



24th World Gas Conference
ARGENTINA | 2009
5-9 October

The Global Energy Challenge:
Reviewing the Strategies
for Natural Gas

FINAL REPORT

Study Group 5.3

Utilization of natural gas in transport sector

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Committee Session 5.3: Methane – A Global Eco-Efficient Mobility Solution

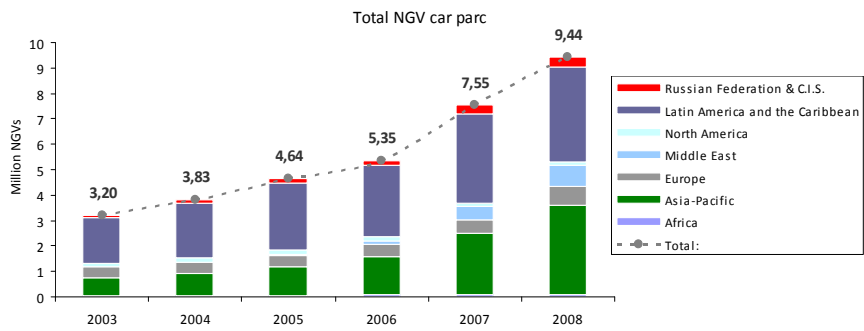


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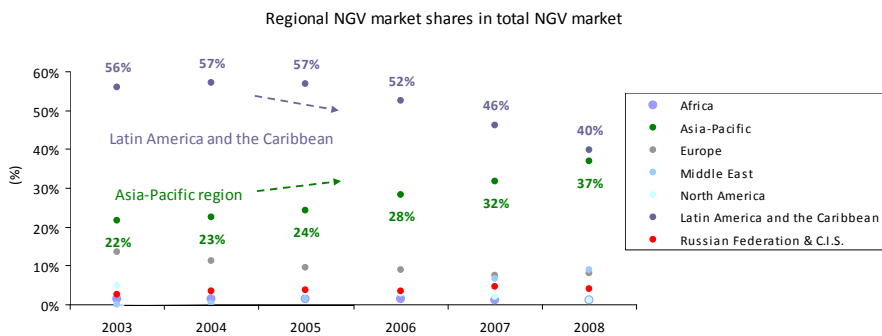
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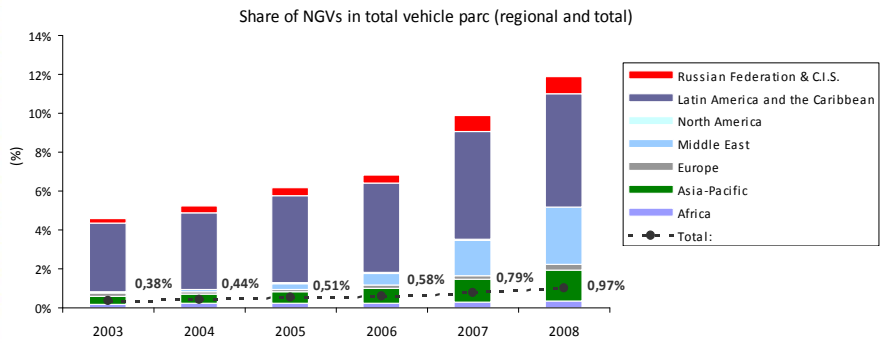
Worldwide Network and Organization of the Study Group



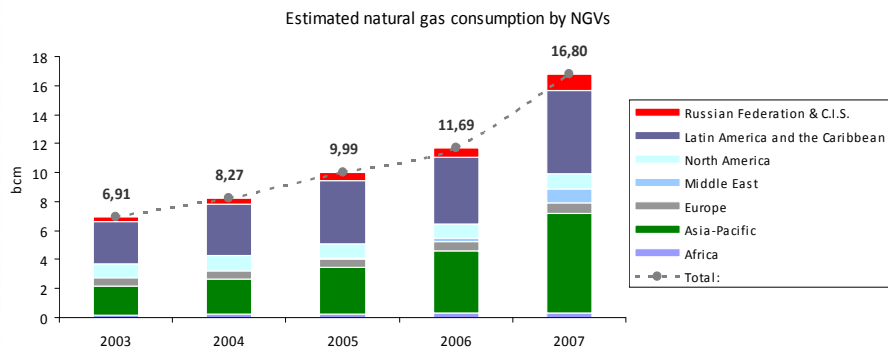
Market Development and Present Market Situation



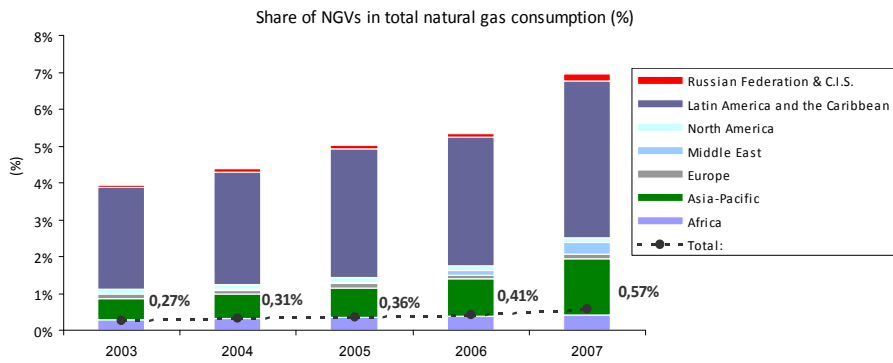
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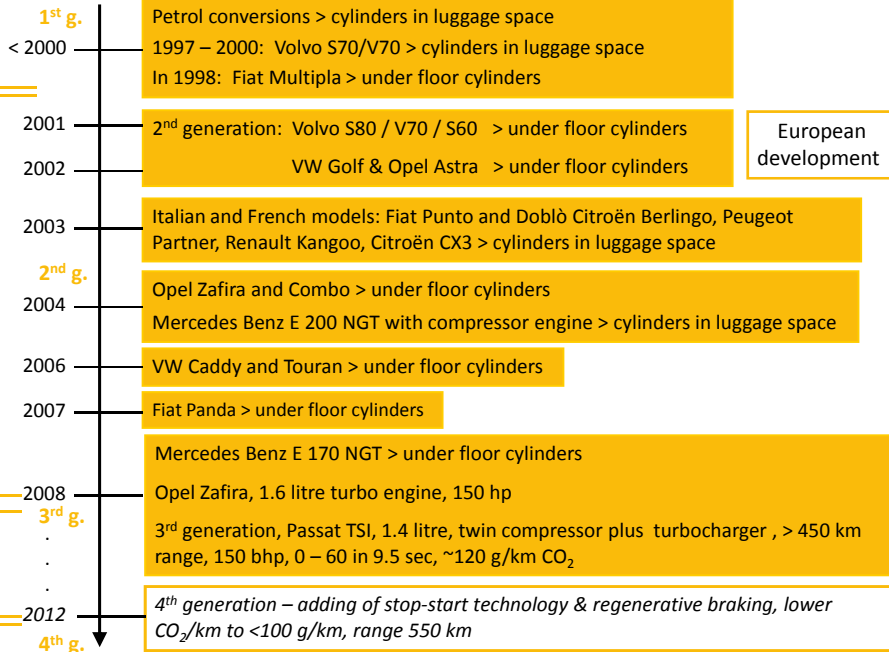
Market Development and Present Market Situation



Market Development and Present Market Situation



Market Development and Present Market Situation



OEM NGV Technology Development



Europe

- Vast majority of new NGV registrations: OEM products or QVM conversions (with the approval of the concerned OEM)
- **HDV segment (vehicles above 12 tonnes):** buses with a typical engine size of around eight liters (Daimler, Iveco, MAN, Scania, Tedom AB Volvo (incl. RVI) engines)
- **MDV segment (weight class 3.5 - 12 tonnes):** mainly 3.5 - 6 tone range > same vehicle available in different configurations: vans, trucks, or small buses (Iveco Daily, Mercedes Sprinter...)
- **LDV / MDV class (< 3.5 tonnes >):** Fiat Ducato, Volkswagen Transporter and Ford Transit (QVM), in France: Citroën Boxer, Peugeot Jumper models, Renault Master
- LPG market mainly retrofitting of light duty gasoline powered vehicles

Summary of Technology Development and an Overview of NGV Industry Today



Asia-Pacific

- Still dominated by a wide range of different quality retrofit systems
- OEM availability in India, Korea, China (coupled with innovative technologies from Western countries):
 - Should provide the required range of vehicles for long term NGV demand
 - Currently tend to be Euro 3 (some Euro 4) quality - depending on national emissions standards
- China - the single most actively growing OEM market worldwide
 - 18 engine manufacturers offered 98 types of NGV engine models (64 kW to 250 kW) in 2007
 - Cummins and Iveco engines present
 - International equipment and European NGV conversion systems suppliers present
 - L-NGVs fleet use expanding
- NG HD trucks development in Japan (25 ton class)
- Replacement with natural gas of two-stroke and three-wheel vehicles

Summary of Technology Development and an Overview of NGV Industry Today



United States

- **OEM** light duty sedans (American Honda Civic GX)
- **Small Vehicle Manufacturers (SVM)** sedans, commercial work trucks and vans
- **HDV and MDV segments** received the most marketing focus from the NGV industry
 - High-pressure, direct injection LNG engines (Westport Innovations) with same characteristics as base diesel engines (Cummins)
 - HD engines (Cummins Westport) already meeting U.S. EPA 2010 emission standards
 - Dedicated spark-ignited replacement (Emissions Solutions) engines for the popular diesel HD engines models
 - Aftermarket conversion system manufacturers for medium gasoline-powered trucks and shuttle bus chasses

Summary of Technology Development and an Overview of NGV Industry Today



Russia

- Mostly HDVs and MDVs conversions
- Customers looking for OEMs
- Restarted development and production in OEM HDV segment:
 - Trucks and special purpose vehicles (KAMAZ)
 - Buses (NEFAZ – Kamaz engine), LIAZ and PAZ (Cummins engine)
- Off-road applications in use or tested: airplane, watercrafts, construction equipment, agricultural tractors, rail road locomotives...

Summary of Technology Development and an Overview of NGV Industry Today



Latin America

- Quick growth rates on retrofit market (up to 20-25% annually) in Argentina then Brazil throughout the mid-to-late 1990s and into 2000s
- Although the retrofit market has been strongest, the quick growth rate has brought more OEM (LDVs), in particular into the Brazilian market
- The active NGV markets in Argentina and Brazil have had concurrent positive effects on other countries; Peru, Venezuela, Colombia, Bolivia, and to a lesser degree in Chile

Summary of Technology Development and an Overview of NGV Industry Today



Vehicles Technology Improvements

- New OEM NGVs will likely use downsized, supercharged engines and possibly also micro or soft hybrid solutions:
 - Before 2012 the car manufacturers will start introducing downsized turbo Otto engines for their standard mainstream product lines
 - These engines would be well suited also for natural gas applications
- Dual fuel turbo vehicles operation on natural gas with pilot diesel injection, possibly also with micro or soft hybrid solutions might enter the market
- The impact of biomethane can bring the emissions down further when considering well-to-wheel emissions

Potential and Promising New Technologies and Assessment of the New Technologies Opportunities

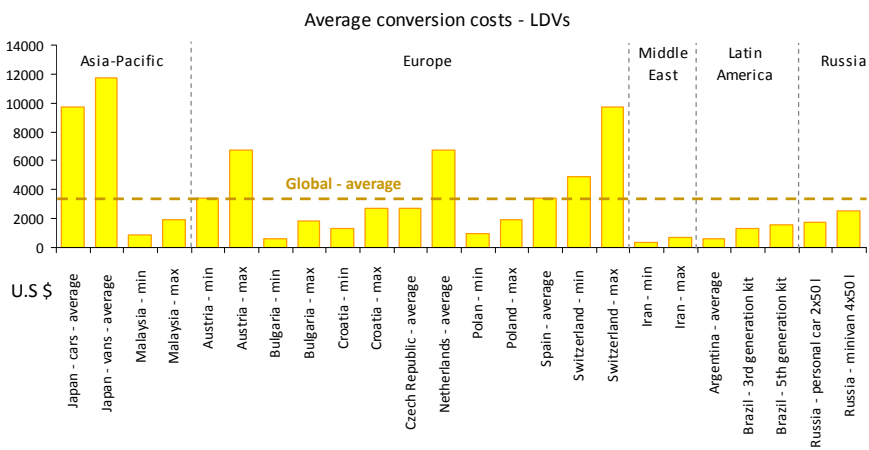


Filling Stations Technology Improvements

- To cut costs and to guarantee safety and reliability
- **Ionic compressor (iKompressor)^(*)** replaces metal piston with liquid
 - Reducing number of moving parts and frictional losses
 - Increased energy efficiency and lower wear and tear
- **RFID – Radio Frequency Identification ^(**)** a way to ensure only certified vehicles are filled
 - RFID antenna located in the fuelling nozzle reads vehicle tag > RFID control system at the dispenser validates data from the vehicle > allows fueling if everything is ok
 - Programmed data determined by the regulatory body issuing the tag > typically: vehicle ID, license number, owner, conversion company ID, date of conversion, inspection, expiry date etc.

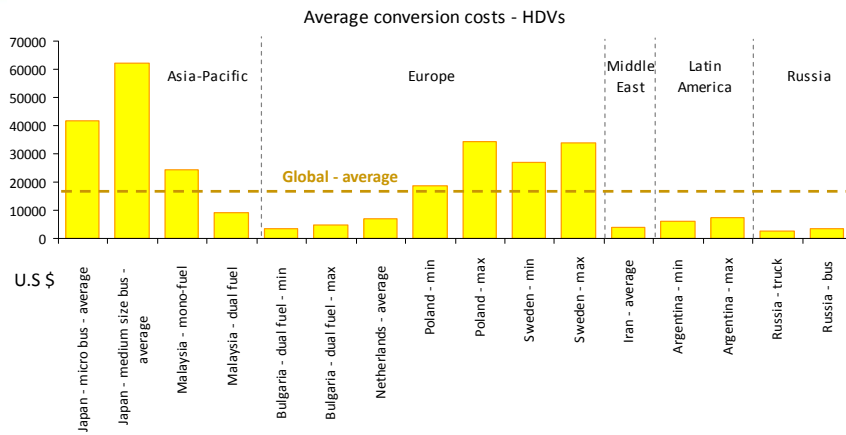
(*) – JV Flowserve & Linde Group (**) - Viridis

Potential and Promising New Technologies and Assessment of the New Technologies Opportunities



NOTE: Highly dependant on type of equipment; cylinder volume, type and number; new or recycled components; approvals and certification etc.

IGU NGV Technical & Commercial Data Base



NOTE: Highly dependant on type of equipment; conversion type (dedicated / dual fuel); cylinder volume, type and number; new or recycled components; approvals and certification etc.

IGU NGV Technical & Commercial Data Base



Supportive measures

Europe	vehicles	methane as fuel	filling stations
Austria	☑ ☐	☐	☑
Bulgaria	☐	☐	
Croatia		☐	
Czech Republic	☑ ☐	☐	
Italy	☑ ☐	*	*
France	☑ ☐	☐	☑
Netherlands		☐	☑
Poland	☑	☐	
Portugal	☐	☐	
Spain	☑	☐	☑
Sweden	☐		☑
Switzerland	☑ ☐	☐	
United Kingdom		☐	☑

Asia - Pacific	vehicles	methane as fuel	filling stations
China	☑	☐	☑ ☐
Japan	☑ ☐	☐	☑ ☐
Malaysia	☐	☑	☐

Middle East	vehicles	methane as fuel	filling stations
Iran	☐	☑	☑

Latin America	vehicles	methane as fuel	filling stations
Argentina	☐ **		
Brazil		☐	

Russia	vehicles	methane as fuel	filling stations
Russia			

- ☑ subsidies / grants / loans
- ☐ tax reductions / exemptions
- * although not reported through questionnaire should be available
- ** in Buenos Aires

IGU NGV Technical & Commercial Data Base



Standards, regulations and codes for vehicles and filling stations

Europe	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection	Asia - Pacific	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection
Austria	☑	☑	☑	☑	China	☑			☑
Bulgaria	☑	☑		☑	Japan	☑	☑		☑
Croatia	☑	☑			Malaysia	☑	☑		☑
Czech Republic	☑	☑	☑	☑					
France	☑		☑	☑	Middle East	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection
Netherlands	☑	☑	☑	☑	Iran	☑	☑	☑	☑
Poland	☑	☑	(☑)	(☑)					
Portugal	☑		☑	☑	Latin America	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection
Spain	☑	☑		☑	Argentina	☑	☑		☑
Sweden	☑		(☑)	n.a.	Brazil	☑	☑		☑
Switzerland	☑		☑	☑					
United Kingdom	☑	☑	☑	☑	United States	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection
					United States	☑	☑	☑	☑
Russia	vehicle incl. inspection	conversion / maintenance shops	garages incl. underground parking	filling stations incl. inspection					
Russia	☑	☑	☑	☑					

IGU NGV Technical & Commercial Data Base



Collecting real life experiences from fleets operators using NGVs

- One-on-one interviews (audits) with fleet operators
- Sharing experiences from real life day-to-day operations
- Maintenance and life-cycle costs, repair intervals, fuelling time and flexibility, safety, additional technical and infrastructure requirements, feedback from drivers, users, mechanics and overall business efficiency compared to liquid fuels
- Advices to future users (what to do, what to avoid, how to improve)

Real Life Experiences – Lessons Learnt



Collecting real life experiences from fleets operators using NGVs

- Natural gas buses, garbage trucks and taxi fleets
- Dual fuel trucks powered on LNG/CNG



Moscow



Lille



Paris



Kuala Lumpur



Hamilton (Canada)



UK



Madrid

Real Life Experiences – Lessons Learnt



Collected experiences – Lessons Learnt and Recommendations

- There are operational differences with NGVs (i.e. buses) compared to diesels > which can be effectively managed
- Careful preparation of the system logistics and organization is needed:
 - compression capacity, CNG buffer stock, maintenance, manpower, CNG vehicles specifics (autonomy, maintenance procedures based on diesel)
- Training and experience of mechanics is diesel oriented (NGVs = challenge - perceived over-sophistication):
 - Training to be integrated with other staff training needs
 - Diesels also becoming more sophisticated (to meet the new emissions standards)

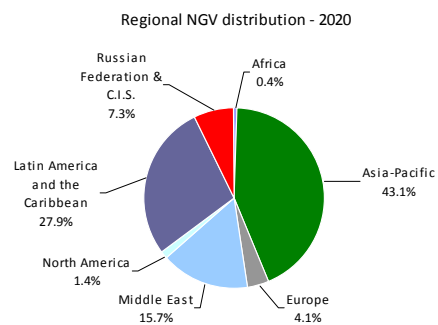
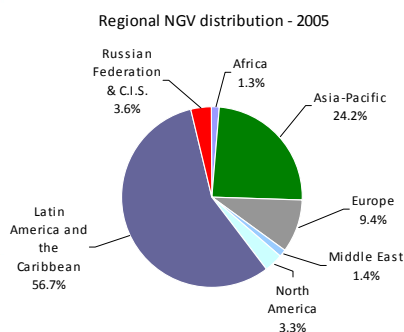
Real Life Experiences – Lessons Learnt



Collected experiences – Lessons Learnt and Recommendations

- CNG station owned by gas company and not the transport enterprise:
 - PRO: Facilitate decision on NGVs (no investments for transport enterprise)
 - CON: Filling station capacity (and other) improvements more complicated (contractual issues)
- NGV related costs could be stabilised by optimising the reliability and costs of the NGV specific spare parts
 - Advice to carry a higher ratio of spare parts to ensure that maintenance tasks are not constrained by parts supply
- Problems with first generation of CNG buses (complexity, reliability, thermal efficiency, lack of manufacturer's support) > significantly overcame in new generations models
- Higher costs for NGVs are balanced by lower fuel costs compared to diesel fuel (in general, resulting in lower life cycle costs)

Real Life Experiences – Lessons Learnt



Regional NGV market development scenarios



Conclusions

- There has been a dramatic increase in the numbers of OEM NGV models in the worldwide vehicle market
- New developments such as high pressure direct injection and turbo charging should increase efficiency, vehicle range, and reduce emissions
- New generation of vehicles are likely to move into the other regions in parallel with the development of more stringent national and local standards
- Generally the life cycle costs of NGVs are comparable or even better to traditionally fuelled vehicles
- Comparative reports of NGV maintenance experiences shows a positive influence of a 'learning curve' related to improved 'best practices' and the development of second generation technologies

Conclusions & Recommendations



Recommendations

- **Appropriate and competitive fuel pricing system relative to petrol and diesel** (based on: energy equivalencies, fuel margins desired, favourable taxation that supports cleaner fuels)
- **Fuel quality/composition and the sale units of CNG (LNG) at the fuel pump** - important considerations into the future
- **Efforts to continue harmonization of worldwide standards and regulations** is needed
- **Natural gas industry should further evaluate the opportunities for biomethane as part of their overall fuel supply portfolio** (consistent with many government policies)
- Emerging technologies and natural gas-based fuels are showing strong future potential and should be encouraged for further study and development (incl. Government sponsored R&D)

Conclusions & Recommendations



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THANK YOU !!!