTY FACTOR = 1.04)
TOTAL PLANT COST (TPC), MM$	287.58	
WORKING CAPITAL, MM$	24.40	(60 DAYS OF OP. EXP. LESS NAT GAS PRODUCT VALUE)
START-UP COST, MM$	5.75	(2.0% OF TPC)
INTEREST BEFORE START-UP, MM$	51.77	(15.0% INTEREST ON 40.0% OF TPC OVER 3.0 YEARS)
ROYALTY, MM$	0.00	
CONTINGENCY, MM$	0.00	(0.0% OF TPC)
TOTAL INVESTMENT, MM$	369.50	

** ANNUAL COST OF INVESTMENT @ 20.0% SIMPLE ROI = $ 73.90 MM

OPERATING EXPENSES:	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
FEEDSTOCKS						
RAW NAT. GAS, TE	35947.00	52.78	105.56	3794.56	1328.23	2.00
UTILITIES						
ELECTRIC POWER, MWH	61.00	10.55	28.30	1.73	0.60	
RAW WATER, TE	4921.00	0.00	0.06	0.29	0.10	
CATALYSTS & CHEMICALS				1.64	0.57	
TAX				5.82	2.04	
MAINT. MAT. & CONTRACT LAB.				13.77	5.03	
MAINT. LAB. & SUPERVISION, MEN	23		30700	3.00	1.10	
OPER. LAB. & SUPERVISION, MEN	30		30700	3.92	1.43	
ADMIN. & SUPPORT LABOUR				1.38	0.51	
OTHER EXPENSES				17.21	6.28	
TOTAL EXPENSES				3843.34	1345.89	

**** TOTAL ANNUAL COSTS (OPERATING + INVESTMENT) = $ 1345.89 MM + $ 73.90 MM = $ 1419.79 MM

OPERATING CREDITS:	SG	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
BY-PRODUCTS:							
NAT GAS, TE		32444.00	52.96	105.93	3436.73	1202.98	2.00
PRODUCTS:							
ETHANE, TE	0.374	1556.00	51.89	164.31	255.67	89.49	3.17
PROPANE, TE	0.508	919.00	50.39	213.79	196.47	68.77	4.24
N-BUTANE, TE	0.584	259.00	49.49	266.72	69.08	24.18	5.39
C5+ COND., TE	0.695	212.00	48.39	211.28	44.79	15.68	4.37
I-BUTANE, TE	0.563	190.00	49.40	281.05	53.40	18.69	5.69
TOTAL (OR AVG)	0.444	3136.01	50.86	197.51	619.41	216.81	3.88

**** TOTAL ANNUAL CREDITS (PRODUCTS + BYPRODUCTS) = $ 216.81 MM + $ 1202.98 MM = $ 1419.79 MM

DETAILED SUMMARY OF PROCESS & ECONOMIC DATA FOR CASE# 5

CASE STUDY TITLE : NEW ALTERNATIVE FUELS PLANTS: MOSST STUDY
CASE DESCRIPTION : NEW LNG PLANT IN TORONTO

PROCESS NAME : LNG — PROCESS CODE : 30

CAPACITY, TE/D :	19.19	ON-STREAM FACTOR :	0.950
CAPACITY, GJ/D :	1000.37	THERMAL EFFICIENCY :	84.3 %
LOCATION :	TORONTO	STARTUP DATE :	4Q 1983

INVESTMENT:

		*** BASIS ***
TOTAL FIELD COST (TFC), MM$	4.971	
LAND COST, MM$	0.006	(1.0 ACRES @ 6333 $/ACRE)
HOME OFFICE COST (HOC), MM$	0.497	(10.0% OF TFC)
CAT & CHEM INVENTORY, MM$	0.011	
UNCERTAINTY CONTRIBUTION, MM$	0.055	(UNCERTAINTY FACTOR = 1.01)
TOTAL PLANT COST (TPC), MM$	5.540	
WORKING CAPITAL, MM$	0.393	(60 DAYS OF OPERATING EXPENSES)
START-UP COST, MM$	0.111	(2.0% OF TPC)
INTEREST BEFORE START-UP, MM$	0.332	(15.0% INTEREST ON 40.0% OF TPC OVER 1.0 YEARS)
ROYALTY, MM$	0.000	
CONTINGENCY, MM$	0.000	(0.0% OF TPC)
TOTAL INVESTMENT, MM$	6.376	

** ANNUAL COST OF INVESTMENT @ 20.0% SIMPLE ROI = $ 1.28 MM

OPERATING EXPENSES:	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
FEEDSTOCKS						
NAT GAS, TE	19.190	52.964	248.931	4.777	1.656	4.700
UTILITIES						
ELECTRIC POWER, MWH	16.130	10.551	32.100	0.518	0.180	
CATALYSTS & CHEMICALS				0.011	0.004	
MAINT. MAT. & CONTRACT LAB.				0.272	0.099	
MAINT. LAB. & SUPERVISION, MEN	0		30700	0.000	0.000	
OPER. LAB. & SUPERVISION, MEN	4		30700	0.522	0.191	
ADMIN. & SUPPORT LABOUR				0.104	0.038	
OTHER EXPENSES				0.340	0.124	
TOTAL EXPENSES				6.545	2.292	

**** TOTAL ANNUAL COSTS (OPERATING + INVESTMENT) = $ 2.29 MM + $ 1.28 MM = $ 3.57 MM

OPERATING CREDITS:	SG	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
PRODUCTS:							
LNG, TE	0.425	19.190	52.130	536.100	10.288	3.567	10.284
TOTAL (OR AVG)	0.425	19.190	52.130	536.100	10.288	3.567	10.284

**** TOTAL ANNUAL CREDITS (PRODUCTS + BYPRODUCTS) = $ 3.57 MM + $ 0.00 MM = $ 3.57 MM

DETAILED SUMMARY OF PROCESS & ECONOMIC DATA FOR CASE# 1

CASE STUDY TITLE :
CASE DESCRIPTION : new meoh-ng plant in edmonton

PROCESS NAME : MEOH-NG   PROCESS CODE : 2

CAPACITY, TE/D :	2000	ON-STREAM FACTOR :	0.900
CAPACITY, GJ/D :	45414	THERMAL EFFICIENCY :	61.1 %
LOCATION :	EDMONTON	STARTUP DATE :	4Q 1983

INVESTMENT:

		*** BASIS ***
TOTAL FIELD COST (TFC), MM$	239.836	(SCALE EXPONENT: .699675)
LAND COST, MM$	0.309	(48.7 ACRES @ 6333 $/ACRE)
HOME OFFICE COST (HOC), MM$	23.984	(10.0% OF TFC)
CAT & CHEM INVENTORY, MM$	6.176	
UNCERTAINTY CONTRIBUTION, MM$	5.406	(UNCERTAINTY FACTOR = 1.02)
TOTAL PLANT COST (TPC), MM$	275.710	
WORKING CAPITAL, MM$	14.859	(60 DAYS OF OPERATING EXPENSES)
START-UP COST, MM$	5.514	(2.0% OF TPC)
INTEREST BEFORE START-UP, MM$	49.628	(15.0% INTEREST ON 40.0% OF TPC OVER 3.0 YEARS)
ROYALTY, MM$	3.021	
CONTINGENCY, MM$	0.000	(0.0% OF TPC)
TOTAL INVESTMENT, MM$	348.732	

** ANNUAL COST OF INVESTMENT @ 10.0% SIMPLE ROI = $ 34.87 MM

OPERATING EXPENSES:	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
FEEDSTOCKS						
NAT GAS, TE	1378.600	52.964	105.928	146.032	47.972	2.000
UTILITIES						
BFW, TE	2962.200	0.000	2.533	7.504	2.465	
ELECTRIC POWER, MWH	124.000	10.551	28.300	3.509	1.153	
COOLING WATER, TE	224030.000	0.000	0.154	34.501	11.333	
CATALYSTS & CHEMICALS				7.732	2.540	
MAINT. MAT. & CONTRACT LAB.				13.142	4.797	
MAINT. LAB. & SUPERVISION, MEN	60		30700	7.835	2.860	
OPER. LAB. & SUPERVISION, MEN	60		30700	7.835	2.860	
ADMIN. & SUPPORT LABOUR				3.134	1.144	
OTHER EXPENSES				16.427	5.996	
TOTAL EXPENSES				247.650	83.119	

**** TOTAL ANNUAL COSTS (OPERATING + INVESTMENT) = $ 83.12 MM + $ 34.87 MM = $ 117.99 MM

OPERATING CREDITS:	SG	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
PRODUCTS:							
METHANOL, TE	0.796	2000.000	22.707	179.592	359.184	117.992	7.909
TOTAL (OR AVG)	0.796	2000.000	22.707	179.592	359.184	117.992	7.909

**** TOTAL ANNUAL CREDITS (PRODUCTS + BYPRODUCTS) = $ 117.99 MM + $ 0.00 MM = $ 117.99 MM

DETAILED SUMMARY OF PROCESS & ECONOMIC DATA FOR CASE# 1

CASE STUDY TITLE :
CASE DESCRIPTION : new ethanol plant in edmonton

PROCESS NAME : ETOH-ETHYLENE   PROCESS CODE : 7

CAPACITY, TE/D :	1075	ON-STREAM FACTOR :	0.900
CAPACITY, GJ/D :	31964.1	THERMAL EFFICIENCY :	59.0 %
LOCATION :	EDMONTON	STARTUP DATE :	4Q 1983

INVESTMENT:

		*** BASIS ***
TOTAL FIELD COST (TFC), MM$	117.72	
LAND COST, MM$	0.19	(30.0 ACRES @ 6333 $/ACRE)
HOME OFFICE COST (HOC), MM$	11.77	(10.0% OF TFC)
CAT & CHEM INVENTORY, MM$	1.06	
UNCERTAINTY CONTRIBUTION, MM$	2.62	(UNCERTAINTY FACTOR = 1.02)
TOTAL PLANT COST (TPC), MM$	133.35	
WORKING CAPITAL, MM$	28.37	(60 DAYS OF OPERATING EXPENSES)
START-UP COST, MM$	2.67	(2.0% OF TPC)
INTEREST BEFORE START-UP, MM$	24.00	(15.0% INTEREST ON 40.0% OF TPC OVER 3.0 YEARS)
ROYALTY, MM$	1.64	
CONTINGENCY, MM$	0.00	(0.0% OF TPC)
TOTAL INVESTMENT, MM$	190.04	

** ANNUAL COST OF INVESTMENT @ 20.0% SIMPLE ROI = $ 38.01 MM

OPERATING EXPENSES:	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
FEEDSTOCKS						
ETHYLENE, TE	690.20	50.35	513.00	354.07	116.31	10.19
UTILITIES						
NAT GAS, TE	35.74	52.96	105.93	3.79	1.24	2.00
ELECTRIC POWER, MWH	116.00	10.55	28.30	3.28	1.08	
POTABLE WATER, TE	2873.00	0.00	0.14	0.41	0.13	
COOLING WATER, TE	160570.00	0.00	0.15	24.73	8.12	
MP STEAM, TE	5841.00	2.79	10.00	58.41	19.19	3.58
CATALYSTS & CHEMICALS				5.85	1.92	
MAINT. MAT. & CONTRACT LAB.				6.45	2.35	
MAINT. LAB. & SUPERVISION, MEN	25		30700	3.26	1.19	
OPER. LAB. & SUPERVISION, MEN	25		30700	3.26	1.19	
ADMIN. & SUPPORT LABOUR				1.31	0.48	
OTHER EXPENSES				8.06	2.94	
TOTAL EXPENSES				472.89	156.16	

**** TOTAL ANNUAL COSTS (OPERATING + INVESTMENT) = $ 156.16 MM + $ 38.01 MM = $ 194.17 MM

OPERATING CREDITS:	SG	UNITS PER DAY	GJ/UNIT	$/UNIT	M$/SD	MM$/YR	$/GJ
PRODUCTS:							
ETHANOL, TE	0.796	1075.00	29.73	549.84	591.07	194.17	18.49
TOTAL (OR AVG)	0.796	1075.00	29.73	549.84	591.07	194.17	18.49

**** TOTAL ANNUAL CREDITS (PRODUCTS + BYPRODUCTS) = $ 194.17 MM + $ 0.00 MM = $ 194.17 MM

APPENDIX D - NOTES ON PLANT GATE COST WORKSHEETS

APPENDIX D - NOTES ON PLANT GATE COST WORKSHEETS

LOCATION & TIME: All plants considered in this study are assumed to be located in the vicinity of Edmonton or Toronto, except that the conventional fuels refinery is based on a S. Ontario location. Capital costs assume a new plant, ready for start up in 4Q83. This is the same as the replacement cost of an existing facility.

RETURN ON INVESTMENT: The following values for pretax ROI have been assumed:

Plant	%ROI
Propane (straddle)	20
Methanol (from NG)	10
Ethanol (from Ethylene)	20
LNG	20
Refinery (retail case)	14.7
Refinery (wholesale case)	-7.0

The above assigned ROI values, which are based on replacement cost of plant, are generally consistent with the market (wholesale) price of the fuel.

PLANT CAPACITIES, ON STREAM FACTORS AND THROUGHPUTS:

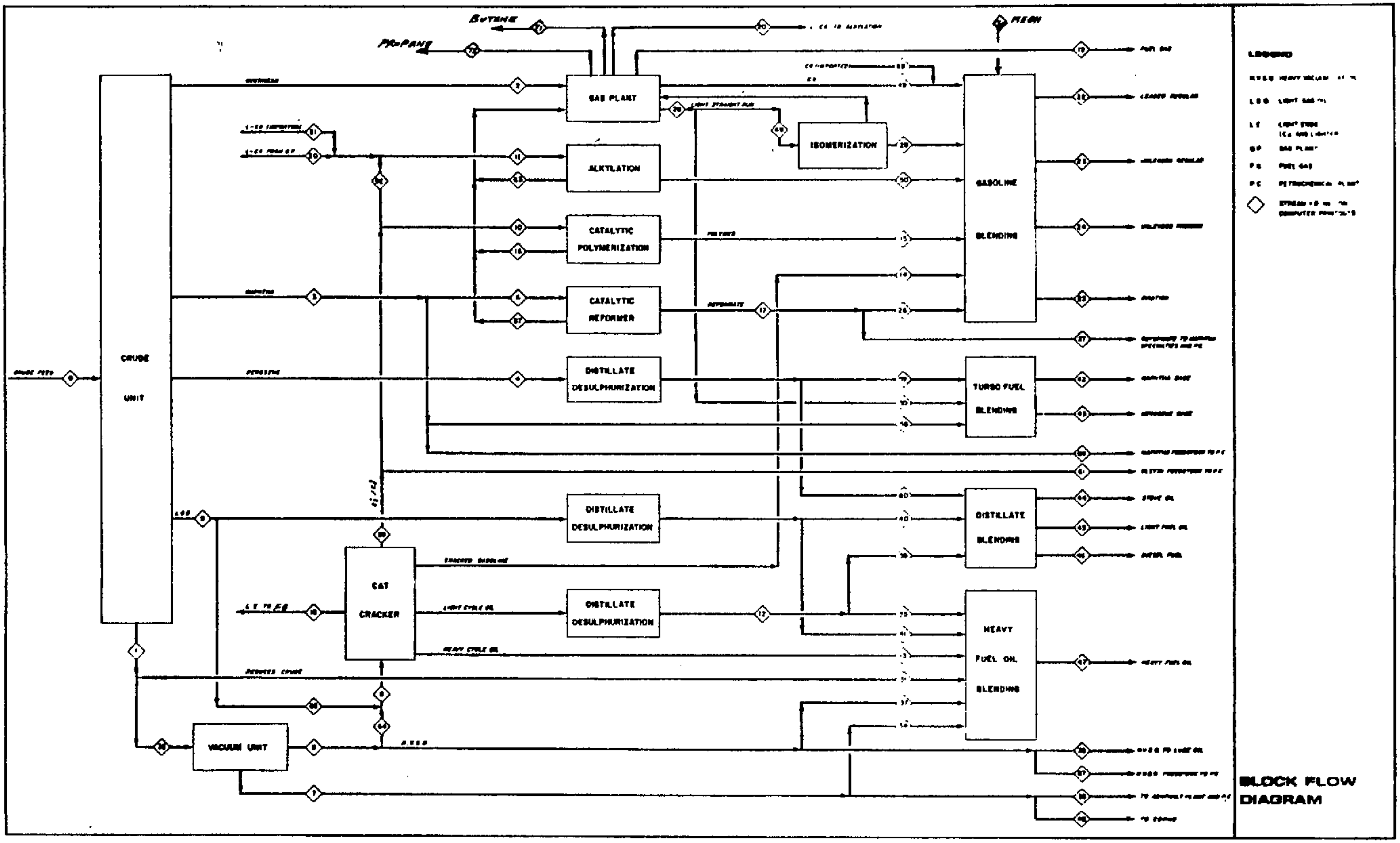
Plant	Design Capacity	Stream Factor (%)	Throughput (% design)
Propane	919 Te/d	.96	100
Methanol	2000 "	.90	100
Ethanol	1075 "	.90	100
LNG	19.2 "	.95	100
Refinery (crude)	85000 BPSD	.95	69

The impact of lower % throughput on these alternative fuels is least for propane and most for LNG. Sensitivities for this variable are as follows:

Fuel	% change in plant gate cost/ % change in throughput
Propane	0.05
Methanol	0.3
Ethanol	0.2
LNG	0.36
Refinery (retail case)	0.09

UNCERTAINTY FACTORS: These are factors associated with the assigned costs of plants to reflect uncertainties inherent in the design and/or estimate.

COMMODITY & LABOUR COSTS: See Appendix E for 4Q83 prices used in development of plant gate costs.


BUTANE
PROPANE
MEOH
GAS PLANT
ALKYLATION
CATALYTIC POLYMERIZATION
CATALYTIC REFORMER
DISTILLATE DESULPHURIZATION
ISOMERIZATION
GASOLINE BLENDING
TURBO FUEL BLENDING
DISTILLATE BLENDING
HEAVY FUEL OIL BLENDING
CRUDE UNIT
CAT CRACKER
DISTILLATE DESULPHURIZATION
DISTILLATE DESULPHURIZATION
VACUUM UNIT
CRACKED GASOLINE
LIGHT CYCLE OIL
HEAVY CYCLE OIL
REDUCED CRUDE
LIGHT STRAIGHT RUN
LEGEND
BLOCK FLOW DIAGRAM

CASE : CONVENTIONAL REFINERY

***** FEED BLEND *****

CRUDE ORIGIN	LV %	BPCD
IPL1	77.3	45202.1
COND	3.8	2222.1
SYNCR	10.5	6140.01
DOMH	8.4	4912

No. MBP	LV %	S.G.	API	SULFUR WT%	BPCD	Lbs/hr FEED	Lbs/hr SULFUR
Total	100				58476.2	713517	2607.32
Average		.837635	37.428	.365418			

***** MATERIAL BALANCE *****

(All flows are BPCD unless otherwise stated.)

CRUDE

*** FEED ***

< 0 > CRUDE FEED= 58476.2

*** PRODUCT ***

< 2 > OVERHEAD= 8434.12

< 28 > LSR= 6188.19

< 3 > NAPHTHA= 8001.4

< 4 > KEROSENE= 12268.2

< 5 > LGO= 5895.6

< 1 > REDUCED CRUDE= 23876.9

STREAM NAME	SG	IBP	EP
LSR	.686379	8	190.008
NAPHTHA	.754108	190.008	299.857
KEROSENE	.810905	299.857	500
LGO	.855297	500	600
REDUCED CRUDE	.940926	600	1300

VACUUM

*** FEED ***

< 32 > REDUCED CRUDE= 23876.9

*** PRODUCT ***

< 6 > HVGO= 18161.1

< 7 > RESIDUUM= 5715.79

STREAM NAME	SG	IBP	EP
REDUCED CRUDE	.940926	600	1310
HVGO	.907206	600	1035
RESIDUUM	1.04807	1035	1310

CAT CRACKER

*** FEED ***

< 64 > HVGO= 18161.1

< 65 > LGO = 3079.96

< 8 > FCCU FEED= 21241.1

*** PRODUCT ***

< 12 > LCO= 3398.57

< 13 > HCO= 849.643

< 14 > CRACKED GAS= 12827.1

< 39 > C3/C4 -FCCU= 5277.67

< 18 > LE FROM CAT CRACKER (FOE)= 1704.71

AVAILABLE C3/C4 OLEFINS= 5277.67

CONVERSION Wt%= 78.5601 CONVERSION Vol %= 80

COKE. WT% 6.71536

COKE .#/HR 18694.1

CASE : CONVENTIONAL REFINERY

CAT POLY

xxx FEED xxx
< 10 > CAT POLY FEED= 0
xxx PRODUCT xxx
< 15 > POLYMER= 0
< 16 > LE FROM POLY (FOE)= 0

ALKYLATION

xxx FEED xxx
< 11 > ALKYLATION FEED= 6528.46
< 62 > C3/C4 TO ALKYL= 4477.67
< 20 > I-C4 FR. GAS PLANT= 446.422
< 21 > I-C4 IMPORTED= 1604.37
xxx PRODUCT xxx
< 50 > ALKYLATE= 4693.02
< 63 > LE FROM ALKYL (FOE)= 526.239

CAT REFORMER

xxx FEED xxx
< 9 > REFORMER FEED= 7500
xxx PRODUCT xxx
< 17 > REFORMATE= 6392.63
< 57 > LE FROM REFORMER (FOE)= 879.605
CONVERSION(LV%)= 85.2351 Severity (RON Clear)= 93 FEED KW= 11.8378

GAS PLANT

xxx FEED xxx
< 2 > OVERHEAD= 8434.12
< 57 > LE FROM REFORMER (FOE)= 879.605
< 16 > LE FROM POLY (FOE)= 0
< 63 > LE FROM ALKYL (FOE)= 526.239
xxx PRODUCT xxx
< 19 > FUEL GAS (FOE)= 2366.6
< 20 > I-C4 FR. GAS PLANT= 446.422
< 49 > REF C4 TO BLENDING = 2414.8
< 69 > LSR= 6155.44
< 71 > BUTANE= 0
< 72 > PROPANE= 1090.3

ISOMERIZATION

xxx FEED xxx
< 69 > LSR= 6155.44
xxx PRODUCT xxx
< 29 > LSR+ISO= 6155.44

xxx BY-PASS= 100 % xxx

GASOLINE BLENDING

xxx FEED xxx
< 29 > LSR+ISO= 6155.44
< 26 > REFORMATE= 4868.63
< 50 > ALKYLATE= 4693.02
< 15 > POLYMER= 0
< 14 > CRACKED GAS= 12827.1
< 49 > REF C4 TO BLENDING = 2414.8
< 68 > IMPORTED C4= 605.813
< 70 > MEOH= 0
xxx PRODUCT xxx
< 22 > LEADED REGULAR= 15322
< 23 > UNLEADED REGULAR= 15569
< 24 > UNLEADED PREMIUM= 0
< 25 > AVIATION GASOLINE= 68

xxx GASOLINE COMPOSITION xxx

	LR	UR	UP	AV
LSR	.388875	.0129838	0	0
CRACKED GAS	.481527	.35	0	0
REFORMATE	.0669158	.246859	0	0
POLYMER	0	0	0	0
ALKYLATE	0	.297157	0	.905
C4	.0626827	.093	0	.095
MEOH	0	0	0	0

TURBO FUEL BLENDING

xxx FEED xxx
< 30 > LSR= 32.75
< 58 > NAPHTHA= 501.4
< 59 > KEROSENE= 2907.85
xxx PRODUCT xxx
< 42 > JET FUEL B= 262
< 43 > JET FUEL A= 3180

xxx TURBO FUEL COMPOSITION xxx

	NAPHTHA BASE (JET B)	KEROSENE BASE (JET A)
LSR	.125	0
NAPHTHA	.7	.1
KEROSENE	.175	.9

DISTILLATE BLENDING

xxx FEED xxx
< 60 > KEROSENE= 9360.36
< 40 > LGO= 2811.07
< 38 > LCO= 3108.57
xxx PRODUCT xxx
< 44 > STOVE OIL= 0
< 45 > LIGHT FUEL OIL= 4640
< 46 > DIESEL FUEL= 10640

xxx DISTILLATE COMPOSITION xxx

	STOVE OIL	DIESEL FUEL	LFO
KEROSENE	1	.686	.444249
LCO	0	.05	.555296
LGO	0	.264	4.55449E-04

HEAVY FUEL OIL BLENDING

xxx FEED xxx
< 41 > LGO= 4.56775
< 35 > LCO= 290
< 13 > HCO= 849.643
< 37 > HVGO= 0
< 31 > REDUCED CRUDE= 0
< 34 > VAC RESIDUUM= 1925.79
xxx PRODUCT xxx
< 47 > HEAVY FUEL OIL= 3070

CASE : CONVENTIONAL REFINERY

OTHER PRODUCTS

< 27 > NAPHTHA SPECIALTIES= 1524
< 36 > HVGO TO LUBE OIL= 0
< 48 > RESID TO COKING= 0
< 33 > VAC RESID TO ASPHALT PLANT= 3790
< 61 > OLEFIN PETROCHEMICAL FEED= 800
< 66 > NAPHTHA PETROCHEMICAL FEED= 0
< 67 > VGO PETROCHEMICAL FEED= 0
< 71 > BUTANE= 0
< 72 > PROPANE= 1090.3

DISTILLATE DESULFURIZATION

STREAM	TOTAL BPCD	DDS FEED BPCD	BY-PASS
KEROSENE	12268.2	0	100
LGO	2815.64	0	100
LCO	3398.57	0	100
HCO	849.643	0	100
VAC RESIDUUM	1925.79	0	100

TOTAL FEED,BPCD 0

PRODUCT SLATES & SPECIFICATIONS

AVIATION TURBO FUELS

JET FUEL B,BPCD	262		
S.G.	.755581		
ASTM 20/50/90	225.387	256.008	373.56
RVP,PSIA	2.15085		
SMOKE PT,MM	.755581		
SULFUR WT%	.0227798		
JET FUEL A,BPCD	3180		
S.G.	.805226		
POUR POINT,F	-54.4766		
ASTM 10/50/90 ,F	339.73	390.392	460.226
FLASH POINT ,F	129.588		
SMOKE PT,MM	.805226		
SULFUR WT%	.0492737		

MIDDLE DISTILLATES

DIESEL FUEL,BPCD	10640		
POUR POINT ,F	-37.9692		
S.G.	.829055		
ASTM 10/50/90 ,F	369.182	446.52	551.455
FLASH POINT ,F	138.416		
CETANE NUMBER	45.4467		
VISCOSITY @ 100 F,C.S.	1.81528		
CHAR FACTOR	11.6596		
MEABP ,F	443.237		
SULFUR WT%	.109198		

CASE : CONVENTIONAL REFINERY

LIGHT FUEL OIL,BPCD	4640		
POUR POINT ,F	-63.8373		
S.G.	.882342		
ASTM 10/50/90 ,F	381.111	477.128	593.435
FLASH POINT ,F	145.086		
VISCOSITY @ 100 F,C.S.	2.31495		
CHAR FACTOR	11.074		
SULFUR WT%	.281895		

STOVE OIL,BPCD	0		
POUR POINT ,F	-51.5978		
S.G.	.810905		
ASTM 10/50/90 ,F	356.713	401.6	462.786
FLASH POINT ,F	131.93		
VISCOSITY @ 100 F,C.S.	1.40758		
SULFUR WT%	.0527973		

HEAVY FUEL OIL

HEAVY FUEL OIL,BPCD	3070
VISCOSITY @ 122 F, C.S	290.748
SULFUR WT%	1.17603

GASOLINE

LEADED REGULAR,BPCD	15322
TEL Addition,cc/IG:	1.75
RON / MON / (R+M)/2 (Clear)	87.2095 / 78.8821 / 83.0458
RON / MON / (R+M)/2	93.6454 / 84.6104 / 89.1279
RVP,psia	10.9271
UNLEADED REGULAR,BPCD	15569
RON / MON / (R+M)/2	92.5 / 85.6406 / 89.0703
RVP,psia	11.0181
UNLEADED PREMIUM,BPCD	0
RON / MON / (R+M)/2	0 / 0 / 0
RVP,psia	0
AVIATION GASOLINE,BPCD	68
RON / MON / (R+M)/2	92.9829 / 90.8 / 91.9
RVP,psia	10.7934

REFINERY SIMULATION PROGRAM

CASE:ETOH-LEADED

CASE : 10% ETHANOL BLEND

CRUDE ORIGIN	LV %	BPCD
IPL1	77.3	42122.8
COND	3.8	2070.72
SYNCR	10.5	5721.73
DOMH	8.4	4577.38

No. HBP	LV %	S.G.	API	SULFUR WT%	BPCD	Lbs/hr FEED	Lbs/hr SULFUR
Total	100				54492.6	664918	2429.7
Average		.837635	37.428	.365418			

xxxx MATERIAL BALANCE xxxx

(All flows are BPCD unless otherwise stated.)

CRUDE

xxx FEED xxx

< 0 > CRUDE FEED= 54492.6

xxx PRODUCT xxx

< 2 > OVERHEAD= 13510.9

< 28 > LSR= 11417.9

< 3 > NAPHTHA= 1807.4

< 4 > KEROSENE= 10334.6

< 5 > LGO= 6062.48

< 1 > REDUCED CRUDE= 22777.3

STREAM NAME	SG	IBP	EP
LSR	.717542	0	273.204
NAPHTHA	.769032	273.204	299.892
KEROSENE	.807655	299.892	480
LGO	.851977	480	590
REDUCED CRUDE	.939173	590	1300

VACUUM

xxx FEED xxx

< 32 > REDUCED CRUDE= 22777.3

xxx PRODUCT xxx

< 6 > HVGO= 17318.1

< 7 > RESIDUUM= 5459.18

STREAM NAME	SG	IBP	EP
REDUCED CRUDE	.939173	590	1310
HVGO	.905564	590	1030
RESIDUUM	1.04579	1030	1310

CAT CRACKER

xxx FEED xxx

< 64 > HVGO= 17318.1

< 65 > LGO = 2361.56

< 8 > FCCU FEED= 19679.7

xxx PRODUCT xxx

< 12 > LCO= 4723.12

< 13 > HCO= 1180.78

< 14 > CRACKED GAS= 10749.8

< 39 > C3/C4 -FCCU= 4062.49

< 18 > LE FROM CAT CRACKER (FOE)= 1192.69

AVAILABLE C3/C4 OLEFINS= 4062.49

CONVERSION Wt%= 68.3723 CONVERSION Vol %= 70

COKE, WT% 5.35565

COKE ,#/HR 13804.6

CASE : 10% ETHANOL BLEND

CAT POLY

xxx FEED xxx
< 10 > CAT POLY FEED= 0
xxx PRODUCT xxx
< 15 > POLYMER= 0
< 16 > LE FROM POLY (FOE)= 0

ALKYLATION

xxx FEED xxx
< 11 > ALKYLATION FEED= 4758.57
< 62 > C3/C4 TO ALKYL= 3262.49
< 20 > I-C4 FR. GAS PLANT= 301.7
< 21 > I-C4 IMPORTED= 1194.38
xxx PRODUCT xxx
< 50 > ALKYLATE= 3425.86
< 63 > LE FROM ALKYL (FOE)= 378.86

CAT REFORMER

xxx FEED xxx
< 9 > REFORMER FEED= 1755
xxx PRODUCT xxx
< 17 > REFORMATE= 1525.18
< 57 > LE FROM REFORMER (FOE)= 150.871
CONVERSION(LV%)= 86.9048 Severity (RON Clear)= 90 FEED KW= 11.8272

GAS PLANT

xxx FEED xxx
< 2 > OVERHEAD= 13510.9
< 57 > LE FROM REFORMER (FOE)= 150.871
< 16 > LE FROM POLY (FOE)= 0
< 63 > LE FROM ALKYL (FOE)= 378.86
xxx PRODUCT xxx
< 19 > FUEL GAS (FOE)= 1416.34
< 20 > I-C4 FR. GAS PLANT= 301.7
< 49 > REF C4 TO BLENDING = 2399.32
< 69 > LSR= 11286.9
< 71 > BUTANE= 0
< 72 > PROPANE= 790.352

ISOMERIZATION

xxx FEED xxx
< 69 > LSR= 11286.9
xxx PRODUCT xxx
< 29 > LSR+ISO= 11286.9

xxx BY-PASS= 100 % xxx

GASOLINE BLENDING

xxx FEED xxx
< 29 > LSR+ISO= 11286.9
< 26 > REFORMATE= 1.17542
< 50 > ALKYLATE= 3425.86
< 15 > POLYMER= 0
< 14 > CRACKED GAS= 10749.8
< 49 > REF C4 TO BLENDING = 2399.32
< 68 > IMPORTED C4= 956.738
< 70 > OCT BOOSTER= 3095.9
xxx PRODUCT xxx
< 22 > LEADED REGULAR= 15322
< 23 > UNLEADED REGULAR= 15569
< 24 > UNLEADED PREMIUM= 0
< 25 > AVIATION GASOLINE= 68

CASE : 10% ETHANOL BLEND

xxx GASOLINE COMPOSITION xxx

	LR	UR	UP	AV
LSR	.534977	.199232	0	0
CRACKED GAS	.284983	.41	0	0
REFORMATE	7.67142E-05	0	0	0
POLYMER	0	0	0	0
ALKYLATE	0	.215768	0	.905
C4	.0799626	.075	0	.095
MEOH	0	0	0	0

TURBO FUEL BLENDING

xxx FEED xxx
< 30 > LSR= 131
< 58 > NAPHTHA= 52.4
< 59 > KEROSENE= 3258.6
xxx PRODUCT xxx
< 42 > JET FUEL B= 262
< 43 > JET FUEL A= 3180

xxx TURBO FUEL COMPOSITION xxx

	NAPHTHA BASE (JET B)	KEROSENE BASE (JET A)
LSR	.5	0
NAPHTHA	.2	0
KEROSENE	.3	1

DISTILLATE BLENDING

xxx FEED xxx
< 60 > KEROSENE= 7076.01
< 40 > LGO= 3700.88
< 38 > LCO= 4503.12
xxx PRODUCT xxx
< 44 > STOVE OIL= 0
< 45 > LIGHT FUEL OIL= 4640
< 46 > DIESEL FUEL= 10640

xxx DISTILLATE COMPOSITION xxx

	STOVE OIL	DIESEL FUEL	LFO
KEROSENE	1	.5223	.327312
LCO	0	.13	.672397
LGO	0	.3477	2.91127E-04

HEAVY FUEL OIL BLENDING

xxx FEED xxx
< 41 > LGO= .0402832
< 35 > LCO= 220
< 13 > HCO= 1180.78
< 37 > HVGO= 0
< 31 > REDUCED CRUDE= 0
< 34 > VAC RESIDUUM= 1669.18
xxx PRODUCT xxx
< 47 > HEAVY FUEL OIL= 3070

CASE : 10% ETHANOL BLEND

OTHER PRODUCTS

< 27 > NAPHTHA SPECIALTIES= 1524
< 36 > HVGO TO LUBE OIL= 0
< 48 > RESID TO COKING= 0
< 33 > VAC RESID TO ASPHALT PLANT= 3790
< 61 > OLEFIN PETROCHEMICAL FEED= 800
< 66 > NAPHTHA PETROCHEMICAL FEED= 0
< 67 > VGO PETROCHEMICAL FEED= 0
< 71 > BUTANE= 0
< 72 > PROPANE= 790.352

DISTILLATE DESULFURIZATION

STREAM	TOTAL BPCD	DDS FEED BPCD	BY-PASS
KEROSENE	10334.6	0	100
LGO	3700.92	0	100
LCO	4723.12	0	100
HCO	1180.78	0	100
VAC RESIDUUM	1669.18	0	100

TOTAL FEED,BPCD 0

PRODUCT SLATES & SPECIFICATIONS

AVIATION TURBO FUELS

JET FUEL B,BPCD	262		
S.G.	.754874		
ASTM 20/50/90	201.449	275.785	410.534
RVP,PSIA	2.21147		
SMOKE PT,MM	.754874		
SULFUR WT%	.026516		
JET FUEL A,BPCD	3180		
S.G.	.807655		
POUR POINT,F	-55.0353		
ASTM 10/50/90 ,F	353.214	391.957	446.727
FLASH POINT ,F	130.152		
SMOKE PT,MM	.807655		
SULFUR WT%	.0465498		

MIDDLE DISTILLATES

DIESEL FUEL,BPCD	10640		
POUR POINT ,F	-37.0394		
S.G.	.838475		
ASTM 10/50/90 ,F	374.045	467.76	553.688
FLASH POINT ,F	141.068		
CETANE NUMBER	45.1807		
VISCOSITY @ 100 F,C.S.	1.97916		
CHAR FACTOR	11.5839		
MEABP ,F	456.299		
SULFUR WT%	.132356		

CASE : 10% ETHANOL BLEND

LIGHT FUEL OIL,BPCD	4640		
POUR POINT ,F	-59.1771		
S.G.	.88737		
ASTM 10/50/90 ,F	391.088	492.057	598.468
FLASH POINT ,F	150.608		
VISCOSITY @ 100 F,C.S.	2.52907		
CHAR FACTOR	11.0616		
SULFUR WT%	.269509		

STOVE OIL,BPCD	0		
POUR POINT ,F	-55.0353		
S.G.	.807655		
ASTM 10/50/90 ,F	353.214	391.957	446.727
FLASH POINT ,F	130.152		
VISCOSITY @ 100 F,C.S.	1.3375		
SULFUR WT%	.0465498		

HEAVY FUEL OIL

HEAVY FUEL OIL,BPCD	3070
VISCOSITY @ 122 F, C.S	194.314
SULFUR WT%	1.05935

GASOLINE

LEADED REGULAR,BPCD	15322
TEL Addition,cc/IG:	1.2
RON / MON / (R+M)/2 (Clear)	88.8457 / 79.9929 / 84.4193
RON / MON / (R+M)/2	93.6702 / 84.2366 / 88.9534
RVP,psia	10.9943

UNLEADED REGULAR,BPCD	15569
RON / MON / (R+M)/2	93.3095 / 84.8821 / 89.0958
RVP,psia	11.0248

UNLEADED PREMIUM,BPCD	0
RON / MON / (R+M)/2	0 / 0 / 0
RVP,psia	0

AVIATION GASOLINE,BPCD	68
RON / MON / (R+M)/2	92.9829 / 90.8 / 91.9
RVP,psia	10.7934

CASE : 9.5% OXINOL BLEND

xxxx FEED BLEND xxxx

CRUDE ORIGIN	LV %	BPCD
IPL1	77.3	42918.7
COND	3.8	2109.84
SYNCR	10.5	5829.83
DOMH	8.4	4663.87

No. MPF	LV %	S.G.	API	SULFUR WT%	BPCD	Lbs/hr FEED	Lbs/hr SULFUR
Total	100				55522.2	677473	2475.61
Average		.837635	37.428	.365418			

xxxx MATERIAL BALANCE xxxx

(All flows are BPCD unless otherwise stated.)

CRUDE

xxx FEED xxx
< 0 > CRUDE FEED= 55522.2
xxx PRODUCT xxx
< 2 > OVERHEAD= 12104.8
< 28 > LSR= 9972.29
< 3 > NAPHTHA= 3501.4
< 4 > KEROSENE= 11647.6
< 5 > LGO= 5597.77
< 1 > REDUCED CRUDE= 22670.7

STREAM NAME	SG	IBP	EP
LSR	.710421	8	249.19
NAPHTHA	.764882	249.19	299.87
KEROSENE	.810908	299.87	500
LGO	.855297	500	600
REDUCED CRUDE	.940926	600	1300

VACUUM

xxx FEED xxx
< 32 > REDUCED CRUDE= 22670.7
xxx PRODUCT xxx
< 6 > HVGO= 17243.7
< 7 > RESIDUUM= 5427.05

STREAM NAME	SG	IBP	EP
REDUCED CRUDE	.940926	600	1310
HVGO	.907206	600	1035
RESIDUUM	1.04807	1035	1310

CAT CRACKER

xxx FEED xxx
< 64 > HVGO= 17243.7
< 65 > LGO = 2645.23
< 8 > FCCU FEED= 19888.9
xxx PRODUCT xxx
< 12 > LCO= 3977.78
< 13 > HCO= 994.446
< 14 > CRACKED GAS= 11405.5
< 39 > C3/C4 -FCCU= 4521.89
< 18 > LE FROM CAT CRACKER (FOE)= 1407.4
AVAILABLE C3/C4 OLEFINS= 4521.89
CONVERSION Wt%= 73.4065 CONVERSION Vol %= 75
COKE, WT% 6.15387
COKE ,#/HR 16051.6

CASE : 9.5% OXINOL BLEND

CAT POLY

xxx FEED xxx
< 10 > CAT POLY FEED= 0
xxx PRODUCT xxx
< 15 > POLYMER= 0
< 16 > LE FROM POLY (FOE)= 0

ALKYLATION

xxx FEED xxx
< 11 > ALKYLATION FEED= 5430.08
< 62 > C3/C4 TO ALKYL= 3721.89
< 20 > I-C4 FR. GAS PLANT= 329.013
< 21 > I-C4 IMPORTED= 1379.17
xxx PRODUCT xxx
< 50 > ALKYLATE= 3904.94
< 63 > LE FROM ALKYL (FOE)= 436.458

CAT REFORMER

xxx FEED xxx
< 9 > REFORMER FEED= 3000
xxx PRODUCT xxx
< 17 > REFORMATE= 2606.7
< 57 > LE FROM REFORMER (FOE)= 257.886
CONVERSION(LV%)= 86.89   Severity (RON Clear)= 90   FEED KW= 11.8291

GAS PLANT

xxx FEED xxx
< 2 > OVERHEAD= 12104.8
< 57 > LE FROM REFORMER (FOE)= 257.886
< 16 > LE FROM POLY (FOE)= 0
< 63 > LE FROM ALKYL (FOE)= 436.458
xxx PRODUCT xxx
< 19 > FUEL GAS (FOE)= 1692.09
< 20 > I-C4 FR. GAS PLANT= 329.013
< 49 > REF C4 TO BLENDING = 1733.7
< 69 > LSR= 9891.07
< 71 > BUTANE= 0
< 72 > PROPANE= 864.063

ISOMERIZATION

xxx FEED xxx
< 69 > LSR= 9891.07
xxx PRODUCT xxx
< 29 > LSR+ISO= 9891.07

xxx BY-PASS= 100 % xxx

GASOLINE BLENDING

xxx FEED xxx
< 29 > LSR+ISO= 9891.07
< 26 > REFORMATE= 1082.7
< 50 > ALKYLATE= 3904.94
< 15 > POLYMER= 0
< 14 > CRACKED GAS= 11405.5
< 49 > REF C4 TO BLENDING = 1733.7
< 68 > IMPORTED C4= 196.776
< 70 > OCT BOOSTER= 2941.11
xxx PRODUCT xxx
< 22 > LEADED REGULAR= 15322
< 23 > UNLEADED REGULAR= 15569
< 24 > UNLEADED PREMIUM= 0
< 25 > AVIATION GASOLINE= 68

CASE : 9.5% OXINOL BLEND

xxx GASOLINE COMPOSITION xxx

	LR	UR	UP	AV
LSR	.563566	.0814189	0	0
CRACKED GAS	.287132	.45	0	0
REFORMATE	0	.0695423	0	0
POLYMER	0	0	0	0
ALKYLATE	0	.246539	0	.905
C4	.0543027	.0575	0	.095
MEOH	0	0	0	0

TURBO FUEL BLENDING

xxx FEED xxx
< 30 > LSR= 81.22
< 58 > NAPHTHA= 501.4
< 59 > KEROSENE= 2859.38
xxx PRODUCT xxx
< 42 > JET FUEL B= 262
< 43 > JET FUEL A= 3180

xxx TURBO FUEL COMPOSITION xxx

	NAPHTHA BASE (JET B)	KEROSENE BASE (JET A)
LSR	.31	0
NAPHTHA	.7	.1
KEROSENE	-9.99999E-03	.9

DISTILLATE BLENDING

xxx FEED xxx
< 60 > KEROSENE= 8788.19
< 40 > LGO= 2949.04
< 38 > LCO= 3542.78
xxx PRODUCT xxx
< 44 > STOVE OIL= 0
< 45 > LIGHT FUEL OIL= 4640
< 46 > DIESEL FUEL= 10640

xxx DISTILLATE COMPOSITION xxx

	STOVE OIL	DIESEL FUEL	LFO
KEROSENE	1	.648	.408072
LCO	0	.075	.591548
LGO	0	.277	3.80154E-04

HEAVY FUEL OIL BLENDING

xxx FEED xxx
< 41 > LGO= 3.5036
< 35 > LCO= 435
< 13 > HCO= 994.446
< 37 > HVGO= 0
< 31 > REDUCED CRUDE= 0
< 34 > VAC RESIDUUM= 1637.05
xxx PRODUCT xxx
< 47 > HEAVY FUEL OIL= 3070

OTHER PRODUCTS

< 27 > NAPHTHA SPECIALTIES= 1524
< 36 > HVGO TO LUBE OIL= 0
< 48 > RESID TO COKING= 0
< 33 > VAC RESID TO ASPHALT PLANT= 3790
< 61 > OLEFIN PETROCHEMICAL FEED= 800
< 66 > NAPHTHA PETROCHEMICAL FEED= 0
< 67 > VGO PETROCHEMICAL FEED= 0
< 71 > BUTANE= 0
< 72 > PROPANE= 864.063

DISTILLATE DESULFURIZATION

STREAM	TOTAL BPCD	DDS FEED BPCD	BY-PASS
KEROSENE	11647.6	0	100
LGO	2952.54	0	100
LCO	3977.78	0	100
HCO	994.446	0	100
VAC RESIDUUM	1637.05	0	100

TOTAL FEED,BPCD 0

PRODUCT SLATES & SPECIFICATIONS

AVIATION TURBO FUELS

JET FUEL B,BPCD	262		
S.G.	.747539		
ASTM 20/50/90	220.695	269.993	287.477
RVP,PSIA	2.02075		
SMOKE PT,MM	.747539		
SULFUR WT%	.0160257		

JET FUEL A,BPCD	3180		
S.G.	.806306		
POUR POINT,F	-55.3287		
ASTM 10/50/90 ,F	340.08	390.401	460.228
FLASH POINT ,F	125.344		
SMOKE PT,MM	.806306		
SULFUR WT%	.049303		

MIDDLE DISTILLATES

DIESEL FUEL,BPCD	10640		
POUR POINT ,F	-37.2472		
S.G.	.832474		
ASTM 10/50/90 ,F	370.847	453.843	554.982
FLASH POINT ,F	139.314		
CETANE NUMBER	45.2928		
VISCOSITY @ 100 F,C.S.	1.87876		
CHAR FACTOR	11.6344		
MEABP ,F	448.553		
SULFUR WT%	.117951		

CASE : 9.5% OXINOL BLEND

LIGHT FUEL OIL,BPCD	4640
POUR POINT ,F	-61.9696
S.G.	.884041
ASTM 10/50/90 ,F	384.781 482.209 595.168
FLASH POINT ,F	147.13
VISCOSITY @ 100 F,C.S.	2.39066
CHAR FACTOR	11.0714
SULFUR WT%	.269362

STOVE OIL,BPCD	0
POUR POINT ,F	-51.5951
S.G.	.810908
ASTM 10/50/90 ,F	356.725 401.608 462.788
FLASH POINT ,F	131.936
VISCOSITY @ 100 F,C.S.	1.40764
SULFUR WT%	.0527999

HEAVY FUEL OIL

HEAVY FUEL OIL,BPCD	3070
VISCOSITY @ 122 F, C.S	104.572
SULFUR WT%	1.06701

GASOLINE

LEADED REGULAR,BPCD	15322
TEL Addition,cc/IG:	1.75
RON / MON / (R+M)/2 (Clear)	86.3803 / 78.9183 / 82.6493
RON / MON / (R+M)/2	93.0827 / 84.9986 / 89.0407
RVP,psia	10.8572

UNLEADED REGULAR,BPCD	15569
RON / MON / (R+M)/2	92.7141 / 85.2458 / 88.98
RVP,psia	11.0819

UNLEADED PREMIUM,BPCD	0
RON / MON / (R+M)/2	0 / 0 / 0
RVP,psia	0

AVIATION GASOLINE,BPCD	68
RON / MON / (R+M)/2	92.9829 / 90.8 / 91.9
RVP,psia	10.7934

APPENDIX E - COMMODITY PRICES IN 4Q83

APPENDIX E COMMODITY PRICES IN 4Q83

Major Resource Costs

Natural Gas (3)

	$/GJ	End User	$/GJ(4)
Alta. Wholesale Price	1.59	Alta. Industrial (1)	2.00
		Alta. Commercial (2)	2.40
Distribution & Other Costs	+1.04		
Alta. Border Price	=2.63		
TCPL Tariff	+0.94		
Toronto City Gate Price	=3.57		
NGGL Tax	+0.15		
Canadian Ownership Charge	+0.14		
Toronto Wholesale Price	=3.86	Toronto Industrial (1)	3.94
		Toronto Commercial (2)	4.70

(1) Suitable for large scale MeOH-NG plant or refinery

(2) Suitable for CNG refuelling station

(3) Sources: EPN, Nov. 1983; EMR, Energy Statistics Handbook; Northwestern Utilities and Consumers' Gas.

(4) Difference between wholesale and end user cost is utility company charge.

Domestic Crude (1)	$/BBL
Old Oil (avg. wellhead)	29.46
Petroleum Compensation Charge	3.76
Canadian Ownership Charge	1.15
TCPL Tariff (Edmon-Toronto)	1.11
Alta. Gathering Charge	0.52
Blended Price at Toronto Refinery Gate	36.00 ($226.5/cu.m.)

(1) Source: EPN, Nov. 1983

Other Commodities

Utilities

Electric Power	2.83¢/kwh (Edmonton)
Electric Power	3.21¢/kwh (Toronto)
Raw Water	6¢/Te
Boiler Feedwater	$2.53/Te
Cooling Water (recirc)	15.4¢/Te
Potable Water	14¢/Te
Medium Pressure Steam	$3.58/GJ (Edmonton)

Feedstocks and Byproducts

Ethylene	$ 513/Te	(Edmonton)
Butanes	$ 225/cu.m.	(Toronto)
TEL (100%)	$ 4.8/kg	(Toronto)
Propane(3)	$ 167/cu.m.	(Toronto)
Sulphur	$ 70/Te	(Toronto)
Heavy Fuel Oil	$ 187/cu.m.	(Toronto)
Ethanol	$ 481/cu.m.	(Toronto) (2)
Methanol	$ 186/cu.m.	(Toronto) (2)
TBA	$ 360/cu.m.	(Toronto)
Oxinol	$ 271/cu.m.	(Toronto)

(1) These are prices f.o.b. fuels plant gate except where noted. Product prices are calculated using the Alternative Fuels Economics model program (see Appendices C & D).

(2) Includes $43/cu.m. rail transportation cost from Edmonton plant.

(3) Refinery by-product.

Labour (1)

Manufacturing plant operating/maintenance labour	$30700/yr
Refuelling station labour	$6.5-7.0/hr.

(1) Excluding burdens and benefits and supervising staff.

APPENDIX F - FACTORS FOR CONVERSION OF BRITISH TO SI UNITS

APPENDIX F - FACTORS FOR CONVERSION OF BRITISH TO SI UNITS

(kg)	=	.4536	(lb)
(kg/h)	=	.4536	(lb/h)
(Te)	=	.907	(ST)
(Te/d)	=	.907	(STPD)
(GJ)	=	1.0551	(MMBTU)
(kPa)	=	6.895	(psi)
(GJ/kg)	=	2.326	(MMBTU/lb)
(GJ/Te)	=	1.163	(MMBTU/ST)
(kJ/kg)	=	2.326	(BTU/lb)
(Mwh)	=	.2931	(MMBTU)
(m3/d)	=	.15899	(BPD)
(Nm3/m3)	=	.1684	(SCFB)
(Nm3)	=	.0268	(SCF)
(Sm3)	=	.0283	(SCF)
(GJ/m3)	=	6.652	(MMBTU/BBL)
litre	=	158.63	(BBL)
litre	=	3.778	(U.S. gal)
litre	=	4.536	(Imp. gal)
¢/litre	=	.6305	($/BBL)
¢/litre	=	.2647	(¢/U.S. gal)
¢/litre	=	.2205	(¢/Imp. gal)
$/GJ	=	.9478	($/MMBTU)
$/Te	=	1.1025	($/ST)
$/Te	=	6.305/sg	($/BBL)
$/Sm3	=	35.3	($/SCF)

APPENDIX G - GLOSSARY OF TERMS

APPENDIX G - GLOSSARY OF TERMS

Miscellaneous

SI	Spark ignition
CI	Compression ignition
FOE	Fuel oil equivalent of material (on energy basis)
FOEB*	Energy equivalent of material in barrels of fuel oil
NGGL	Natural gas and gas liquids
TCPL	Trans Canada Pipelines Ltd.
MM**	$(10)^6$
M	$(10)^3$
M$/SD	Thousands of $ per stream day
BPCD	Barrels per calendar day
BBL	Barrel
DDS	Distillate desulphurization unit
FCC	Fluid catalytic cracking unit

Properties

LV%	Liquid volume %
IBP	Initial boiling point (TBP basis) of material
EP	End point (TBP basis) of material
TBP	True boiling point distillation
API	Gravity based on American Petroleum Institute method
SG	Specific gravity
RVP	Reid vapour pressure
MeABP	Mean average boiling point
RON	Research octane number
MON	Motor octane number

*	Energy content of fuel oil is assumed to be 6.4 MMBTU(HHV)/BBL
**	Millimeters when applied to smoke point

Materials

RL Gasoline	Regular leaded gasoline
MeOH	Methanol
MeOH 100%	Methanol - fuel grade
MeOH 90%	90v% methanol, 10v% RL gasoline
MeOH blend	90.5v% RL gasoline, 4.75v% MeOH, 4.75v% BuOH
BuOH	t-Butanol (tertiary butanol)
MeOH + cet	95v% methanol, 5v% cetane enhancer
EtOH	Ethanol (100%)
EtOH blend	90v% RL gasoline, 10v% ethanol
C3	Propane or propane & propylene
C3/diesel	80v% propane, 20v% diesel, concurrent injection
C4	Butanes
IC4	Iso-Butane
TEL	Tetraethyl lead
BFW	Boiler feedwater
MP steam	Medium pressure steam
SYNCR	Syncrude
DOMH	Domestic heavy crude
COND	C5+condensate
IPL1	InterProvincial Pipeline #1 crude
LCO	Light cycle oil from FCC unit
HCO	Heavy cycle oil from FCC unit
LSR	Light straight run naphtha
LGO	Light (straight run) gas oil
HVGO	Heavy vacuum gas oil
LE	Light ends (i.e. ethanol and lighter gases)
LNG	Liquefied natural gas
CNG	Compressed natural gas at 16.5 MPa pressure