



Gas Fuels for Heavy Vehicles

**Andrew Thorp
Cenaught Limited**

Andrew Thorp BE Mechatronics (2007)

Worked in the automotive industry for ten years, recently finished study at University of Auckland

Experience working in Asia for pilot study CNG conversion of light trucks

Started Cenaught early this year to put my automotive industry experience and Mechatronics knowledge towards finding workable alternatives to petroleum fuel

Interested in biogas for transportation because it is available using mature technology and does not interfere with the agricultural commodity markets

I believe New Zealand can utilise our existing knowledge and skills gained in the CNG era to make biogas a large-scale alternative to diesel, as European countries are presently doing.

Topics covered in this presentation

Brief overview of CNG

Why use gas fuels (natural gas and biogas)?

Retrofitting existing diesel vehicles to CNG compared to buying new

Engine conversion equipment

Most suitable vehicles for gas fuel operation

Potential cost savings from running CNG vehicles

Barriers to CNG and biogas uptake

Established heavy vehicle CNG programs

Overseas subsidies available for heavy vehicle CNG

Current new CNG vehicle suppliers





Brief overview of CNG

New Zealand was a world leader in CNG technology in the 1980s

CNG is natural gas which is compressed to 200 bar (3000 psi) using an electrically driven filling station compressor

High pressure gas is transferred to the vehicles and stored in special onboard cylinders made of steel or composite materials

The gas is reduced from the storage cylinder pressure to ~100 psi and delivered into the vehicle engine using electronic control systems similar to modern petrol engines.

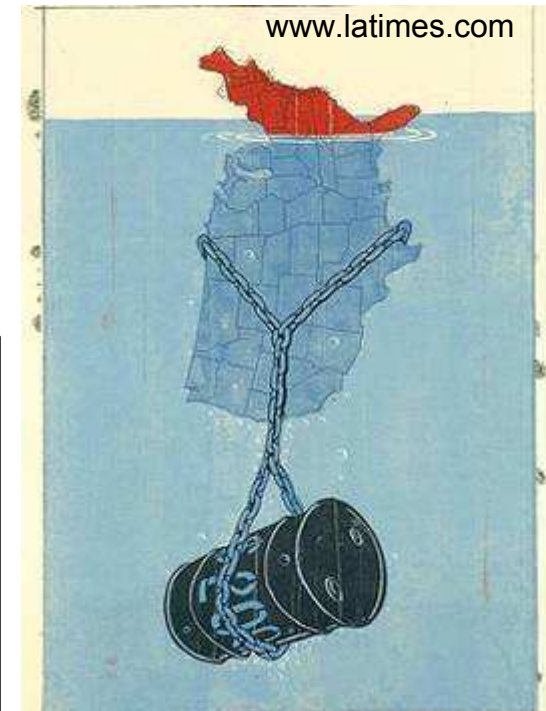
Biogas is equivalent to natural gas for vehicle fuel once processed to remove impurities.

Why use gas fuels (CNG and biogas)?



Traditionally **cost**: CNG is perceived to be cheaper than diesel. NZ CNG industry formed out of the 1970s oil shocks

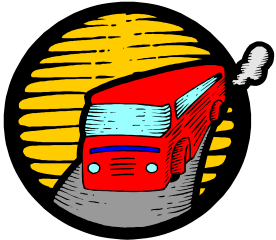
Biogas is able to remain insulated from oil prices and is (potentially) more predictable



Oil at US\$200/bbl = diesel at ~NZ\$2.80/litre



Why use gas fuels (CNG and biogas)?



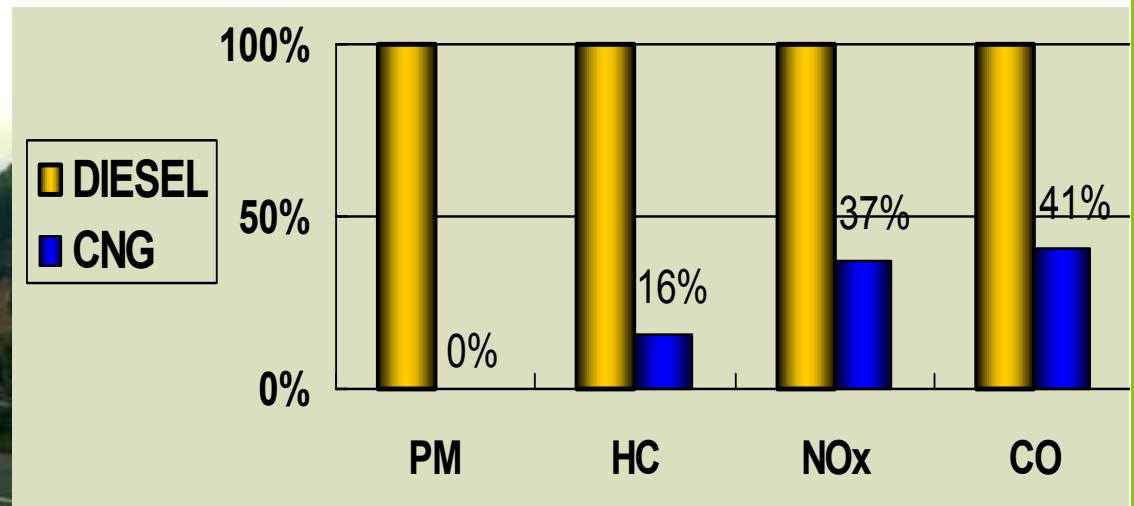
Emissions:

Indian and Chinese governments mandate CNG in cities to curb smoke emissions from older diesel engines

Diesel exhaust from older diesel vehicles is recognised as harmful to public health

CNG exhaust contains virtually no particulate matter
NOx and other pollutants reduced without emission control

Claimed 20% reduction in CO₂ output compared to diesel



Why use gas fuels (CNG and biogas)



Company policy- commitment to alternative fuels

Point of difference among similar operators

Triple bottom line goals (People, Planet, Profit)

Carbon-neutral marketing of 100% renewable fuel

Value of promoting vehicle fuel made from waste

Biogas helps counteract “food miles” issues

Be seen doing something positive toward the environment

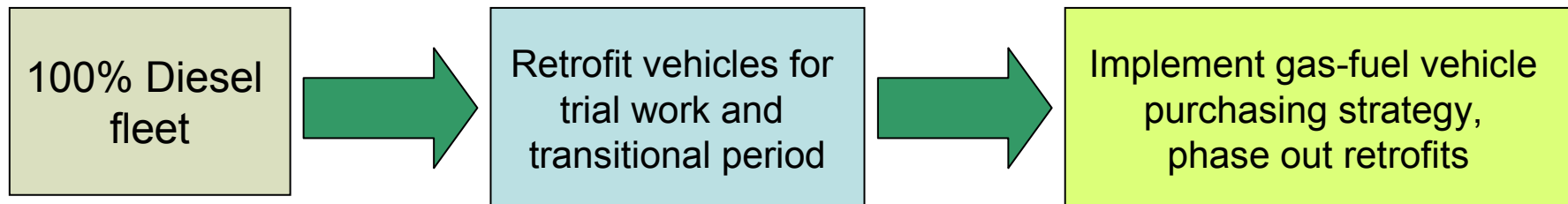


Retrofitting existing diesel vehicles to CNG compared to buying new

New CNG vehicles are typically 10-15% more expensive compared to equivalent diesel vehicles, a CNG bus can be NZ\$70,000 more than an equivalent diesel bus

A heavy diesel vehicle can be reliably converted to gas operation for 10-15kNZ depending on the technology used and options selected

Easier change-over period, retain existing parts inventories and workshop knowledge



Retrofit current vehicles to smooth the transition to gas fuel, then implement a new vehicle purchasing plan

Engine conversion equipment

Electronic injection:

gas is metered into air stream by electronic control similar to petrol injection on modern cars

- Electronic speed control
- Closed loop emission control
- Engine protection systems
- Very good efficiency



Multi-point gas injection



Bi-fuel direct CNG injector developed by Westport www.westport.com



Innovative direct CNG fuel injector developed by Westport

Engine conversion equipment

Two main modes of using CNG:

Mono-fuel:

CNG only

Also LNG common for high-mileage vehicles

Mono-fuel is best choice for fixed-route vehicles

Bi-fuel:

CNG and diesel together simultaneously, typically 20% diesel, 80% gas

Also growing use of LNG bi-fuel for very large trucks

Retrofit bi-fuel equipment does not modify the diesel engine and can be removed easily when vehicles are sold

Suitable for long-distance travel where 100% diesel is used when the gas runs out

Most suitable vehicles for gas fuel conversion

- 5-15 year old vehicles
- Known routes or travelling distances each shift/day
- All vehicles return to central point at some time during shift
- Concrete trucks
- Refuse trucks
- City-circuit buses
- Courier vans

Fixed body trucks 5-10 tonne GVM
engine power 80-250kW range
<350km average range per shift/day



75% reduction in fuel cost
~20% due to employee fuel theft

350km range

400kg weight increase

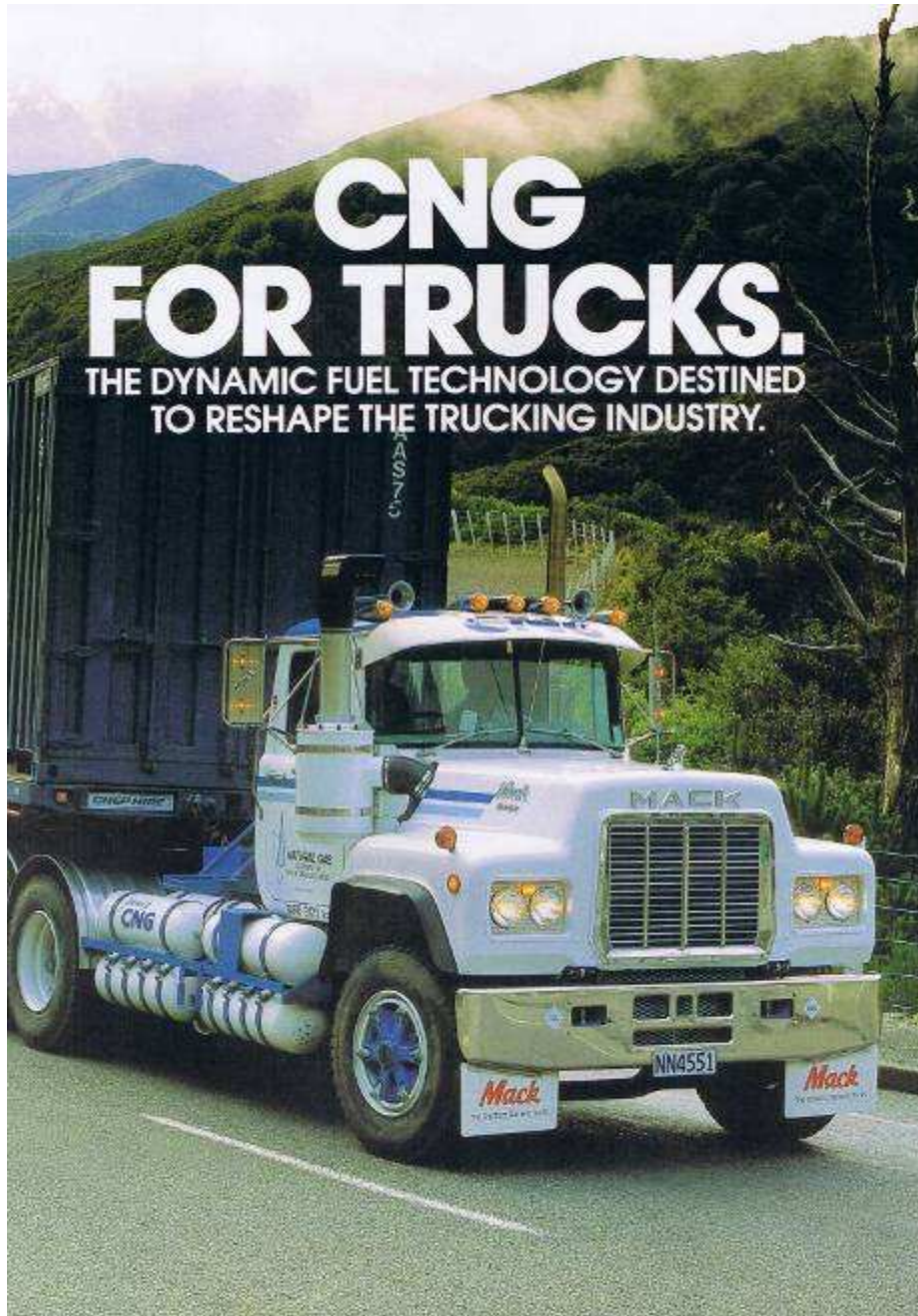
Added engine protection systems
to reduce driver-abuse, a common
cause of engine failures

Potential cost savings from running CNG vehicles

- CNG figure includes compression costs, taxes and 15% engine efficiency reduction
- Raw natural gas cost \$17/GJ
- Diesel cost \$1.92/l (\$50.66/GJ)

400km range	
40 litres/100km	48 m ³ /100km
160l diesel	190m ³ CNG
\$307 to fill diesel	\$142 to fill CNG
54% less fuel cost than diesel	
~100kg diesel tank	700kg CNG cylinders (steel)
	400kg CNG cylinders (composite)

If plant and vehicle costs are subsidised during the transition phase then CNG fuel for heavy vehicles makes good sense today



**CNG
FOR TRUCKS.**
THE DYNAMIC FUEL TECHNOLOGY DESTINED
TO RESHAPE THE TRUCKING INDUSTRY.

CNG SAVINGS AND PAY-BACK

Savings in fuel bills following a switch from diesel to CNG appear to range from about 19% to 22%. In the table below, we've calculated the effect of a 20% saving on typical fuel bills, and equated these to a pay-back period for a typical conversion costing \$12,000.

Your present diesel bills		Savings		Payback
Per month	Per year	Per month	Per year	
\$1,000	\$12,000	\$200	\$2,400	5 years
\$2,000	\$24,000	\$400	\$4,800	2.5 years
\$3,000	\$36,000	\$600	\$7,200	1.66 years
\$4,000	\$48,000	\$800	\$9,600	1.25 years
\$5,000	\$60,000	\$1,000	\$12,000	1 year
\$6,000	\$72,000	\$1,200	\$14,400	0.83 years

TRUCKING • July 1988

6*4 Mack R-series diesel converted to CNG
 300 hp (224kW) turbo intercooler
 Tare 9120kg
 12 * 70wl cylinders add 600kg
 350km range
 30 min refuelling time

Trucking 1988

Barriers to CNG and biogas uptake

High cost of compressor and refuelling plant

Vehicles cost more than diesel equivalent

New knowledge required to operate and service vehicles

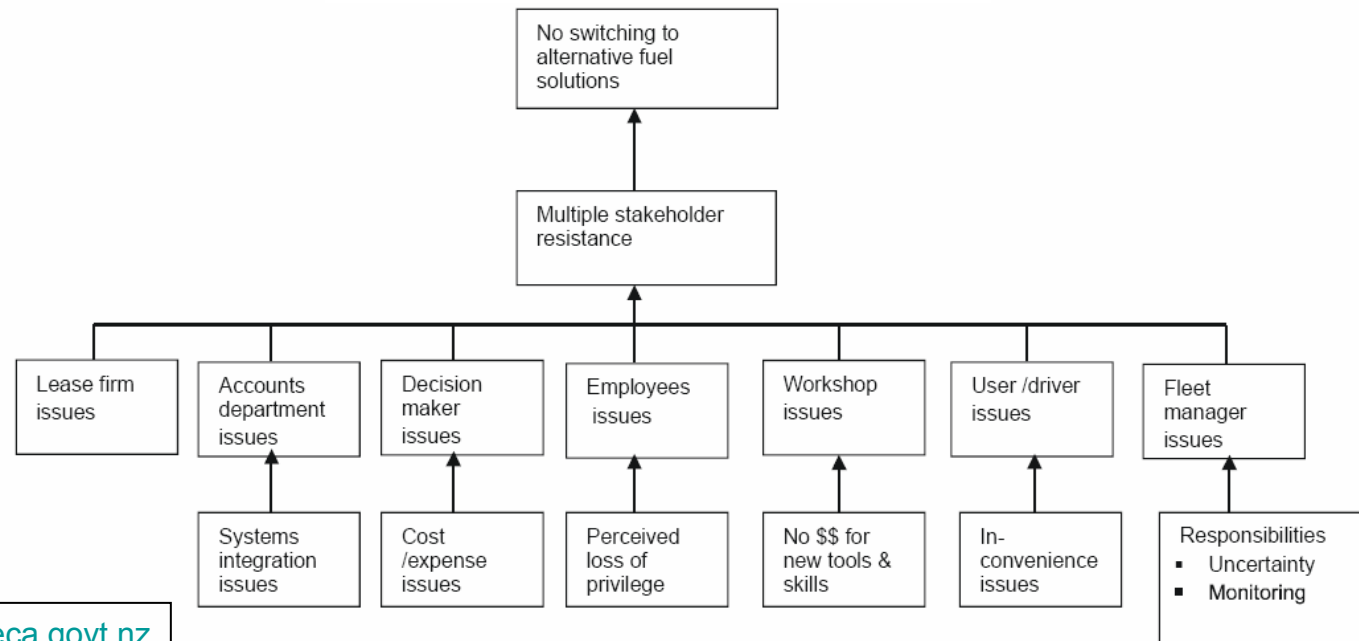
Fears over limited range and refilling of vehicles

“Been there, done that, didn’t work” attitude

Limited resale value of CNG vehicles in NZ

Company resistance to new ideas restricts the uptake of CNG when there are not significant hardship factors to drive change

Stakeholder issues problem tree



Established heavy vehicle CNG programs

UPS (USA) began developing fleet CNG in 1980s
Currently 800 out of ~95000 vehicles CNG powered as a
commitment to alternative fuels



Transperth Central Area Transit (CAT):
23 Mercedes buses using CNG since 1996
adding 451 urban route CNG buses



Boral Concrete (Sydney) 2007
five Iveco CNG powered concrete trucks



Caratrans Limited (UK) since 1999
27 out of 66 fleet vehicles converted to CNG at
800,000km, now total of 22 million km on CNG



Los Angeles County Metropolitan Transportation Authority
2,250 CNG buses, representing 90% of MTA's fleet

Brisbane Transport
430 Scania and MAN buses on CNG out of 900 total fleet



Europe: IVECO currently
3900 CNG buses operating in EU cities

Data www.ngvglobal.com

CNG is well established around the
world as a reliable heavy vehicle fuel

Overseas subsidies available for heavy vehicle CNG

USA “Clean School Bus” program provides
\$60,000 per vehicle for new or retrofit CNG

South Korea
12000 city buses on CNG supported by subsidy of
USD\$22,500 per bus
USD\$50,000 per garbage truck

Singapore: Green Vehicle Rebate
5% open market value rebate at registration of CNG bus
RUC reduced to 20%

RUC reductions in many Asian countries, government controlled
natural gas price



New Zealand needs government
support to get infrastructure installed
to support both biogas and CNG for
heavy vehicles

New CNG vehicles

Iveco produce a variety of dedicated CNG vehicles



www.sugre.info

Isuzu Elf CNG
available since 1993



www.fleetsandfuels.com

MAN NL202, CNG Route bus



www.us1.webpublications.com.au

Mercedes
“Econic” CNG
205kW 6.4 litre
engine

More new CNG vehicles
are becoming available
every year as the demand
increases



www.theautochannel.com

Cummins Westport CNG and
LNG engine supplier- 240kW
Los Angeles Metro bus



www.cngservices.co.uk

Conclusions

CNG is typically 20-40% cheaper overall to run than diesel

CNG retrofit significantly improves exhaust pollution in regions where older diesel engines are operating

The approach to gas fuel uptake should consider retrofit equipment as a transitional technology, followed by a strategic new vehicle purchasing plan

Set-up costs and employee resistance are significant barriers to gas fuel uptake

New CNG vehicles are becoming available in growing numbers as the worldwide demand increases

Company policy and management interest have to drive change and carry more influence than cost or emissions reasons to switch to CNG for heavy vehicle fuel.

Natural gas and biomethane are well established overseas as suitable fuels for heavy vehicles where fleet operators wish to make a long term commitment to alternative fuels



Thank You

andrew.thorp@cenaught.com