

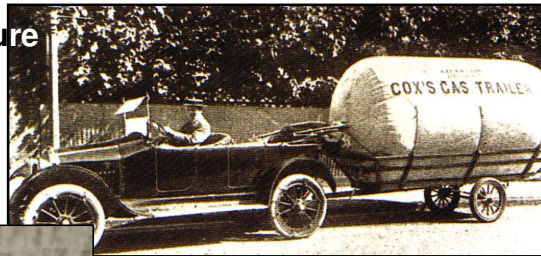
Natural Gas Vehicle Technology



Basic Information about Light-Duty Vehicles

History Natural Gas Vehicles

- 1910's : Low-pressure bag carried on a trailer (USA)



- 1930's Wood-Gas (Germany)



© ENOVA, 2003

Gaseous Vehicle Fuels

- **LPG (Liquefied Petroleum Gas)**
 - Propane, butane, mixture
 - 3 – 15 bar (45 – 625 psi) at ambient temperature
- **CNG (Compressed Natural Gas)**
 - Methane CH₄
 - 200 bar (3000 psi) at ambient temperature
- **LNG (Liquefied Natural Gas)**
 - Methane CH₄
 - Cryogenic : Liquefied at -162°C (typical for vehicle use -140°C @ 3 to 5 bar)
- **H₂ (Hydrogen)**
 - CH₂ (350 bar (5150 psi) compressed) or LH₂ (liquefied, -253°C)

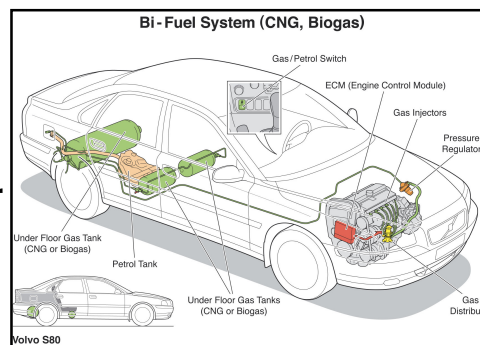


© ENOVA, 2003

CNG system overview Light-Duty

▪ Typical CNG Components in a Natural Gas Vehicle

- Fill receptacle
- Storage tank(s)
- Piping and fittings
- High Pressure Regulator
- Fuel-rail
- CNG injectors
- ECU



Source : Volvo



© ENOVA, 2003

CNG storage

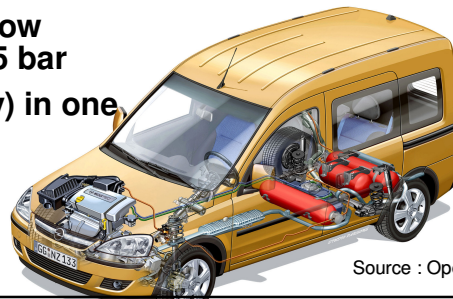
- Storage in gaseous phase
- Storage under high pressure : 200 bar / 3000 psi
- Storage in one or more cylinders



Source : Barbotti, Argentina

LPG storage

- Storage in liquid phase
- Storage under low pressure : 3 - 15 bar
- Storage (mostly) in one cylinder



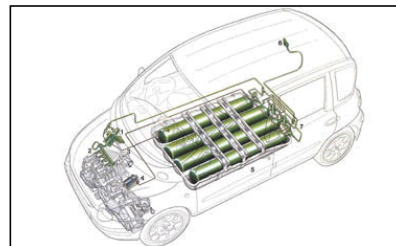
Source : Opel



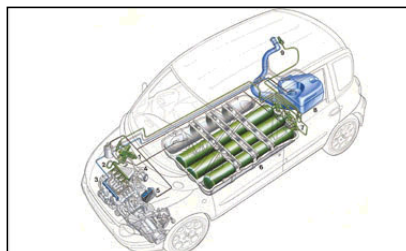
© ENOVA, 2003

CNG fuel systems Light-Duty

- Mono-Fuel
 - CNG only (dedicated)



- Bi-Fuel
 - CNG & Petrol



Source : Fiat Auto Spa



© ENOVA, 2003

Mono-Fuel system Light-Duty

Advantages

- Optimised engine possible
 - ✓ Higher power output
 - ✓ Lower fuel consumption
 - ✓ Better exhaust gas emissions
- More available space for CNG tanks
- Better access to incentive programs

Disadvantages

- Higher system price
- Restricted (total) range
- Dependency on filling station availability

Petrol limp-home system

- Maximum 15 liter petrol allowed (according 70/220/EEC)



Source : Nissan



© ENOVA, 2003

Dedicated CNG engine Light-Duty

- Optimised compression-ratio
- Optimised ignition map
- Optimised catalytic convertor



Source : DCAG



© ENOVA, 2003

Bi-Fuel system Light-Duty

■ Advantages

- Low cost system (retrofit only)
- Not dependent of infrastructure
- Higher (total) range due to double fuel system



■ Disadvantages

- Compromise on engine technology
- No optimal storage solutions



© ENOVA, 2003

Four generations of CNG equipment

Comparable to LPG

■ 1st generation

- Carburetor vehicles without catalytic convertor

■ 2nd generation

- Closed-loop carburetor and TBI / SPI engines (Euro 1 / 2)

■ 3rd generation

- Closed-loop MPI engines (Euro 2 / 3)

■ 4th generation

- Closed-loop and lean-burn sequential engines (Euro 3 / 4)

TBI = Throttle Body Injection

SPI = Single Port Injection

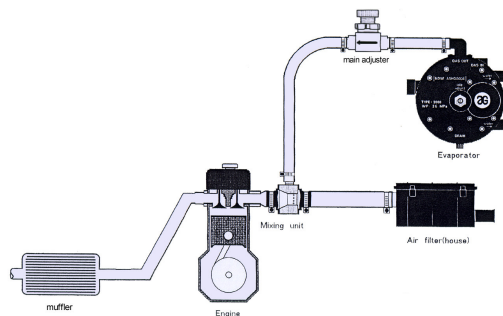
MPI = Multi Port Injection



© ENOVA, 2003

1st Generation CNG system

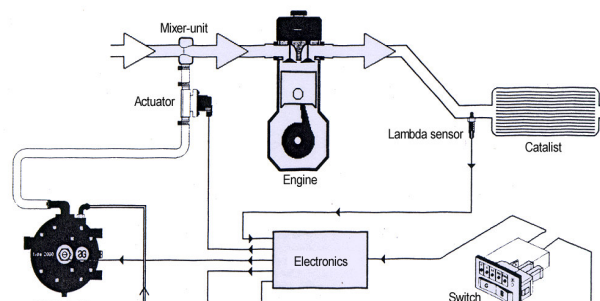
- For carburetor engines without catalytic convertor
 - Venturi type mixer unit
 - Mechanical mixture-adjustment



© ENOVA, 2003

2nd Generation CNG system

- For closed-loop carburetor and TBI / SPI engines
 - Venturi type mixer unit
 - Closed-loop automatic mixture-adjustment (steppermotor) Lambda-Control



© ENOVA, 2003

