Energy Economies – West Vancouver Municipal Fleet Conversion to Compressed Natural Gas (CNG)

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July, 1991

ABSTRACT

West Vancouver commenced its studies into converting its Municipal fleet to alternative fuels in 1981. Through delays in determining the best alternative fuel and in obtaining funding, the program did not start until 1984 when 27 public works and parks vehicles were converted to dual-fuelled gasoline and CNG. Subsequently 12 police patrol vehicles were also converted.

This paper looks at the factors used in deciding to go to CNG compared with propane. It sets out projected cost comparisons, final costs and current fuel savings.

To assist others who may be contemplating converting to alternate fuels, this layman's guide provides a table of conversion factors and a sample costing procedure.

ENERGY ECONOMIES
WEST VANCOUVER WJNICIPAL FLEET CONVERSION
TO COMPRESSED NATURAL GAS (CNG)

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PURPOSE

Since 1984 West Vancouver has had vehicles operating on compressed natural gas. We have endeavoured over the years since then to assist other Municipalities who were enquiring into the benefits of converting their fleets. While our assistance has been acknowledged as being helpful, as Municipal Manager since January 1973 for the District of West Vancouver, I believed a comprehensive paper. setting forth our reasons for converting and the benefits which have accrued to the Municipality would be an invaluable tool assisting those investigating the NGV (natural gas vehicle) program. Unfortunately the preparation of such a paper had a very low priority in the Municipal Manager's daily experience.

There was a Municipal purpose to be served in the preparation of such a paper; to convince the Police Department that there were good reasons to convert their vehicles to CNG.

Since my retirement as Municipal Manager at the end of 1990, the opportunity and time became available to do this work.

While this paper will hopefully serve the Municipality to persuade its police to convert their vehicles, and hopefully will assist other Municipalities in their research and decision-making, it is also self-serving to Terry Lester who has been advised by the Department of Municipal Affairs' Board of Examiners that upon preparation of a case study and acceptance by the Board of Examiners, the author would be eligible for an advanced certificate in Municipal Administration.

Therefore many interests are being served here. In my years of experience as a professional administrator I have found that where self-interests are appropriately combined with public interest, a better product or result will be obtained.

ACKNOWLEDGEMENTS

It is with pleasure that I acknowledge the very considerable assistance I received from many people and organizations while researching, organizing the data and preparing the report. If there are errors they are mine alone for failing to understand a rather complex subject. Certainly the technical research papers were daunting and I make no pretence of having a full understanding of the technical jargon, research and experimental methodologies nor necessarily, the results thereof.

Those to whom my grateful thanks are extended are:

- Public Technology Incorporated (PTI) - This is the technical arm of the International City Management Association which provided many research papers on NGV operations in the United States. I am particularly grateful for the information provided respecting police vehicle conversions.

- Dr. Lorne Gettel and Dale Brown of the Engine Systems and Alternate Fuels Group at B.C. Research for their time, understanding and assistance in making the B.C. Research Database on NGV's available to me.

- Bill Hennessy, B.C. Gas for having ready answers to my many questions and with advanced appreciation extended to him for assisting West Vancouver in hopefully obtaining the grant which his Corporation has available to convert the remaining vehicles which we now wish to change.

- John Goyan, Purchasing Agent and John Pollitt, Public Works Manager and the people who back them up at the District of West Vancouver for their file research and willing assistance.

A very special thank you is extended to John Pollitt, Wayne Mowat, Bill Laut and Clay Ronaghan, Public Works and Maintenance employees, for the many hours of dedicated research and perseverance over the past 7 years in creating a physical C.N.G. conversion system which works.

I.T. Lester
'West Vancouver, B.C.
July, 1991

BACKGROUND

MUNICIPAL MANAGER'S ATTITUDE/PHILOSOPHY

I learned early in my management career that to be a successful manager, one had to respond positively to the taxpayer's expectation of getting the biggest bang for the least buck. In order to do this one must have a fertile mind which constantly seeks innovative but effective methods of performance, knowledge of where to access. information on innovations elsewhere and a willingness to acknowledge the expertise and experience of others who may have gone before you. The pride of authorship will never have place in the persona of the successful manager.

PTI MEMBERSHIP

As stated previously, Public Technology Incorporated is the technical arm of the International City Management Association which was created to ensure that Municipalities had access to the latest technologies available from private industry and research corporations to aid Municipalities in the effective and efficient delivery of services to their citizens.

In 1991 there are nearly three hundred Municipal members of PTI ranging from very small villages to the two largest cities in the United States, New York City and Los Angeles. In Canada only eight Municipalities have seen the benefits of this organization including Regina, Quebec City and of course West Vancouver.

West Vancouver was the second Municipality in Canada to join, as a result of seeking out a computer software package which would assist us in evaluating our future Fire Department needs, particularly with reference to siting of fire halls.. PTI provided the software package and hands-on assistance in our use of their Fire Station Location Package. As a result of the exercise, instead of the Municipality planning for seven fire halls in the future, it was determined that with appropriate location of new halls and relocation of existing halls, the Municipality would only require a total of five fire halls. (We currently have four.) This of course represents enormous manpower cost savings' for the future.

Other information which we accessed by a request to their "ANSWER" telephone line included a system of police car rehabilitation, first done in Walnut Grove, California, in which we completely rebuild our police patrol vehicles after eighteen months of service giving a further fourteen to sixteen months of service. A rebuild saves the Municipality, two-thirds the cost of a new vehicle.

Public Technology publishes on an annual basis a manual entitled "Solutions" which in 1991 contained five hundred twenty-six pages of innovations being tried or practiced in Municipalities in North America. There were twelve pages on energy conservation this year including one referencing the City of Edmonton having established an Energy Conservation Committee.

ENERGY CONSERVATION COMMITTEE

In May, 1980, the Municipal Manager appointed West Vancouver's Energy Conservation Committee to look at ways of conserving energy in Municipal buildings, vehicles and public utilities for which we were responsible.

The Energy Conservation Committee commenced its work by reviewing information on conservation processes and procedures throughout North America. Flowing from the data gathered, the Committee undertook energy audits of Municipal buildings which resulted in changes making the heating systems more efficient and reduction in lighting levels. B.C. Hydro which had produced thermograms (heat loss pictures) assisted in the audits of the major Municipal facilities including the Municipal Hall, Recreation Centre, Ice Arena and Public Works building. Subsequently Council was prevailed upon to permit B.C. Hydro to display its thermograms during Community Day at which time many thousands of citizens were able to view the thermograms of their homes.

The Committee also investigated street light conversions from incandescent and mercury vapour to high pressure sodium fixtures. This changeover is an invaluable energy saver when one realizes that four hundred watts mercury vapour can be replaced with one hundred fifty watts high pressure sodium. In the same way, three hundred watts of incandescent power provides only 60% of the light of a hundred thirty watt high pressure sodium fixture.

The review of Municipal vehicle energy effectiveness resulted in a policy to acquire small diesel engines in certain of the small pickup trucks as they were being replaced, while at the same time investigating the relative merits of CNG or propane conversion systems. As will be seen in subsequent sections of this paper, while we had concluded our investigations and were ready to make conversions by 1982, our attempts to obtain senior government funding delayed the process until 1984.

Long before we commenced conscious decisions to conserve energy West Vancouver was a leader-in,the conservation field through its recycling efforts. In June, 1972, with a grant from the Municipality, the Society for the Promotion of Environmental Conservation (SPEC) commenced operating a recycling depot in West Vancouver. As a matter of interest, the City of Vancouver started its recycling pilot project with a depot at the Manitoba Works Yard in October, 1973.

In November, 1974, to assist *SPEC,* the Municipality took over the costs of transporting materials from the depot to the buyers and shared the costs of operating the depot by putting our crews on-site occasionally to clean up the area. In 1977, a second depot was opened in the western part of the community in conjunction with SPEC. Only one year later, in 1978, the Municipality took over sole responsibility of the depots and contracted the work out to a private contractor. In 1979 the Municipality commenced a fifteen-mile curbside collection of newspapers, glass and tins while still operating the two depots. This continued through December, 1981, at which time due to a lack of markets, the curbside program was discontinued. The depots continued to operate. In 1983, the Municipality initiated a Municipal-wide curbside newspaper pickup with the program being extended to be jointly run by and servicing the two North Vancouver's. At that time it was the largest program in British Columbia. Again, in 1990, the three Municipalities jointly agreed to a curbside pickup program of newspaper, glass and tins.

Council was requested by the Committee to indicate its degree of support to the staff initiatives and as a result a policy resolution was passed September 2, 1980 which stated that the Council:

> "emphatically and strongly affirms its continued support for the principles of energy conservation and in particular requests the Corporation's Municipal employees and all citizens of the Municipality to give full consideration to the practical applications of good energy conservation and management in their daily lives."

WEST VANCOUVER'S NGV (NATURAL GAS VEHICLE) PROGRAM

A word of caution to those who are contemplating a conversion program - ensure that you and your Council are committed to the concept of energy conservation and determined to be so. The initial capital outlay for CNG conversions may deter you and even redirect you to other alternative fuels such as propane.

For the reasons which will be shown hereafter, in our opinion, this would be a mistake. It is the long term commitment which will maximize your benefits.

WHY CNG (COMPRESSED NATURAL GAS)?

The following is a mix of factors used by West Vancouver in arriving at its decision to go the route of compressed natural gas as opposed to propane and those factors currently known and reported on in various papers. By using both sets of data it is expected that those using this paper to investigate conversions for their Municipalities will have more complete information to assist in their decision-making.

Advantages

1. Reduction in Cost

- Per litre costs of various fuels in West Vancouver as of June, 1991, were:

Unleaded Gas	52.640
Diesel	47.640.
Propane	28.900
CNG	12.50

2. Energy Benefits

- There is a reduction in energy utilization. CNG is more efficient than gasoline at 6,000 BTU's per mile versus 6,670 BTU's per mile. (1)

- The New Zealand Energy Research Development Committee confirmed the above when it reported a 13% efficiency advantage over gasoline.

- Use of a more plentiful scarce non-renewable resource thus permitting a longer period of time to develop other energy sources such as solar photovoltaic cells, hydrogen fuel cells, etc. The Ministry of Energy advised in June, 1991, that British Columbia has current proven marketable oil reserves of 17 million cubic metres compared with proven marketable natural gas reserves of 210 billion cubic metres.

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(1) Evaluation of Vehicular Fuel Additives, June 1981 - PTI

– Distillation of oil to create gasoline or propane requires the expenditure of energy whereas considerably less energy is expended to cleanse and make natural gas available to the end user.

3. Maintenance and Upkeep of Vehicles

– CNG has a higher octane rating than gasoline (130 versus 90) and as a gaseous fuel it offers better engine starting, does not dilute lubricating oil and greatly reduces spark plug and cylinder deposits which in turn reduces engine wear. The City of Atmore, Alabama, reported a comparison of the oil consumed and spark plugs used during a twelve-month period for twenty-seven vehicles, in the first case gasoline-powered only and in the second case duel-fuelled. The oil consumed was twenty-eight cases to twelve cases (twenty-four quart case) respectively and seventy-nine sets versus fourteen sets of spark plugs respectively. (2)

4. Safety

- The National Fire Protection Act 52, Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems, states that natural gas is a flammable gas; it is colourless, tasteless and non-toxic but can cause anoxia (asphyxiation) when it displaces the normal 21% oxygen in air in a confined area without adequate ventilation; it is a light gas weighing about two-thirds as much as air; as used in the systems covered by this standard, it tends to rise and diffuses rapidly in air when it escapes from the system.

– Methane Motoring, a bulletin from the B.C. Government's Methane Energy Development Division of the Department of Energy, reported in 1983 - a recent U.S.A. survey of major fleet operators using natural gas powered vehicles involving 2,400 vehicles driven nearly 175 million miles (281,627,000 kilometres) that there had been 1,300 collisions in the previous 13 years, none of which resulted in a fire or explosion.

– Approximately 250,000 CNG powered vehicles are in operation in Italy. Most of these are privately owned and operated in sharp contrast to the 30,000 natural gas vehicles in the United States, most of which are part of fleets.. While detailed accident data from Italy is not generally available, explosions associated with accidents involving natural gas vehicles have not occurred in thirty years of operation although a number of fires have been reported. (3)

(0) Gaseous Fuel Safety Assessment, November 1983 - Los Alamos National Laboratory

CNG As a Government Vehicle Fuel, July 1981 - Product Information Network (McGraw - Hill Inc.)

- Transport Canada reports the particulars of eighty accidents involving propane fuel and three involving natural gas fuel over the period August, 1981 to May, 1986. These are selected accidents where the fuel type may have been a factor in the extent or severity of the results of the accident. In the case of the propane accidents, there were 58 cases of unintentional fuel leakage, 53 cases of fire and 36 cases of injury. None resulting in fatalities. The types of injury occurring were mostly freezing due to the temperature of escaping propane and burns where fires occurred. The 3 natural gas accidents all were vehicle collisions, 2 of medium severity and 1 of low severity. No leakage, fire or injury due to the characteristics of the fuel occurred. (4)

- Methane has combustion characteristics that make it a unique fuel as far as its safety is concerned among all common fuels. It takes a minimum of from over 5% by volume of methane in air at ambient conditions to just support continuous flame propagation, as compared to around nearly 2% for propane and 1% for gasoline vapour. Thus, it would take a considerable amount of fuel leakage into the air to render the mixture combustible. Buoyancy effects are dominant in the dispersion of methane in air unlike the much heavier than air vapours of gasoline and propane. These, relatively, will tend to linger on following a discharge and disperse far too slowly, thus retaining the hazardous situation for a far longer time and spreading the potential for fire and explosion from and away from the leakage zone. (5)

- A United States Bureau of Mines report shows a much higher temperature is required to ignite natural gas compared with several other common fuels.

Natural Gas	537 degrees centigrade
Propane	466 degrees centigrade
Butane	405 degrees centigrade
Octane	418 degrees centigrade

Natural gas burns quickly; gasoline saturates materials, spreads and burns for a long time. Gasoline vapour is more easily ignited than natural gas. Natural gas dissipates quicker than gasoline as it is lighter than air whereas gasoline and propane will tend to puddle and linger. (6)

- Another measure of fire hazard is to identify the amount of ventilation air required per litre of fuel vapour release in order to prevent fire.

(4) Safety of Gaseous Fuelled Vehicles in Canada, undated - Transport Canada

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(5) Comparative Studies of Methane and Propane as Fuels etc., 1983 - Society of Automotive Engineers Technical Paper Series #831196

CNG As **A** Government Vehicle Fuel, July 1981 - Product Information Network (McGraw - Hill Inc.)

These values are: (7)

CNG	20.0 litres of air
Propane	47.6 litres of air
Gasoline	71.4 litres of air

5. Emissions

- A study conducted to document environmental concerns related to natural gas vehicles concluded that compared to gasoline fuelled vehicles, natural gas fuelled vehicles emit significantly less carbon monoxide, more total hydrocarbons, less non-methane hydrocarbons and that oxides of nitrogen can be higher or lower. In addition, dual-fuelled vehicles operating with gasoline and CNG may emit higher levels of pollutants than baseline gasoline vehicles. A good reason to go to mono-fuelled NGV's only. (8)

- A 1989 study prepared by Air Sensors Incorporated and B.C. Research Corporation for the Canadian Gas Association concerning an advanced micro-processor based natural gas conversion system for use in passenger vehicles and light trucks utilizing electronic fuel injection reported that vehicle emissions meet the applicable standards for the vehicle on natural gas set by both the Environmental Protection Agency and Transport Canada for carbon monoxide, oxides of nitrogen and reactive hydrocarbons. Unburned methane in the exhaust exceeds Federal standards. The standard three-way catalyst is not sensitive to methane oxidation.

Disadvantages

1. Cost

- In 1991 the cost of a compressor station and storage tanks to serve a 100 vehicle fleet was in the range of $300,000. Other than a few moving parts and seals in the pump system and the need for occasional painting to inhibit oxidization, the compressor and storage tanks are virtually indestructible and will have a life well in excess of 20 years. The fuel dispensing portion may be replaced at an earlier time due to changing technology but not necessarily due to deterioration.

  The capital cost of the equipment however may be financed through B.C. Gas over a period of 20 years in which case long term savings in fuel costs will be more than the amount needed to amortize both the compressor station installation and the vehicle conversions.

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(7) Just How Safe is Propane As An Automotive Fuel, Mar./Apr. 1986 - Propane Canada

(8) State of Knowledge of Environmental Concerns Related to Natural Gas Fuelled Vehicles, April 1984 - Singh, M.K.

(9) 2. Reduced Vehicle Range

– A light pickup carrying two fuel cylinders can travel between 75 and 100 miles per day. Additional cylinders if the space is available can extend that range. Alternatively one might use duel-fuelled systems where one is able to switch to CNG to gasoline when the CNG cylinders run out. Vehicle records should enable the fleet operator to determine which vehicles should be converted to which system and the number of cylinders necessary.

In the case of West Vancouver, the Municipality is, after much experience, going away from the dual-fuel system. All new conversions will be mono-fuel (CNG) with the number of cylinders varying between 2 and 4 depending upon the weight of the vehicle. It has been determined that the vehicles can operate for a full day, or several days depending on consumption and distance driven, on one filling thus obviating the necessity to return to the public works yard for filling during the day. All vehicles are fast filled upon return to the yard each evening.

3. Power

- Due to CNG's energy density, a vehicle tuned to burn gasoline will experience a 10 to 15% power loss when using CNG. This is one of the problems experienced earlier on with duel-fuelled systems.

Where carburetion is tuned to the single CNG fuel system, this power loss is reduced considerably.

In the case of the micro-processor electronic fuel injection system previously referred to in the Air Sensors/B.C. Research paper, vehicle performance was tested. The elapsed time from zero to 60 m.p.h. was less than 2 seconds slower on natural gas than on gasoline.

These hydrocarbons for the most part are not as photochemically active as

4. Emissions

– As stated in the earlier section under the heading of Advantages, existing catalytic converters are less reactive to the more stable hydrocarbons such as methane.

those emitted from gasoline carburetion. (9)

5. Availability of External Filling Facilities

— As at April, 1988, the B.C. Ministry of Energy reported there were 46 public refueling stations in B.C. and 115 in the whole of Canada.

For vehicles required to travel any distance away from home base, this could be a real problem although it can be ameliorated through the use of the duel-fuel system previously mentioned.

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(9) Evaluation of Vehicular Fuel Additives, June 1981 - PTI

WHY NOT PROPANE?

1. Propane has a considerably longer history of use in vehicles than CNG and only experiences a 5% power loss relative to gasoline compared with the 10 to 15% previously stated. In addition, propane has similar properties as CNG in terms of a doubling of the engine life, reduction of maintenance costs and reduced emissions, but: Octane rating of gasoline is 90, Propane 110, and CNG 130.

2. The initial capital investment in propane conversions is considerably less than CNG however the long-term fuel cost saving is substantially less than the saving resulting from CNG usage.

3. As of June, 1991, a litre of propane is more than two times the cost of a litre of CNG; 28.90 per litre versus 12.50 per litre.

4. Propane is produced by refining crude petroleum. It is also present in small concentrations as an impurity in most natural gases. Referring back to our commitment to energy conservation as an underlying principle, it does not make sense to waste energy through the refining process when natural gas is so readily available. Additionally, due to the source of propane being either refining of crude petroleum or extraction from natural gas, the potential for increased use of propane is limited. This is unlike methane which is the main constituent of natural gas. The prospects of increased utilization and use of natural gas are extremely high. (10)

5. The Savannah, Georgia, Police Department discontinued using propane in its vehicles December, 1984, following an accidental explosion. Please refer back to the section on Advantages - Safety.

6. Methane is the main hydrocarbon fuel present in the exhaust resulting from natural gas combustion in engines. The non-toxic methane has been shown to have near zero reactivity in the production of photochemical smog. This is in contrast to engine operation with propane, though its emissions may be significantly improved in relation to gasoline operation, nevertheless, it does represent a more reactive exhaust hydrocarbon component than with methane. (11)

Comparison of CNG and Propane Emissions (Grams per Mile) (12)

	CNG	Propane
Hydrocarbons	0.22	1.6
Carbon Monoxide	0.00	5.4
Nitrogen Oxide	0.46	7.1

(10) Comparative Studies of Methane and Propane as Fuels, etc., 1983 - S.A.E. Technical Papers Series #831196

(11) Comparative Studies of Methane and Propane as Fuels etc., 1983 - S.A.E. Technical Paper Series #831196

(12) Evaluation of Vehicular Fuel Additives etc., June 1981 - PTI

EXPERIENCE ELSEWHERE

The following information comes through the services of PTI in 1990. The search was performed on LOGIN, the Local Government Information Network, produced by Control Data Corporation, MN.

1. Australia -There is no list given of which Municipalities but it is reported that Municipal fleets have been converting to CNG not only gasoline-powered but also utilizing a CNG/diesel mix.

2. Black Top Cabs, Vancouver - 128 vehicles converted to CNG.

3. B.C. Hydro - Has converted 150 vehicles to CNG.

4. Canadian Western Natural Gas - has converted 73 vehicles to CNG.

5. Dallas, Texas - Is test-converting 10 selected Municipal vehicles to dual mix CNG and gasoline.

6. Fort Collins, Colorado - Utilizes various alternative fuels including CNG for all Municipal vehicles including police patrol vehicles.

7. Oklahoma Natural Gas Company - operating 120 NGV's. In 1985 began`' converting 70 additional vehicles.

8. Kirkland, WA - As of August, 1985, was operating 23 police vehicles on CNG.

9. Longview, WA - Converted 41 Municipal vehicles in 1983 and added 10 police vehicles in 1984.

10. Memphis, TN - Has converted 18 vehicles to CNG.

11. New Zealand - In 1979 targeted 150,000 to be converted to CNG by the end of 1985. A report in November, 1983, of the B.C. Energy, Mines and Petroleum Resources stated that New Zealand had 46,000 CNG at that time. No additional information has been obtained although CNG is readily available to approximately 700,000 vehicles out of a total New Zealand vehicle population of 1.3 million.

12. Sedgewick County Police of Wichita, KA - Has 128 vehicles on CNG including 100 patrol cars.

13. Southern California Gas - operates 3,000 NGV's. Electronic fuel injection enables the dual-fuelled vehicles to instantaneously change from gasoline to natural gas without hesitation. The system provided by Dual Fuel Systems Incorporated, Montibello, California, eliminates the need for a fuel switch.

14. Other Police Departments - reported as at September, 1985, in the United States, include:

City / State	No. of Police NGV's
.Atmore, AL	6
Brewton, AL	3
Bay Minnete, AL	8
Fayette, AL	3
Livingstone, AL	4
Gulfport, FL	7
Milton, FL	11
Adel, GA	7
Cartersville, GA	8
Eatonton, GA	6
Thomson, GA	5
Hazelcrest, IL	8
Oaklawn, IL	23
St. Charles, IL	11
Hickory, NC	10
Rocky Mt., NC	12

FEDERAL/PROVINCIAL COST SHARING

As previously mentioned, the West Vancouver Energy Conservation Committee carried out investigations in 1980 and 1981 of alternate fuels and vehicle energy conservation which resulted in a recommendation to convert the Municipal fleet, both gasoline and diesel vehicles, to a duel-fuel system with CNG.

The Federal Minister of Energy,. Mines and Resources, in January, 1982, announced a most timely cost sharing program which provided for a $600 grant for each vehicle converted to CNG and a fleet demonstration program "aimed at captive fleet operations such as taxi, school buses and light commercial vehicles." This latter program would share up to 50% of the cost of installing a compressor station and storage tanks. The declared objectives of the program *were:*

1. To provide economic information on CNG as a motor fuel, leading to a better assessment of its best markets and uses;

2. To provide operating experience for assessing known and potential technical problems that need to be resolved to permit wider commercialization of fuel;

3. To improve the opportunity for Canadian industry to develop expertise in CNG conversion technology and equipment design, ultimately leading to the establishment of manufacturing facilities for a range of CNG carburetion equipment;

4. To raise the visibility of this new fuel option among vehicle operators and manufacturers in Canada.

West Vancouver was delighted at both the timeliness and the objectives of the program which, in our opinion, rightly focused on the area of marketing and the fleet operators who were in the best position to assess the relative merits of CNG. Accordingly, in March, 1982, we applied for a cost sharing grant in the amount of $90,000, being one-half the estimated cost of the compressor station plus of course the grant for the vehicle conversions.

Subsequently under letter dated June 15, 1982, the Provincial Government who had become involved in the compressor station demonstration program,, rejected our application stating that our request did not qualify for the following reasons:

1. Our request for a grant of $271,119 was excessive.

   In fact as noted previously, our request was for $90,000. We wondered at the time whether the individuals involved should go back to school to obtain improvement in literacy skills.

2. The West Vancouver program precludes servicing of private vehicles.

   As we had applied under the stated objectives of the Federal program which was to provide facilities for fleet operators, we were astounded that the Provincial Government would use as an excuse that our facilities would not be available to the public. This obviously was the result of a different objective of the Provincial Government from that of the Federal Government.

3. The Provincial Government suggested that West Vancouver instead of converting to CNG, rather convert to propane as it was less costly to do so.

   This suggestion totally mystified West Vancouver as the program was to "assess the commercial, technical and regulatory feasibility of operating vehicles on CNG."

4. General public awareness will probably not occur as there will be no public access to the station. We view this as a poor demonstration.

As previously stated, this was a change in the program's objectives, one which we most emphatically disagreed with. In our opinion fleets and fleet operators were in a better position to assess the validity of the fuel as an alternative and also for the thousands of fleet operators to become comfortable with its usage. Their experience would be more likely to persuade the general public to utilize the fuel after a successful demonstration period than simply telling the public through a wasted advertising program that **X** number of fuelling stations would be available if they chose to convert.

5. The West Vancouver program does not meet the Provincial objective of supporting CNG refueling facilities at retail stations having public access.

   The program was announced in January, 1982, and as of April, 1988, there are only 46 stations in the whole of the Province and only 115 public refueling stations in the whole of Canada. The 1982 goal was to have 100,000 vehicles operating on CNG by 1985. A B.C. Research Report dated April, 1988, states that there were only 19,000 vehicles in the whole of the country.

In numerous letters to both the Federal and Provincial Governments, we urged them to rethink their priorities as we were certain that what was proposed would fail both for reasons of inertia by citizens to change and a reluctance to pay out of one's pocket towards an unproven product.

We were advised by the Federal officials that the West Vancouver proposal merited support but was rejected by the Province and as such the Federal Government could not make the grant unilaterally.

Subsequently the Hon. J. Chretien, Minister of Energy, wrote to the Municipality advising that as the Provincial authorities must approve the demonstration project (compressor station) and would not do so, we would not be eligible under that grant program; however we would be eligible for the grant of $600 per vehicle converted and that the application forms would be sent under separate cover. Despite numerous requests and follow-up by West Vancouver, the forms were likely never sent as they never got to us.

In February, 1983, the Federal Minister announced a new program of a fixed sum of $50,000 to public service stations to install 125 CNG facilities for public usage. This goal was nearly met for as stated herein, there are now 115 stations across the Country.

I still wonder at the efficacy of the program.

THE WEST VANCOUVER CONVERSION EXPERIENCE

Proposed Program

As the Energy Conservation Committee pursued its work during 1980 and 1981, one of the recommendations which arose was the conversion of the Public Works Yard heating system from furnace oil to natural gas. The Works Facilities were relatively new having been completed in 1979. At that time however natural gas main service was unavailable on the fronting road. In discussion with B.C. Hydro, we were advised they would be willing to extend the natural gas line for $28,579 with a portion of the cost, approximately 25%, being refunded after five years. With the takeover of the Gas Division of B.C. Hydro by B.C. Gas, the "refund" ball was dropped. We are currently pursuing this.

The cost of installing the building conversion equipment was quoted at $20,916 which, when coupled with the cost of the main installation and our estimated. annual saving of $8,200 being the difference in price between furnace oil and natural gas at that time, an annual payback period of 6.0 years was projected. If we move the cost of the main to the vehicle conversion program (in order to maximize the cost of that program to be extra conservative in projecting our savings and payback period) the payback period for the building conversion alone was 2.5 years. In either case this told us that we should proceed with the building conversion and the main installation while we investigated the vehicle conversion program further.

Our original vehicle conversion program called for the conversion of 41 units with two fuel cylinders and 7 units with three fuel cylinders. 27 units *were* to be dual-fuelled with gasoline and 21 dual-fuelled with diesel. At the time, there were many locations doing experimental work with dual diesel/CNG fuels and a considerable number of units were operating in New Zealand. Our further research, however, indicated that the cost effectiveness when coupled with the Government's rejection of our grant application simply was not there for the Municipality to convert its diesel units. As a result, the final program converted only 27 gasoline-powered vehicles.

Estimated Costs

The original cost projection based on the 48 vehicles to be converted totaled $257,229. Pre-conversion annual fuel costs were projected at $124,208 compared with estimated post-conversion costs of $76,402 for an annual fuel saving of $47,806. This resulted in a projected payback period of 5.4 years.

Had the Municipality received the vehicle conversion grant of $600 per vehicle the payback period would have been 4.8 years. Had the Municipality also obtained the fuelling station grant of $90,000, the payback period would have been 2.9 years.

Regardless of the foregoing, a payback period of 5.4 years for' the conversion without any grants appealed to us both on the basis of our original philosophy of being energy conscious and of being fuel effective. Most of our vehicles have a life of 7 to 8 years, some as much as 12 and therefore the payback period was attractive. Additionally, the conversion equipment has a 20 to 30 year life other than as changing technology may make the equipment more efficient. This was highly attractive in that at the end of the useful life of the vehicle, the conversion equipment can be transferred to the new vehicle at a cost of only between $600 and $700.

Actual Costs

Implementation of our vehicle conversion program was delayed during the period of our appeals for Federal and/or Provincial funding. As a consequence implementation did not commence until late Spring 1984. At that time although costs had increased we were offered a financing package from B.C. Hydro & Power Authority in the amount of $208,000 for the fuelling facilities at the borrowing rate then paid by B.C. Hydro which in this case was 12.5% over a five year period; a loan of $1,200 per vehicle, interest bearing at the previously mentioned rate payable over two years and an additional loan of $500 per vehicle, interest free repayable over two years.

As Council had previously approved funding in the amount of $190,000 for the conversion program, when we learned of the B.C. Hydro financing program and we made the necessary arrangements with them, it was determined to proceed with the conversion to NGV's notwithstanding the lack of senior Government funding.

It was at this time that we determined to convert only 27 vehicles. At this time the costs we faced were:

1.	Fuelling Station	$200,000	
2.	Gas Main/Meter	$ 34,000	
3.	Vehicle Conversion	$	45,900
	Total	$287,900	

Most Municipal practitioners will know that with a possible exception of foreman vehicles, most operating trucks are relatively low mileage. I suppose the only other exception might be dump trucks, however, most of these are diesel units, which we chose not to convert until greater benefit could be shown. This being the case, our actual dollar saving has not been as large as we would like although the sum is still substantial.

As our compressor unit was paid off through fuel savings after six years (1990), currently all savings represent a total benefit to the taxpayer.

Fuel Savings

A recent analysis of our program, 16 mono-fuelled units and 12 duel-fuelled units, for the months of January and April (representative months) showed a CNG fuel usage of 21,722 litres and gasoline of 2,495.7 litres. Our analysis also showed that two foreman vehicles, duel-fuelled, basically ran on gasoline during those periods. Had they been run on CNG then our numbers would have been considerably different as these vehicles are high-mileage units. This matter is being looked into further.

Extrapolating the two-month usage over the whole year produces a fuel cost of $24,173. If the Municipality had not converted and used gasoline only, the annual cost is projected at $76,488. Therefore, net annual saving is projected at $52,315.

If the 12 dual-fuelled vehicles had been mono-fuelled only with CNG then the projected net annual saving is $58,325.

In December, 1984, following completion of the conversion of the 27 vehicles, our monthly fuel savings were $3,300. This represented a 7.3 year payback period which was greater than originally estimated. As a result, we persuaded the Police Department to convert 12 patrol vehicles which upon completion, monthly fuel savings were $4,700 for a payback period of 5.1 years. This was closer to the original estimate and therefore satisfied our goal.

Unfortunately, for reasons to be commented upon in a following section, the Police Department decided after 18 months to remove the natural gas conversion equipment. This represented a setback to our program but did not defeat it.

In December, 1984, gasoline cost 430 per litre compared with CNG at 13.230 per litre or 3 1/4 times the price of CNG. Since that time gasoline prices have risen to 52.640 per litre (1991) while CNG has reduced in price to 12.50 per litre, 4.2 times the price of CNG. Put another way, CNG has reduced by 5.5% in price while gasoline has increased over 22%. This allowed us to recover our capital cost in 6.3 years rather than our projected 7.3 notwithstanding the loss in savings caused when the Police vehicles were removed from the program.

Police Reluctance

In March, 1985, the Municipality converted 12 Police vehicles at a cost of $37,717. This equipment was removed after 18 months in August, 1986, during which fuel savings were $24,447. The difference would have been recovered after 28 months. West Vancouver patrol vehicles are rebuilt after 18 months and are then operated a further 14 to 16 months. Had the conversion program gone to full term, total gas savings would have been created for the 6 months between the 28 and 34 month period for first-time conversions. Thereafter the cost of converting replacement vehicles would have been recovered after 6 months (labour costs of $600 to $700 per vehicle only) as the existing equipment is transferable to the replacement vehicles.

Why Did the Police Discontinue CNG Usage?

Our garage personnel were advised that patrol members believed the weight of the CNG tanks in the trunk created a handling hazard. This was subsequently disproved when two of the patrol vehicles were put through their paces at the B.C. Police Academy Pursuit Training Track. However, once an idea is ingrained, it takes mighty effort to create change.

In addition to the perceived handling hazard, Police personnel complained about a lack of power when pursuing suspects at high speeds. At that time this conceivably was a problem due to the 10 to 15% power loss which CNG was known to have at that time. However, as we had converted the vehicles to duel-fuel use, it was agreed that for normal patrol functions CNG would be utilized but when the patrol vehicle was on radar picket or on freeway patrol, the system would be switched to gasoline usage. As the timing and carburetion systems would be set for gasoline usage, not CNG, this would allow for the necessary power during high-speed chases.

NEXT? FOR WEST VANCOUVER

A review of our NGV status initiated in the Fall of 1990 indicated that the Municipality had been remiss in not converting certain additions to our fleet (as opposed to replacement of converted vehicles). As indicated previously, we currently have 12 vehicles dual-fuelled and 16 mono-fuelled with CNG. At the end of 1991 we will have converted 3 of the existing dual-fuelled vehicles to mono, added 5 new vehicles converted to mono-fuelled CNG and replaced 2 small diesel-engined pickups with gasoline engines to convert to CNG. This will give the Municipality 9 dual-fuelled vehicles and 26 mono-fuelled CNG vehicles for a total of 35 vehicles being run on CNG. Hopefully a closer watch will be kept on the dual-fuelled vehicles to ensure maximum usage of CNG.

On the assumption that the 35 vehicles will each consume the comparable amount of fuel that the current 28 vehicles each consume, based on current prices per litre of fuel, which obviously will be different in 1992, the projected net annual saving will be $78,516.

FOR WEST VANCOUVER POLICE

Currently the Municipality has 35 police vehicles, 14 of which are assigned patrol duties. Obviously these are the high mileage users and they would be the first candidates for conversion should the department decide to reconsider.

Analysis of 2 patrol vehicles during certain days in April and May of 1991 revealed that for 1 vehicle in 11 days, 1,909 km were travelled at a fuel expenditure of 457.2 litres or an average of 22.87 litres per shift; the second vehicle in 19 days travelled 3,323 km and used 975.4 litres for an average fuel consumption per shift of 25.67 litres. The average fuel consumption for both vehicles per shift was 23.88 litres.

On the asumption of:

Patrol Vehicles	# of Shifts	Litres per Shift	.$/Litre-Gas.	$/Litre-CNG
14	730	23.88	$0.5264	$0.125

Annual gasoline cost would be $128,470, CNG cost would be $30,507 for a net saving of $97,963.

Conversion of the 14 vehicles to CNG would cost an estimated $18,200. This is arrived at as follows:

Cost of Conversion Kit	$ 1,200
Labour	$
Subtotal	$ 1,900
B.C. Gas Grant	$ 60
Subtotal	$ 1,300
14 Vehicles x $1,300	$18,200

Due to the removal of the conversion equipment from Police vehicles in 1986, the Municipality still has fuel tanks available and therefore these are not costed. While we still have the conversion kits, technology has passed them by and therefore new kits will have to be acquired.

As previously noted, annual savings are $97,963, conversion cost $18,200, net annual savings $79,763 for a payback period of 2.7 months.

As a result of the review initiated by the Municipality, requests were made to the Police Department to reconsider their position. The department has produced an internal memorandum which reviews the matter of other Police Departments using CNG, the matter of fuel, efficiency (savings), safety issues, implementation and refuelling. We are pleased with the positive response contained in the report but as the report recommends converting only 1 vehicle as a demo project, we will be more pleased when all patrol vehicles, bylaw officer vehicles and any other high mileage units are converted.

Implicit in the departmental report is a dual-fuelled system. It is my hope that following a successful demonstration program on the dual-fuelled system, consideration will be given to trying the mono-system. The dual-fuelled system still suffers from the earlier experience of power loss when switching from gasoline to CNG. Even though the switch-over occurs virtually instantaneously through the use of micro-processors, the CNG experience will always suffer due to the necessity to tune the vehicle's engine and carburetion for gasoline usage in order to limit exhaust emissions.

B.C. Research has reported that using an advanced micro-processor-based natural gas conversion system, the power loss on a mono-system is negligible; zero to 60 m.p.h. elapsed time is less than 2 seconds slower on natural gas than gasoline.

At an earlier time weight was considered a factor in handling patrol vehicles, however, the police report discounts this concern based on the heavy duty suspension and adjustable air shocks. Additionally, we are currently investigating the usage of aluminum fibre-wrapped cylinders which would reduce the weight by approximately 100 pounds. We are advised that B.C. Gas currently has these cylinders on order but held up pending C.S.A. approval. The cost of the aluminum will be about 20% higher than steel cylinders however both in the interest of weight and cylinder longevity, we consider aluminum cylinders to be better value.

FOR OTHERS

As we mentioned earlier on in this report, conversion to CNG is not for the faint-hearted. It takes a strong will to play one's part in cleaning up the gaseous soup which we have introduced into our life-sustaining air system and to pay the cost to do so. Some have chosen to use propane which will do an adequate job in the first part and in the short term at least do a better job in terms of the capital outlay. I would however **ask** the reader to refer back to the section on *why* West Vancouver did not go the "propane" route.

Conversion to CNG will pay outstanding benefits in terms of self-esteem and respect for the environment while giving the burdened property taxpayer a break, through long term fuel savings.

Even though the Federal and Provincial governments have, in our opinion, failed to target the right audience in their grants program, other jurisdictions can benefit from the grants and financing program provided by B.C. Gas.

B.C. Gas will' finance the cost of the compressor unit either by way of a direct lease-to-purchase plan (a $300,000-100 vehicle compressor unit and storage tanks is paid off at $78,000 per year over 5 years plus a $30,000 buyout charge at the end of the.fifth year) or by renting the unit through a surcharge on fuel consumption. This surcharge brings the price per litre of CNG almost to the same price as that paid commercially for propane. This being the case, there is little monetary benefit to convert to CNG as opposed to propane, however, there is a good long term reason to convert to CNG; due to the enormous reserves of CNG, the probability is that CNG rather than propane will be the fuel of the future.

Additionally, B.C. Gas has a fleet incentive grant program of $200 per vehicle converted plus $200 per certified cylinder installed. For example, most vehicles will take two cylinders and therefore the basic grant per vehicle converted is $600.

For those who are new to CNG terminology and conversion factors, we attach hereto a Conversion Factor Statement and Sample Costing Procedure.

CONVERSION FACTORS AND SAMPLE COSTING PROCEDURE

Confusion

B.C. Gas Invoices in "Gigajoules"
Compressor Station Dispenses in "Kilograms"
Vehicles Consume Fuel in "Litres"

Conversion Factors

1 gj = 31.83 1
1 kg = 1.72 1
1 gal.= 4.546 1
1 1 = 28.687 cu. ft.

1 gal./mile = 2.825 1/kilometer
1 1 CNG = 1 1 unleaded gas.
June 1991 Fuel - West Van.
Per Litre:
Unleaded Gas. 52.640 Propane 28.900
Diesel 47.640 CNG 12.500

Sample Costing

A. VEHICLE CONVERSION ONLY (AFTER COMPRESSOR PAID FOR)

- 3 different West Van. vehicles usage ranged from 2.7 to 9.1 kilometer/litre (Avg. 5.4 km/1); Same vehicles averaged 127 km/day; Average annual usage 33,020 km; Annual Fuel Consumption 6,115 1.

- THEREFORE:

		Gasoline	Propane
Gasoline 6,115 x 52.640 =	$3,219		
CNG 6,115 x 12.500 =	$ 764		
Annual Fuel Cost Savings		$2,455	
Propane 6,115 x 28.900 =	$1,767		
CNG 6,115 x 12.500 =	$ 764		
Annual Fuel Cost Savings			$1,003

CONVERSION COST

Engine Kit	$1,200
Cylinders (2-80 1)	$1,432
Labour	$ 700
	$3,332
B.C. Gas Grant	$ 600
COST	$2,732

CONVERSION PAYBACK PERIOD	-	13.2	32.4 no.

B. INCLUDE COMPRESSOR COST (100 Vehicle Quick Fill - $300,000)

NOTE: B.C. Gas will finance unit on a lease-to-purchase over 5 yr. $78,100/year plus $30,000 buyout at end of term OR on rental agreement only make an additional gigajoule charge on' consumption for total cost/litre of 27.4 cents; compressor has a 20 to 30 year life.

ASSUME 100 VEHICLE FLEET; Additional cost per vehicle $781 plus annual portion of final payment 30,000 - 5 - 100 = $60 total $840 (Interest earnings on annual accumulation for final payment not credited)

- ADDITIONAL PAYBACK PERIOD (Purchase) 4.0 mo. 10.0 mo.

- RENTAL ONLY

Gasoline 6,115 x 52.640 _ $3,219
CNG 6,115 x 27.400 = $1,675
Annual Fuel Cost Savings $1,644 Propane - No

appreciable difference in fuel pr-ice

SAME CONVERSION COST $2,732

- RENTAL PAYBACK PERIOD 19.8 mo.

DIESEL CONVERSIONS

"The production of diesel fuel is inter-related, generally, to the production of gasoline. Therefore, there are some potential problems regarding the future availability of diesel fuel. Accordingly, there is much interest both from economic as well as technical points of view for minimizing the use of diesel fuel, particularly, since diesel engines are quite widely spread and represent a very large number of units of varying sizes and capacities. It would be attractive to use gaseous fuels in these efficient, robust engines for most of the time and provide only a small amount of diesel fuel as an ignition source." (13)

Considerable research has been done in this area by B.C. Research Corporation both on Caterpillar Diesels and Detroit Diesel Allison 6-71 engines. They have a wealth of information available.

P.T.I. reported in 1990 that "Australian Municipal fleets have been converting to compressed natural gas to cut fuel cost. Besides reducing diesel consumption by nearly half, the CNG/diesel mix doubles the life of lube oil, increases engine power, reduces emissions by 70% and prolongs engine life.

The longer engine life expectancy is due to the lowering of the combustion temperature by 194 degrees farenheit. According to the Australian developer, the technology marketed in conversion kit form, can be used on any diesel engine vehicle. The technology operates by restricting the flow of diesel fuel through the fuel injection pump by 50% and replacing it with CNG."

In a technical paper presented to the Engineering Society jointly by B.C. Research and Natural Energy Research Ltd. commenting about test results "It is clear that for peak engine loads the efficiency on dual-fuel is comparable to that for diesel operation while for part load the dual-fuel efficiency is less than for diesel. It should be pointed out that no alterations were made to the fuel injection timing for dual-fuel operation. It has been shown in earlier work that injection timing can have a significant affect on diesel substitution, peak pressures and efficiency. Thus it could be possible to increase dual-fuel engine performance by changing the fuel injection timing."

The Department of Energy, Washington, D.C., Office of Vehicle and Engine Research & Development, reported in February, 1982, concerning the desirability of methane either in the form of compressed natural gas or liquified natural gas as a fuel for both spark ignition and compression ignition engines. The study reported on the attributes and disadvantages of methane as a vehicle fuel, cost. of engine conversion systems, environmental effects, vehicle performance, safety, etc.

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(13) Comparative Studies of Methane and Propane as Fuels etc, 1983 - S.A.E. Technical Paper Series #831196

In an undated report, B.E. Milton of the University of New South Wales, Sydney, Australia, entitled "Improving the Performance of Small Dual-Fuelled Engines" commented "In the long term, use of compression ignition to spark ignition gas engine conversions in the smaller size range is likely to be preferred. However as a diesel conversion, dual-fuelling offers a relatively cheap modification together with the ability to revert to full distillate during the developmental phase of a fuelling infrastructure."

An extensive report from the Ontario Research Foundation, W.A. Getts, entitled "Performance and Emissions of Propane, Natural Gas and Methanol Fuelled Bus Engines" reported on performance and emissions of various types of engines.

In 1984 the City of Hamilton, with grants from both the Provincial and Federal governments, embarked on a demonstration CNG fuelled bus program involving 6 CNG buses. This is reported under title "Demonstration of Propane and Natural Gas as Fuels for City Buses". A copy of this report can be obtained either through B.C. Research or from the Hamilton Street Railway Company.

Most recently B.C. Transit has announced a natural gas fuel bus demonstration project. Attempts were made to obtain information concerning this program for inclusion in this paper, however, such information was not forthcoming.

One has to wonder how long demonstration and research projects around the world will continue to milk the taxpayer's pocket book before realization sets in that existing technology permits diesel conversion now. For example, the Hamilton Project demonstrated that: the cost of fuel for the CNG bus was 55% of that for the 2 stroke diesel; that the prototype bus has a maximum range when filled with CNG to the recommended 3,000 p..s.i. pressure of 375 kilometres; that when the CNG bus was loaded with the equivalent of 73 passengers, fully fuelled and run on a mountain circuit with a 7% gradient, the CNG bus repeatedly climbed the gradient at a speed of not less than 42 km/h and out-distanced the diesel bus; and that in comparing fuel costs, diesel versus CNG, the potential fuel cost savings at 30,000 litres per year per bus was $5,800.

As a result of these findings, I will be requesting the current Municipal Manager of West Vancouver to give serious consideration to converting our diesel-fuelled heavy trucks to a CNG system.

FEDERAL/PROVINCIAL FUNDING AND SUPPORT

As a result of the negative response to our earlier request for funding under the announced Federal program which subsequently was altered by Provincial fiat, and in consideration of the obvious lack of results flowing from the Provincial initiatives, I can only urge that the users in the field be consulted before Federal and Provincial initiatives are announced in order that the results of any funding program are maximized.

There will be progressive growth in the understanding and acceptance of the reliability of alternative fuels through increasing public exposure from greater fleet usage. Obviously, greater fleet usage will occur if the program focuses on that segment of society.

For smaller fleet owners, simplified "how to" information including technical advice, cost, comparison statements and supplier lists should be packaged and targeted to them by the Provincial government.

RESOURCES AVAILABLE

It is hoped that this paper will assist Municipalities who have not yet considered conversion of their fleets to CNG, and to those who have but made a different decision of the extensive material and advice available to them.

If you require assistance, advice is readily available:

1. B.C. Gas for technical assistance and funding.

2. B.C. Research Corporation, 3650 Westbrook Mall, Vancouver, B.C. V6S 2L2; Phone: (604) 224-4331 on a fee for service basis.

3. District of West Vancouver, 750 - 17th Street, West Vancouver, B.C. V7V 3T3 Phone: (604) 922-1211 - Mr. John Goyan, Purchasing Agent.