Overview of NGV in China & Research Status of CAERI

Zou Bowen, Ph.D

China Automotive Engineering Research Institute (CAERI)
China National Gas Vehicle Engineering Research Center (CNGVERC)

Dec, 2013
Outline

1. Automotive and Energy Environment
2. Development of NGV in China
3. Research Status of NGV in CAERI
1. Automotive and Energy Environment

- In 2012, China produced more than 19 million autos, auto population exceeded 120 million.
- 250 million tons of petrol and diesel has been consumed, auto shared over 60%.
- In 2020, auto population maybe reach 250 million, even fuel consumption of each car lower 20%, fuel supply will be still lack of 60 million tons.

Fuel consumption gap estimation in 2020 (100 million tons)

Development of Auto in China Closely Relate to Energy Supply
1. Automotive and Energy Environment

Achievement of auto pollution control is remarkable (2011)

- 54% In-use cars met Euro 3/4/5, auto population ↑ 20%, but CO&HC ↓ 12% & 7%
- Different pollution of each petrol car ↓ 15%~27%, ↓ 11%~25% for diesel car

Task of auto pollution control is still deep-going way (2011)

- Total NOx emission, more than 24 million tons (↑ 30%), auto shared 24% (↑ 7%)
- PM of each diesel car ↓ 11%, but total amount ↑ 4%
1. Automotive and Energy Environment

- The most serious PM pollution happened in north & east of China
- In the begin of this year, thick fog and haze weather covered \( \frac{1}{4} \) area
- Auto becomes the biggest source of PM2.5 in Beijing, shared \( 22\% \) in total

Fog and haze in Beijing  Fog and haze in Shanghai

Reduction of PM Becoming New Attractive Field for All Over China
What’s The Plan of Monitoring & Controlling PM 2.5 in China

- End of 2011, Ministry of environmental protection published ‘PM2.5 national monitoring schedule’

- In Sep 2013, State Council published ‘Prevention Action Plan of Atmospheric Pollution’, China will take comprehensive measures to reduce PM2.5 such as improving the quality of fuel. Now, more and more cities has used Euro 4&5 diesel
Outline

1. Automotive and Energy Environment

2. Development of NGV in China

3. Research Status of NGV in CAERI
2. Development of NGV in China

External & Internal Motivation of NGV Development

- NG, environmentally friendly, almost all the 12th five year plan of environment protection & energy development programmed to improve the proportion of NG in primary energy up to 7.5%.

- NGV, primary energy utilization, higher efficiency of WTW than petrol & diesel, also internal combustion theory, mature tech & industrial chain, much lower fuel price.
2. Development of NGV in China

- Much lower HC, CO₂, NOₓ and SOₓ than petrol & diesel, frees of PM, lead & benzene
- Good to reduce fog & haze weather, e.g. in case a large city in China has 10,000 diesel buses of Euro III, when changed to NGV, 600 tons/year of PM will be reduced
- Even compared with HEV, still lower CO₂ emission on rural road & high way

NGV is one of effective solution of energy & environment auto issue

<table>
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<tr>
<th></th>
<th>HC</th>
<th>CO₂</th>
<th>CO</th>
<th>NOₓ</th>
<th>SOₓ</th>
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<td>Diesel</td>
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<td>0.617</td>
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<td>LPG</td>
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<td>340</td>
<td>9.487</td>
<td>1.016</td>
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<td>NG</td>
<td>0.482</td>
<td>304</td>
<td>8.476</td>
<td>0.847</td>
<td>0.030</td>
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</table>

Emission Comparison of Diff Fuel within WTW

CO₂ Emission Comparison of NGV & HEV(FOEN)
2. Development of NGV in China

Overview of NGV in China

- **32** provinces applied NGV, **4000** gas stations, **3000** for CNG, **1000** for LNG & L-CNG
- **3 million** NGVs, population ranking No.5 in the world, LNGV increased rapidly in recent years, its population exceeded **100,000**
- Alternated **20 million** tons/year of petrol & diesel, reduced **12 million** tons/year of CO$_2$
2. Development of NGV in China

Status of NGV Products

- More than 60 OEMs, 400 car models, engine power ranges from 35~400 kW
- 200,000 NGVs/year from OEM, Euro V for commercial car, Euro IV for passenger car

![Images of NGV models: FAW-Volkswagen CNG Sedan, JAC CNG Sedan, Lifan 620 CNG Sedan, CHANG'AN CNG Mini-van Truck, HENGTONG CNG Bus, Shaanxi LNG Heavy Duty Truck]
2. Development of NGV in China

Status of Supply Chain

- Annual production capacity of 2 million gas tanks from domestic companies
- Domestic key components such as ECU, pressure regulator can be used for OEM
- Equipment such as compressor and fueling machine produced by domestic companies
2. Development of NGV in China

Key Technology Types According to Application

- **Bi-Fuel Passenger Car**
  - Closed-loop MPI
  - Single ECU
  - Fuel Optimal Control
  - OEM Market
  - OEM/After Market

- **Mono-Fuel Commercial Car**
  - Closed-loop MPI
  - Dedicated Engine R&D
  - OEM Market
  - OEM/After Market

- **Dual-Fuel Commercial Car**
  - Base on Common Rail
  - Control of High Alternate Ratio with Good Durability
  - OEM Market
  - OEM/After Market

Application Types

- **Key Technology**

- **Market**
2. Development of NGV in China

Why LNGV grows very rapidly in recent years

**Advantages**
- Easier fuel transportation
- Lower investment and energy consumption
- Longer driving distance, faster refueling, more cleaner, and more safer

**From State**
- Efficient utilization of resources from import & distributed energy
- Reduction pollution of commercial car

**From Market**
- More frequent diesel shortage
- Trucks are more sensitive to fuel cost
## 2. Development of NGV in China

### Incentive Policy from Government

<table>
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<tr>
<th>Guiding Principles</th>
<th>Industry/Technology</th>
<th>Resource &amp; Infrastructure</th>
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<tbody>
<tr>
<td>The 12th Five-Year Plan for National Economic and Social Development of P.R.China</td>
<td>Middle- and Long-Term Plan for Conserving Energy (up to 2020)</td>
<td>The 12th Five-Year Plan for NG development</td>
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<tr>
<td></td>
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<td>The 12th Five-Year Plan for Urban Gas development</td>
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</table>
2. Development of NGV in China

Supporting Conditions of Future Development

- Conventional gas 32 trillion m³, shale gas 25 trillion m³, CBM 14 trillion m³, and significant flammable ice

- Before or after 2015, gas supplying will be more than consumption 46 billion m³ (supplying 276 billion m³, consumption 230 billion m³)

- In 2025-2030, maybe oil and gas will be the same share in prime energy consumption

- In 2015~2016, length of urban gas pipeline will increase from 350,000 km to 600,000 km, there will be more than 5000 gas stations
## 2. Development of NGV in China

### Prospects of NGV

#### Population
- Population will be more than **4 million** in 2015, consuming **30 billion** m³ NG, alternate **26 million** tons petrol & diesel and reduce **16 million** tons CO₂ per year
- Population will be more than **8 million** in 2020, consuming **60 billion** m³ NG, alternate **52 million** tons petrol & diesel and reduce **32 million** tons CO₂ per year

#### Extended Area
- Faster development in South & East of China because of much better gas supply
- Faster development in small cities because of more and more gas stations

#### Car types
- For passenger car, taxi increase steadily, private car and mini van grow rapidly
- For commercial car, city bus increase steadily, intercity bus & trucks grow rapidly
3. Research Status of NGV in CAERI

Overview of China National Gas Vehicle Engineering Research Center

- Organized by CAERI, the 1st national engineering center of the whole auto industry
- R&D core tech., also supply tech. service & consultation to enterprise or government
- Cooperated with overseas institutes & companies, Toyota, Delphi, Bosch & SwRI
- CAERI set up a son company for commercialization of R&D achievements, more than 80,000 NGVs per year use CAERI’s EMS products

Delphi Visit CAERI for Cooperation of ECU R&D
Toyota Visit CAERI to Cooperate with Development of Bi-fuel Sedan
CAERI Visit KEIHIN for Cooperation of Key Components
3. Research Status of NGV in CAERI

Bi-fuel Technology of Passenger Car

- Meet Euro IV\&V
- Optimal gas ignition control on each engine working point
- OBD for malfunction of gas leakage
- ISO-15765 protocol
- CCP calibration tool
- AutoSAR software design

Gasoline/NG bi-fuel system diagram
3. Research Status of NGV in CAERI

Application of Bi-fuel System

- Developed more than 60 car models for more than 20 domestic and oversea OEMs
- Some car models have realized mass production

Suzuki SX4 Bi-fuel Sedan
Mitsubishi Lancer Bi-fuel Sedan
Toyota corolla Bi-fuel Sedan for Thailand
DFM Funshion Bi-fuel MPV for Iran

Grate Wall Bi-fuel Pick-up
3. Research Status of NGV in CAERI

Mono-fuel Tech. of Commercial Car

- Meet Euro V/VI
- Sequential Injection/Ignition
- 154-Pin, 32-bit MCU
- Torque based control
- Compatible with lean-burn or stoichiometric
- Closed-loop Boost Control
- Support EGR control
- Diagnostic based on SAE J1939
3. Research Status of NGV in CAERI

Application of mono-fuel system

Mono-fuel system has been widely used on trucks, buses and fork trucks.
3. Research Status of NGV in CAERI

Dual-fuel Tech. of Commercial Car

- Same engine power output as pure diesel
- Smoking control logic
- More than 65% substitution of diesel, saving 1 RMB/km
- Protection of thermal load, such as exhaust temperature and coolant temperature
3. Research Status of NGV in CAERI

Application of Dual-Fuel System

- Applied for CNPC’s trucks in Qinghai oilfield, running on the 3500~4000m altitude
- 70%~75% substitution of diesel by road test

BEIBEN with WP10 213kw
HOWO with HINO T11C-UH
SAG with WP12 279kw

YUCHAI 6J engine 160kw
Breath in Much Cleaner Air
Smile in Lower Carbon Life

Thank you for Attention

www.caeri.com.cn
ngv@caeri.com.cn