

**Informal Document for the
104th meeting of
Group of Experts on General Safety
United Nations, Geneva
15-19 April 2012
submitted by the Chairman of the
LNG Task Force**

**LNG Heavy Duty Trucks
Case Studies**

Explanation/Justification

This compendium of case studies is provided in response to a question raised by the French delegation to the Amendments proposed to Regulation 110 pertaining to the use of LNG as a vehicular fuel. It supports other informal documents and formal document ECE-TRANS-WP.29-GRSG-2013-7e presented to the 104th meeting of the Group of Experts on General Safety on 15-19 April 2013 in Geneva at the Palais Nations.

LNG Heavy Duty Trucks Case Studies Europe

Coca Cola introduces liquefied biomethane trucks in its London delivery routes 2010



- Fleet of 14 biomethane gas powered vehicles in service since March
- These vehicles successfully serviced our London 2012 Olympic and Paralympic logistics activity
- Performs well on all environmental levels; Climate Change, Air Quality and Noise
- Reliability and Driver Acceptance has been as high as for conventional vehicles
- Economics can be challenging, though opportunities for levelling exist



Coca-Cola Enterprises

Fourteen dedicated (gas only) trucks were tested on renewable biogas

➤ Worked commenced with Cenex during 2010 in developing the test methodology and deploying the pilot vehicles. Key measureables;

- CO₂
- Air quality performance NOx and PM
- Fuel Consumption
- Noise levels
- Driver acceptance & reliability
- Economics



	Iveco Stralis CNG	Iveco Stralis Diesel
GVW	26 tonnes	26 tonnes
Maximum payload	18.2 tonnes	18.9 tonnes
Engine capacity	7.79 litres	7.79 litres
Engine power	272 PS	310 PS
Emissions after treatment	3 Way catalyst system	SCR catalyst system
Emissions rating	EEV	EEV
Gearbox	6 speed automatic	12 speed automated manual
Fuel tank capacity	880 litres @ 200 bar	300 litres



Coca-Cola Enterprises



Tailpipe emissions & noise have been greatly reduced

TAILPIPE EMISSIONS

Emissions analysis conducted by Milbrook Proving Ground and Loughborough University

- NOx Reduction (gas) – 85.8%
- PM Reduction (gas) – 97.1%

Fuel efficiency calculated at Milbrook Proving Ground

- Gas 34.9Kg per 100Km
- Diesel 31.9L per 100Km

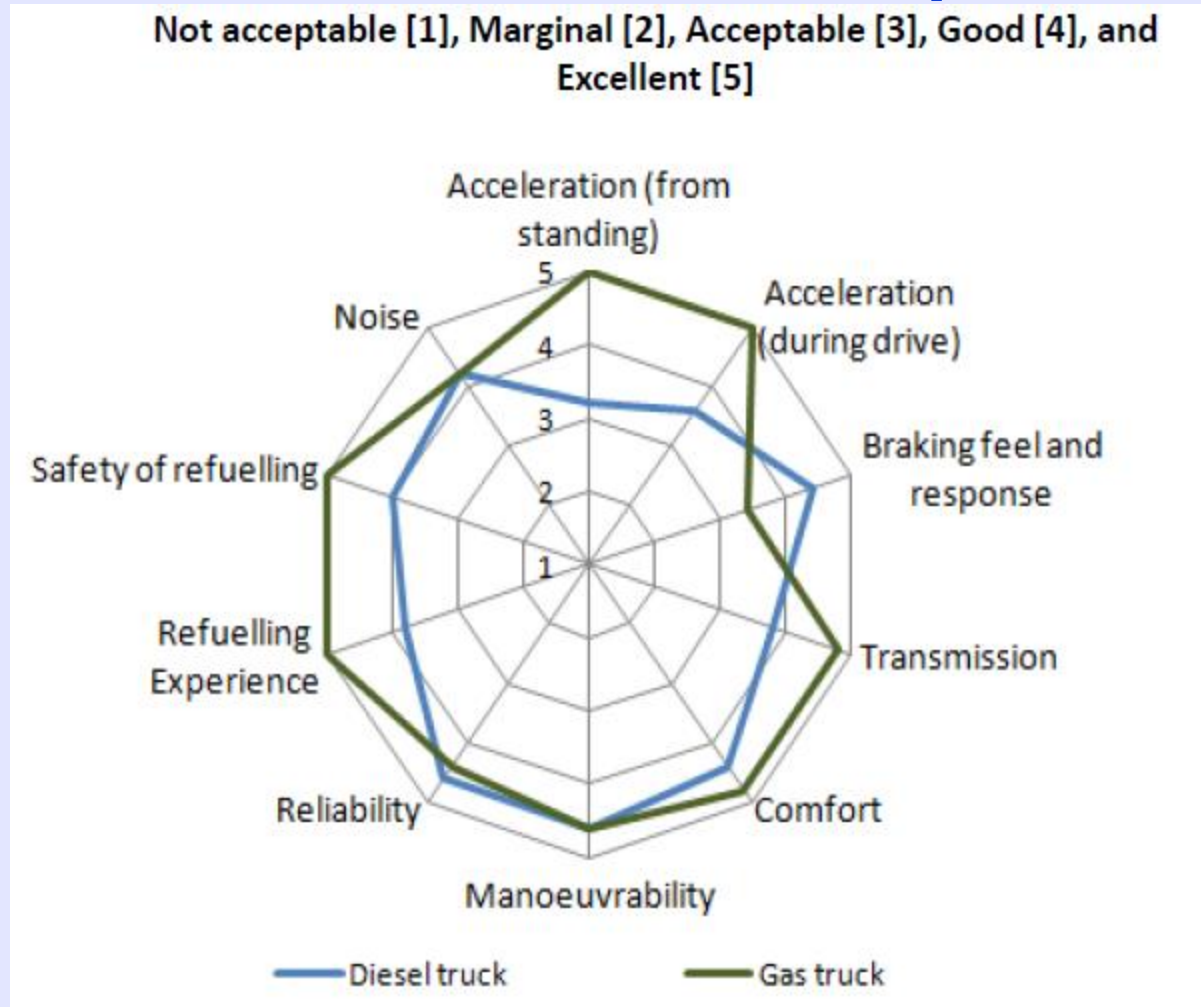
Emission	Gas Variant g/km	Diesel Variant (g/km)
Nox	0.539	3.799
PM	0.002	0.069

NOISE EMISSIONS

Noise measurement	Diesel Stralis dB(A)	Gas Stralis dB(A)	Reduction dB(A)
20 kph drive-by	73.3	69.2	4.1
Idle	77.7	67.2	10.5
Hot engine start-up	76.6	68.5	8.1



Driver acceptance has been as high or higher with natural gas compared to diesel

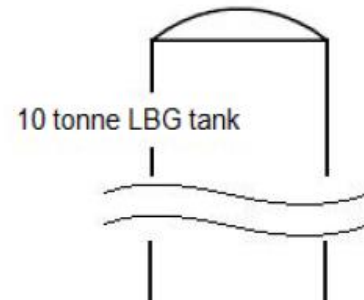


Diesel 'Uptime'
100%

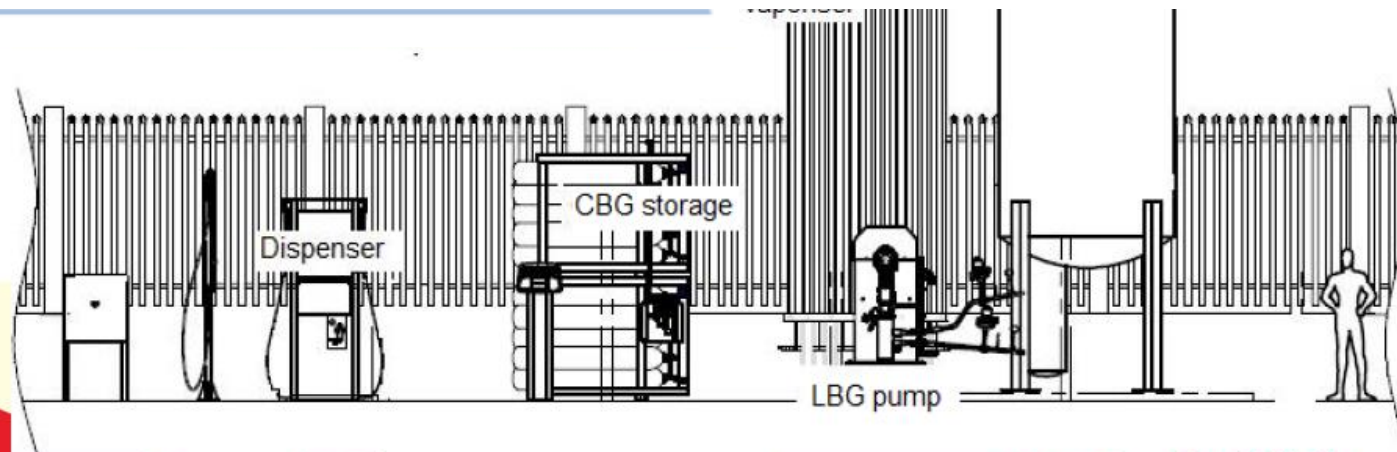
Biogas 'Uptime'
99.2%

Economic viability depends on specific operational characteristics and is significantly affected by factors such as infrastructure availability & annual mileage

Cost item	Gas operating cost differential
Vehicle cost	53.3%
Maintenance	6.8%
Fuel	-12.8%



Economic viability is clearly dependant on specific operational characteristics and is likely to be significantly affected by factors such as infrastructural availability and annual mileage



Coca-Cola Enterprises

Vos Logistics: opening up the market for LNG transportation in the Netherlands



Brussels, 24 October 2012

Annemarie Timmermans
LNG project manager

Background to VOS LNG experience: A Pioneer's Tale

- 2006 → start of initiative
- 2007 → first LNG Truck RAI (Amsterdam)
- 2009 / 2010 → development & opening fuel station
- technical testing vehicles
- registration with Dutch authorities (RDW)
- official start pilot
- 2011 → evaluation pilot phase
- 2012 → expansion of LNG fleet to 15 trucks
- 2013 → further fleet expansion planned



Operational results (to October 2012) were generally favorable despite some issues with the truck operations

▪ trucks

- reliability to be improved
- specific technical issues: fuel level measurement not accurate; temporary loss of power; engine not running smoothly

▪ refueling station

- technical issues mainly in the first year; no major problems
- vulnerability: nearest LNG stations not within 50 km range

▪ operational usage

- same yearly mileage as diesel trucks within distribution fleet (90,000 km)
- consumption of 27 kg LNG on 100 km (compared to 32 liter diesel on 100 km)
- range of 750/800 km

€ Results: Higher vehicle costs but fuel savings gives 6 year break even

Type of truck	DIESEL	LNG	<i>(subsidy)</i>
Km/Year	90,000	90,000	
Consumption L/100Km	32 Liter		
Consumption Kg/100Km		27 kg	
Initial investment	€ 85,000	€ 145,000	
<i>(Subsidy)</i>			<i>(€ 20,000)</i>
Net investment	€ 85,000	€ 145,000	<i>(€ 125,000)</i>
Running costs p/year	€ 40,000	€ 30,000	
Extra investment		€ 60,000	<i>(€ 40,000)</i>
Financial advantage/year		€ 10,000	
Break even point		6 years	<i>(4 years)</i>

Benefit of LNG to Vos Logistics: Improved emissions & smaller CO₂ footprint without relying on diesel

- clean fuel:
 - CO₂ emission - 30%
 - Particle emission - 85%
 - Noise reduction - 50%
- if replaced by LBG, CO₂ emission will be reduced with 80%
- LNG can easily be replaced by renewable biogas
- LNG trucks are admitted in city centers
- LNG is widely available
- LNG prices are stable (less dependency on oil price)

Challenges of LNG are non-technical due to a lack of: government support, fuel infrastructure & regulations

- lack of initiative & development on the part of OEM's
- gain control over cost of maintenance
- gain insight into life cycle and residual value

- involvement of more LNG suppliers / refueling station operators
- development of European LNG refueling station network
- standard regulations refueling stations (local, national and European)

- lack of structural subsidy commitment from national government
- currently no extra benefits operating environmental friendly trucks (toll, road taxes, exclusive roads)

- creating awareness and acceptance with business, customers, competitors, authorities

Rolande: LNG Distribution Trucks Netherland, France & Germany



Rolande LCNG

Rolande LNG B.V.



- Pioneer in Europe for LNG as a substitute for diesel
- Since 2007 first truck driving on LNG
- Active in
 - LNG deliveries in The Netherlands, France, Scandinavia, Switzerland and Germany
 - Filling stations
 - Truck conversions



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Business case: LNG Supermarket Distribution (Netherlands)

- 10x IVECO Stralis LNG Supermarket distribution
- 2 years > 2 million kilometres
- Fuel consumption 28 kg / 100 km
- Diesel trucks in similar conditions 31 L / 100 km





Business Case: LNG for Supermarket Distribution (NL)

Supermarket distribution NL	Diesel EEV	LNG EEV
<ul style="list-style-type: none"> Fuel consumption / 100 km Nett investment 	31 L	28 kg + € 40.000,-
<ul style="list-style-type: none"> Total distance (7 years operation) Diesel Fuel quantity LNG Fuel quantity 	750.000 km 232.500 Litre 210.000 Kg	
<ul style="list-style-type: none"> Fuel costs savings LNG 	Fuel quantity difference * Diesel price + price difference LNG <-> Diesel (incl. 17 cents excise duty)	
<ul style="list-style-type: none"> Example NL: 	$22.500 * 1.28 + 210.000 * 0.15 = \text{€}60.300$	

Business Case: LNG for Supermarket Distribution (FR)

- 1x IVECO Stralis LNG Supermarket distribution
- 8000 kilometres
- Fuel consumption 25 kg / 100 km
- Diesel trucks in similar conditions 30 L / 100 km

STRALIS AT 440S33 GNL

LE MOYEN DE TRANSPORT ROUTIER LE PLUS PROPRE DEPUIS L'INVENTION DU CAMION





Business Case: LNG for Supermarket Distribution (FR)

Supermarket distribution FR

Diesel
EEV

LNG
EEV

LIQUIFIED BIOGAS

- Fuel consumption / 100 km
- Nett investment

30 L

25 kg

+ € 40.000,-

- Total distance (7 years operation)
- Diesel Fuel quantity
- LNG Fuel quantity

750.000 km

225.000 Litre

187.500 Kg

- Fuel costs savings LNG
- Fuel quantity difference * Diesel price + price difference LNG <-> Diesel (no excise duty)

- Example FR:** $37.500 * 1.34 + 187.500 * 0.30 = €106.500$

Business Case: LNG for Medium range haulage (Germany)

- 1x IVECO Stralis LNG Medium range haulage
- 6000 kilometres
- Fuel consumption 24 kg / 100 km
- Diesel trucks in similar conditions 30 L / 100 km



LIQUIFIED BIOGAS





Business Case: LNG for Medium range haulage (Germany)

Medium range haulage D

**Diesel
EEV**

**LNG
EEV**

LIQUIFIED BIOGAS

- Fuel consumption / 100 km 30 L 24 kg
- Nett investment + € 40.000,-

- Total distance (7 years operation) 750.000 km
- Diesel Fuel quantity 225.000 Litre
- LNG Fuel quantity 180.000 Kg

- Fuel costs savings LNG Fuel quantity difference * Diesel price + price difference LNG <-> Diesel (incl. 8 cents excise duty)

- **Example D:** **$45.000 * 1.28 + 180.000 * 0.24 = €100.800$**



Simon Loos: Municipal Logistics (Netherlands)



■ 100% family owned company, since 1938

■ Transport, Warehousing, VAL
& Logistic Consultancy

■ Over 20 locations throughout the Netherlands

■ 85.000 m2 warehouse

■ 1.065 employees

■ 510 trucks and 645 semi trailers

■ Turnover 2011: 94 mio €



2009 : test 2 CNG trucks
2010 : order 30 LNG trucks
2011 : order 60 Euro 6 trucks
2012 : >Euro 6 reefer engine
2013 : reefer engines CO₂ reefer engines
: LNG powered reefer engines
: Electric vehicles

30 LNG deliver trucks deployed in 2012



- 2009 test with 2 CNG trucks – *successful but bigger driving range required*
 - 2010 order 30 LNG trucks – *partnership MercedesBenz and LNG Europe*
 - Incentive of local authorities
 - 2 years permit procedure (pillar to post...)
-
- 2012 all trucks deployed – *mostly tractor-2axle semitrailer; 7 rigids with PTO driven reefer*





An overall positive experience with 30 LNG trucks

- Safe driving range 600 – 700 km
- Fuel consumption approx. diesel
- Refuelling station at customer site
- Refuelling by driver
- Service interval shorter
- Higher mileage required
- Refuelling schedule



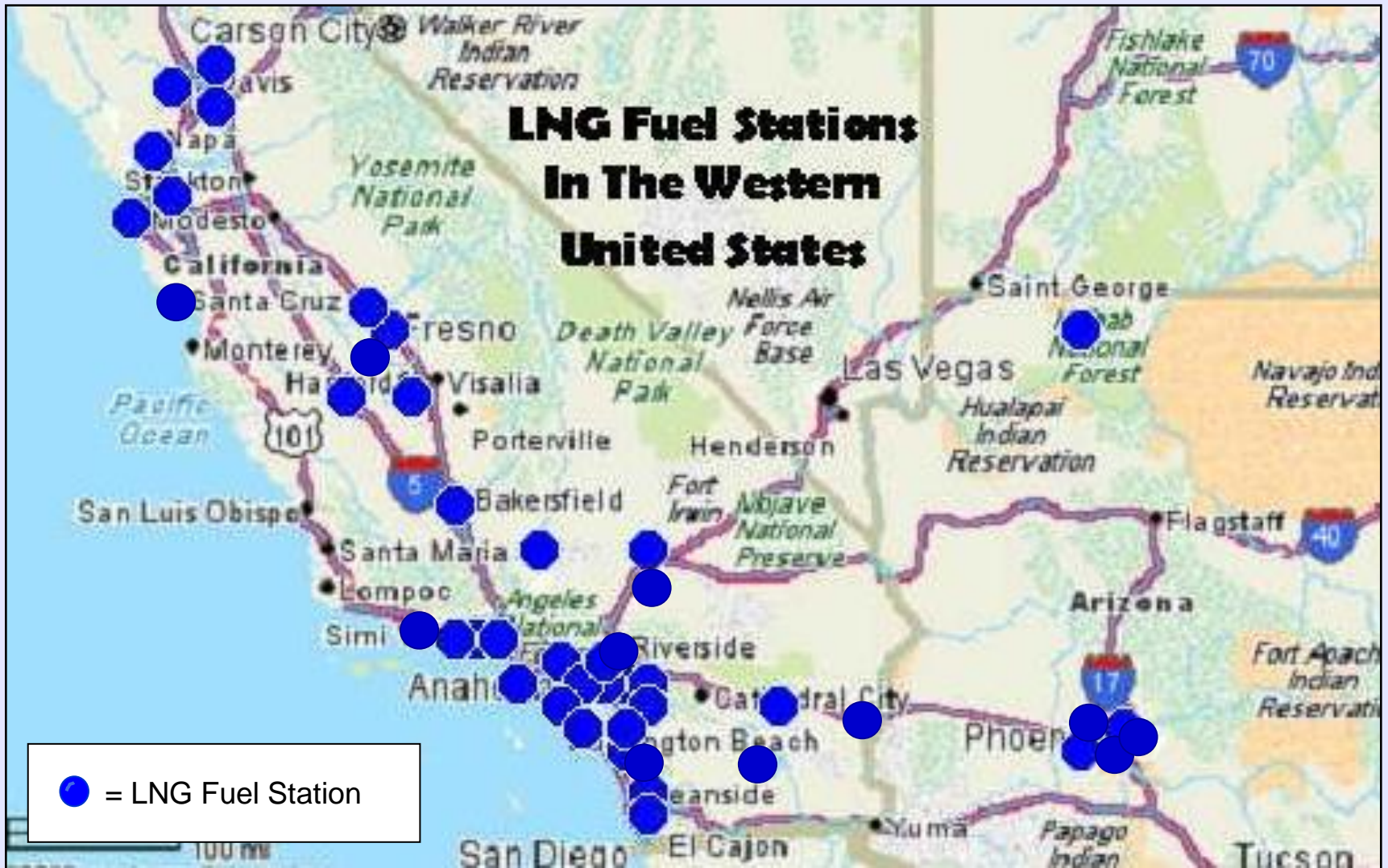


Experience with 30 LNG trucks: Some challenges remain

- Fuel gauge reliability
- Managing boil off
- Fuel quality impact (kWh/ton)
- Reliable fuel consumption data
- Excise

LNG Heavy Duty Trucks Case Studies North America

LNG fuel station 'corridors' are expanding as LNG truck fleets continue to grow



Gordon Exel, *Case Studies in N. America: LNG Heavy Trucks*, NGV Summit, FC Business Intelligence, Brussels October 2012

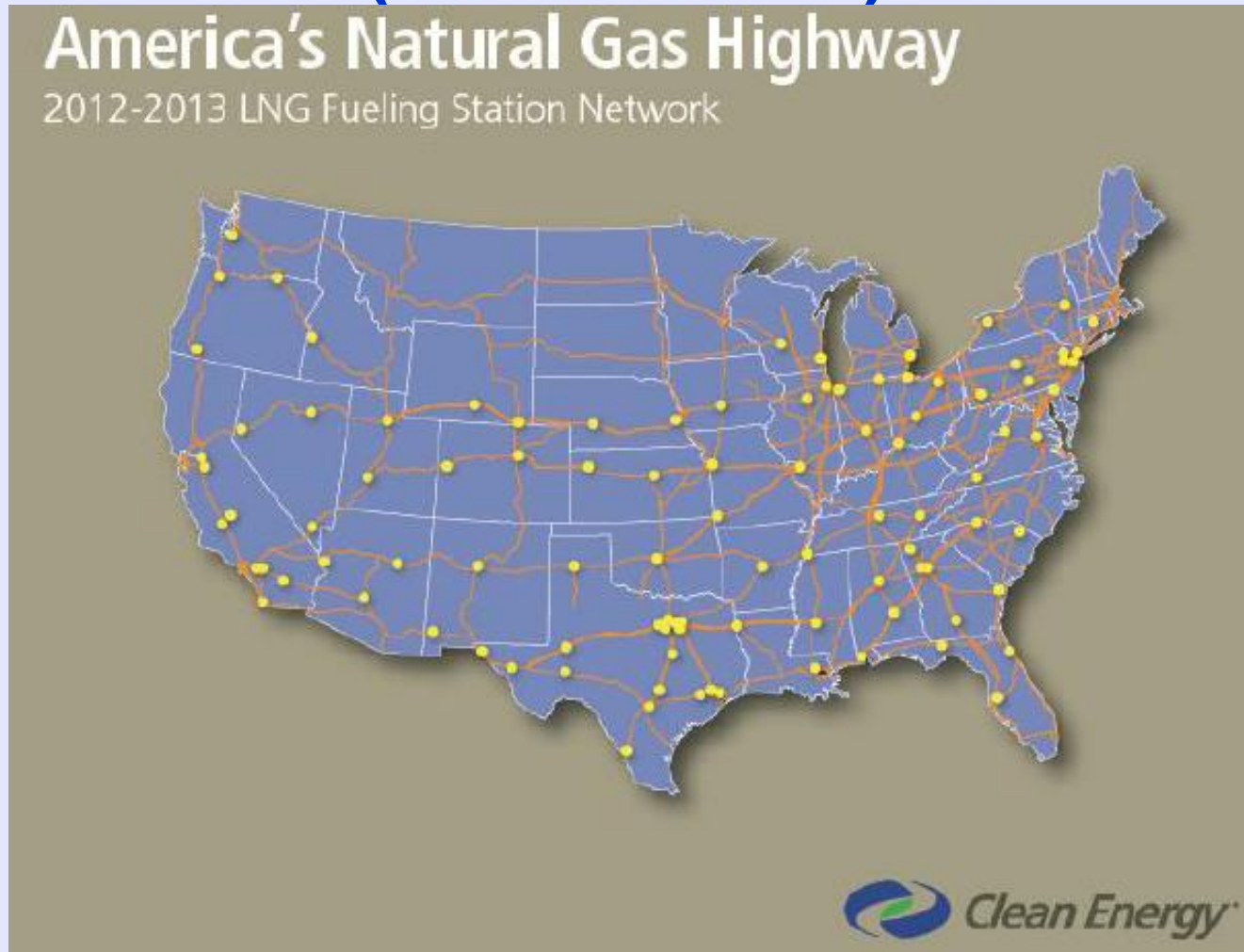


LNG stations in Southern California support LNG trucking to seaports in Los Angeles & Long Beach



Gordon Exel, *Case Studies in N. America: LNG Heavy Trucks*, NGV Summit, FC Business Intelligence, Brussels October 2012

American vision of LNG fuelling network, supported by private sector funding (\$150+ million)



N. American LNG Truck Case Studies

United Parcel Service

- Largest private fleet in USA – environment, energy security concerns
- 82 new LNG tractors – operating between Los Angeles, Las Vegas and Salt Lake City Distribution Centres
- 688 mile (1107 km) corridor with 3 fuel stations
- 4 fuelling stations
 - – public access
- ~5100 tonne annual GHGe reductions from implementation



City of Fresno, California

The Results

- LNG Best Fit for Refuse Truck Fleet; All New Trucks are LNG Powered since 2004. Currently 81 Trucks using LNG with 45 new trucks on order.
- CNG Best Fit for Transit Buses; All New Buses are CNG Powered or Advanced Hybrid Design. Currently 54 Buses using CNG.
- Cost Savings from use of Natural Gas Fuels in Fiscal Year 2008 = \$3,200,000.



City of
FRESNO

gna GLADSTEIN,
NEANDROSS
& ASSOCIATES

Eric Neandros, *Developments in US L-NGV Market*, LNG is HOT workshop, Brussels 2009

N. American LNG Truck Case Studies

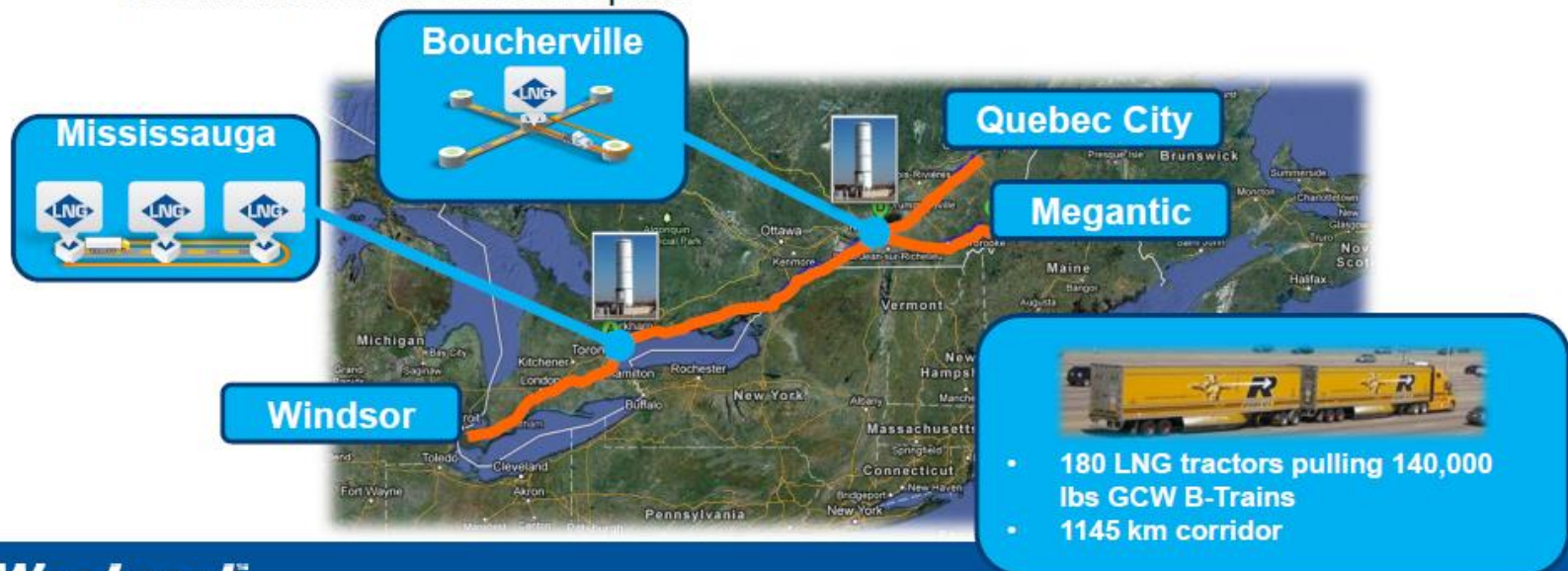
Robert Transport, Canada

Expandable Infrastructure

- Initially used mobile refueler
- Added permanent stations with 15,000 gal LNG storage
- Expandable to 30,000 gal with second vessel on same footprint

Building Corridors

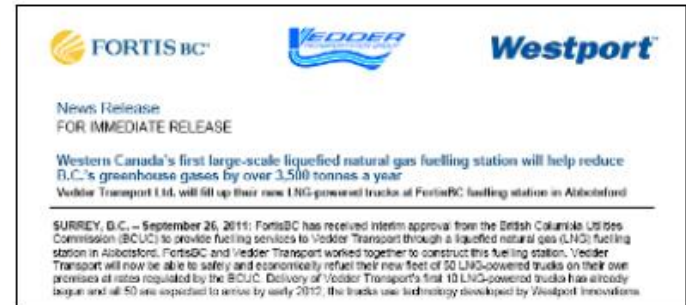
- Initial “hub” station in Boucherville
- Added station in Mississauga, opened up 401 corridor through to Windsor
- Planned fueling in Quebec City, opens corridor in opposite direction



N. American LNG Truck Case Studies

Vedder Transport

- Largest fleet in British Columbia, Canada – high environmental commitment
- 50 new LNG tractors
- Hauling milk, food, forestry and waste products in dedicated service
- 3500 tonne annual GHGe reductions from implementation
- Cost reductions result in ~16 month payback
- 1 fuelling station – public access



LNG FOR TRUCKS

The fuel suppliers' views....

**Also as fleet operators of
trucks & ships**

Shell Vision LNG Vehicles Road & Marine Transport

Shell
LNG

TOMORROW'S FUEL TODAY

LNG in Transport from vision into reality
Lauran Wetemans – GM, DLNG



Shell Vision....

LNG trucks in N. America

GREEN CORRIDOR - CANADA



- Canadian Green Corridor, 1500 km Vancouver – Calgary - Edmonton
- Shell Flying J Network
- Sites opening end 2012



Shell Vision Europe: LNG ships & trucks

- Focus on Marine & Road
- North West Europe
- Including Addressing Own Demand
 - 2 barges with ISB on Rhine

“Shell owns 1,800+ vessels & target 25% to be using LNG by 2025.” (Poli-techs, March 2013, Brussels)

GATE



GASNOR



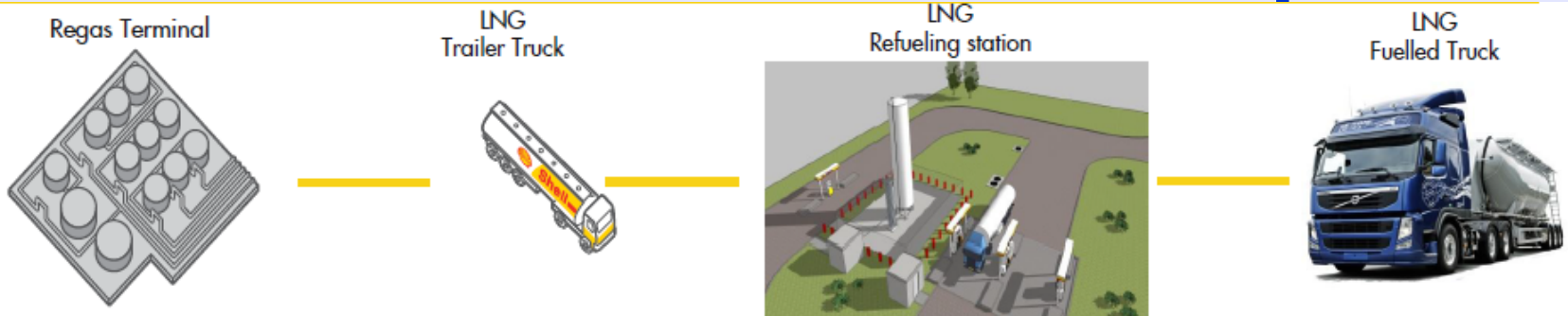
ROAD



INLAND WATERWAYS



Shell view of LNG for Transport



CRITICAL SUCCESS FACTORS

Conversion Cost

- LNG refueling station will be 3-5 times more expensive than current diesel station
- Increased availability of LNG fuelled trucks at a lower cost
- Cost reduction across the supply chain

PRICING

- Governed to lower your total costs of ownership
- Enabling to provide customers a high quality fuel at discounted diesel prices

REFUELING NETWORK

- Network Plan for LNG sites on existing Truck network
- Align with customer priorities

Linde is a leader supplier of LNG and LNG fuel stations

Linde North America has purchased 23 LNG trucks for own distribution fleet



- **Peterbilt and Kenworth LNG trucks** with LNG fuel system and 8.9L NG engine
 - Cummins West Port ISLG Engine
 - 350 HP
- Trucks deployed in **Southern California, Texas and Midwest**
- Lower weight, spark ignited units has even **improved pay-load**



Take-out: Good driver experience and economics in line with expectations. Linde always operating weight restricted which is limiting areas were low horse power engines can be used.

Linde view of what's required for LNG to penetrate the heavy truck market

- Codes & standards need to come in place, beyond local ones
- Industry must put „Safety first“
- Gas quality requirements needs to be sorted out (not that easy)
- Never accept solutions allowing methane to free air to be adopted
- Hen & egg situation can be solved
- LNG and CNG goes hand-in-hand and LNG is not a viable option for every heavy vehicle!
- Biomethane likely to play significant role on many markets as transport fuel and EU wide regulations on certificate trading needed
- All stakeholders need to work close together to align expectations and set priorities during early market phase

Consortium of Dutch Stakeholders join forces for LNG in Transport

Nationaal LNG Platform

Introduction of
Liquefied Natural Gas as a
clean transport fuel solution



Jan-Joris van Dijk

24 October 2012

The Dutch National LNG Platform Visions

- Connecting companies and authorities that are active in the introduction of LNG as a clean fuel for the transport industry:
 - Operating under a common flag, reinforcing one another, avoid fragmentation.
 - Realizing a sizeable market share over the full LNG chain.
 - Coordinating the communication with authorities

Targeting to have by 2015:

- **50** inland ships
- **50** sea vessels
- **500** trucks

running on LNG

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