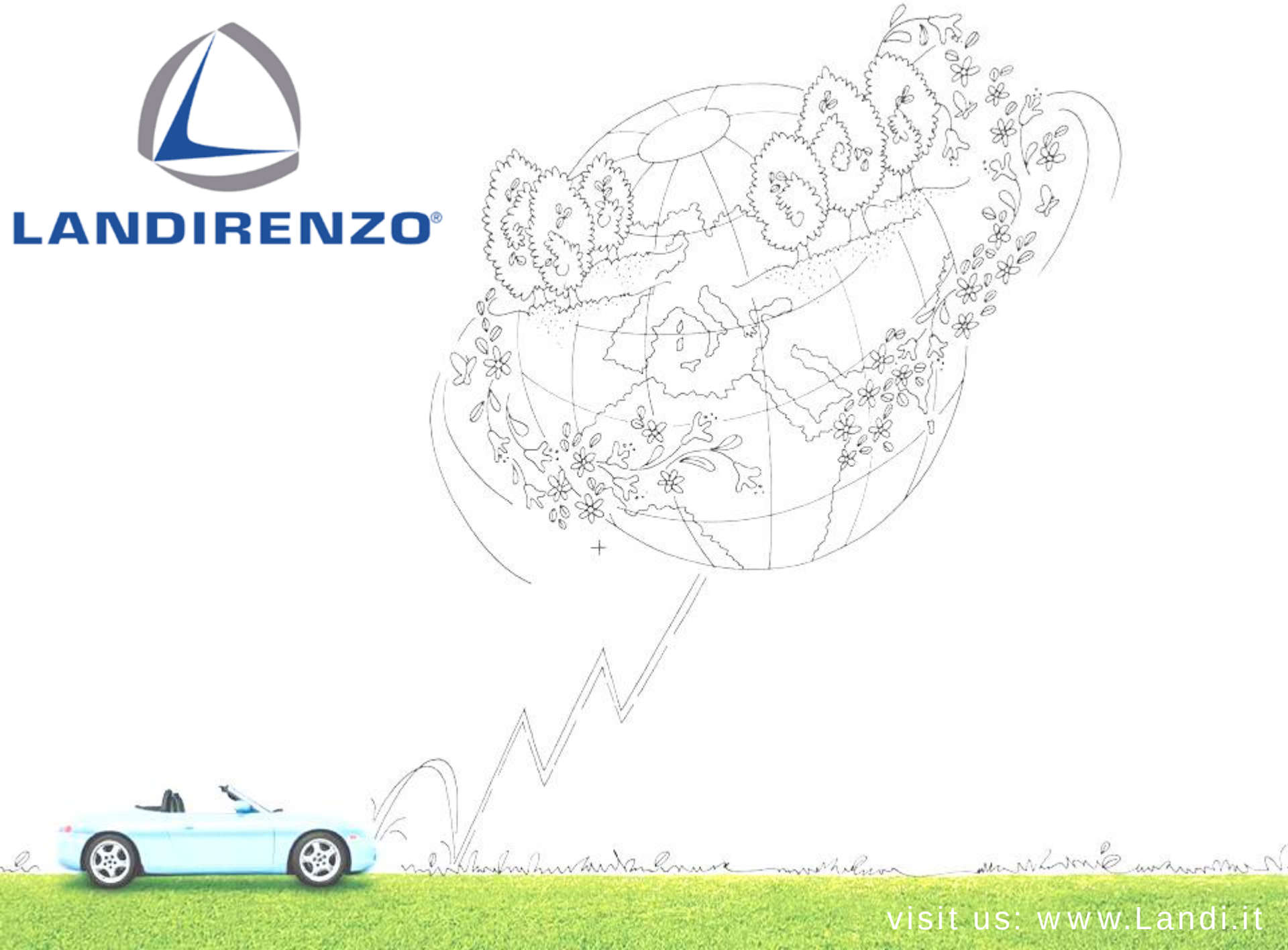
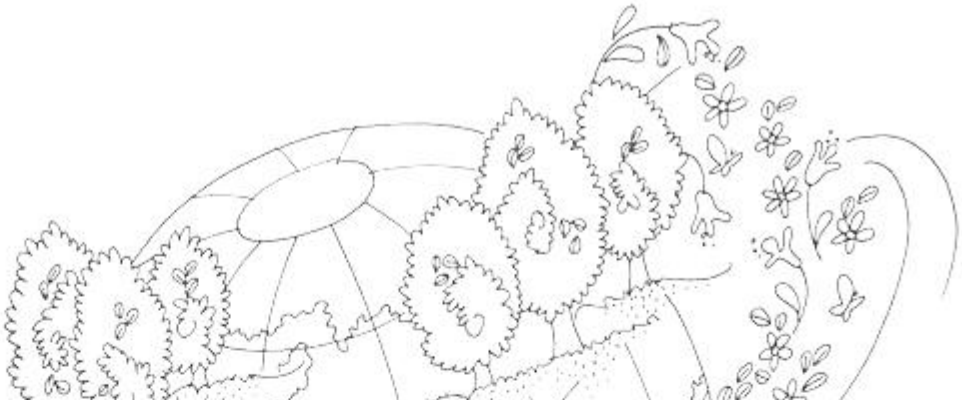
LANDIRENZO®



visit us: www.Landi.it

LANDIRENZO®



Meeting di Lavoro

Strategie di Sviluppo dell'IDROMETANO

Le attività di R&D su metano e idrogeno

Daniele Ceccarini – R&D Manager

ECOMONDO – 28 Ottobre 2009

Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- Electronic Pressure Regulator
- Hydrogen Components
- Hydromethane

Landi Renzo – The World Leader in CNG and LPG Alternative Fuel Systems

- World leader in Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) alternative fuel systems for cars and light commercial vehicles
- CNG and LPG fuel systems are a fast growing and environmentally friendly alternative to traditional fuels
- Landi's products are distributed worldwide in more than 50 countries
- Landi has subsidiaries in 7 countries
- Landi markets its systems through two main channels
  - Aftermarket
  - Car manufacturers
- Landi's lean business model focuses on R&D and distribution with substantial outsourcing of production
- In 2008, Landi reported consolidated revenues of €206m
  - 2004 to 2008 Revenues CAGR of 37%

Landi Renzo

Components

CNG Reducers

Electronic Control Unit

LPG Reducers

LPG / CNG Injectors

History of the Group – Over 50 Years of Experience and Innovation

1954	Renzo Landi, father of the current owner, founds "Officine Meccaniche Renzo Landi", producing systems for conversion of vehicles to run on gas
1960s	Sells products directly to installers and establishes a sales network in Italy
1963–64	International expansion as products are exported to Europe and Asia, and subsequently to South America
1965	Begins to outsource manufacturing, but retains R&D activities and assembly
1968	Introduction of Renzomatic, a pressure reducer for LPG conversion. First product in the market to electronically control the "idle speed" condition
1978	Corporate reorganisation as Landi Renzo S.r.L, which controls the company's subsidiaries, is formed
1980s	Further evolution of business model as company uses distributors to deal with end-market installers
	Introduction of TN1, the first pressure reducer operated electronically
1990s	Acquired 70% of Eurogas Holding BV in 1995, a Dutch company operating in the same sector. Then in 1999 it formed a Polish subsidiary, Landi Renzo Polska
	Acquisition of MED S.p.A., a specialist in gas valves and car alarm systems to improve electronic capabilities
2001	After receiving ISO 9001 certification (1996), the Company was the first in the industry to obtain ISO/TS 16949 certification for automotive high quality standards
	Production facility opened in Brazil
	Subsidiary opened in China
2003	Subsidiary opened in Pakistan (includes production facility)
2005	Subsidiary opened in Iran
2007	Stock Exchange quotation
2008	Lovato Acquisition

Historic Pictures

Landi's First Location – Outside and Inside Snapshot

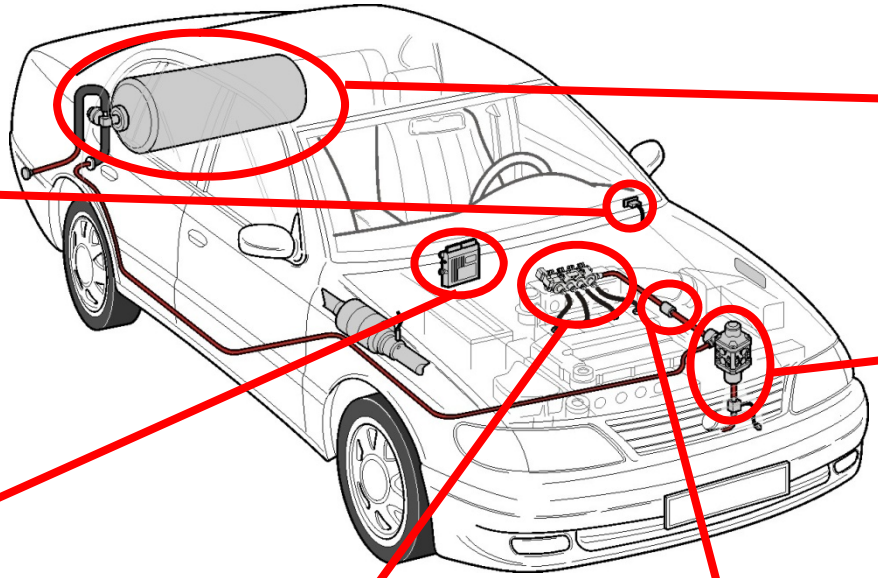
Tokyo's International Fair (1963)

Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- Electronic Pressure Regulator
- Hydrogen Components
- Hydromethane

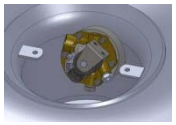
Typical CNG system

Current LR multipoint injection system



Switch

Tank/Multivalve



Pressure Regulator

GAS-ECU

Injectors - Rail

Filter

Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- Electronic Pressure Regulator
- Hydrogen Components
- Hydromethane

Gas Systems Trends

Drivers	Trends			Gas Systems Approach
CO_2 & Fuel Consumption Reduction	Downsizing	Otto Engines	Turbo + Direct Injection	Split Fuel: Petrol additional Injections
				Specific Pressure Reducers for Turbo apps.
				Electronic Pressure Reducer (CNG & LPG)
				Biomethane/Hydromethane components
		Diesel Engines	Turbo multistage	Dual-Fuel
	Hybrids/ Electric/ Infomobility			Gas+ Hybrids
				Hydrogen components

Gas Systems Trends

Drivers	Trends			Gas Systems Approach
Emissions	New Emissions Regulations e.g. Euro V / VI	Otto Engines	Basse Engine emissions	Injector Repeatability
				Fuel adaptation strategies
			Durability	Durability at160.000km
			OBD	Improved Communication Master / Slave
				Improved OBD functions
		Diesel Engines	Complex After-treament	CNG conversion
				Dual-Fuel

Gas Systems Trends

Drivers	Trends	Gas Systems Approach
Customer Requests	Efficiency Reliability Costs Safety	Continuous quality improvment Cost reduction Self-Calibrating ECU for Aftermarket applications FMEA – redundancy, safety
Global OEM's strategy	Flexible Components Reduced development costs/time	Fuel adaptation strategies Modular components and ECU Modern development processes

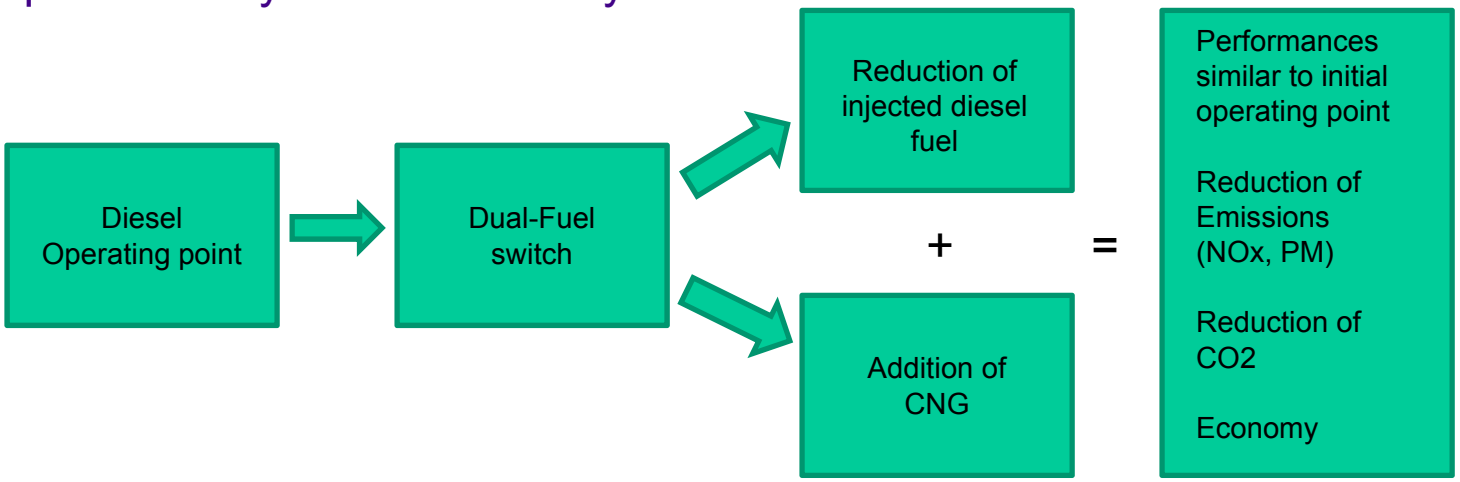
Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- **Dual-Fuel**
- Electronic Pressure Regulator
- Hydrogen Components
- Hydromethane

Dual Fuel: Diesel/CNG

Conversion of diesel engines into diesel/CNG engines
The system can operates as normal diesel engine, or in new operating mode diesel/CNG

Cheapest and quickest way to convert "dirty" diesels

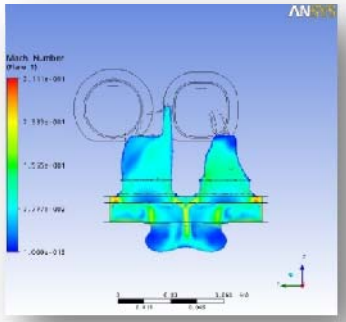


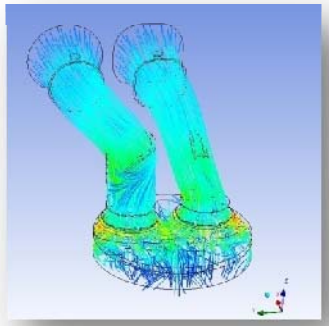
Project Focus
1. Pollution reduction
2. Saving of petrol-based fuel, reduction of CO2
3. Saving of money
4. Comfort (less noise)

Dual Fuel: Diesel/CNG

Development phases

1. Mathematical Model.
2. Engine Tests
3. Vehicle Tests





Current activities

1. Development of a stand-alone aftermarket system

Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- **Electronic Pressure Regulator**
- Hydrogen Components
- Hydromethane

Electronic Pressure Regulator

Current Mechanical regulator

Characteristics:

- Pressure regulation using diaphragm/spring system
- One or two stages

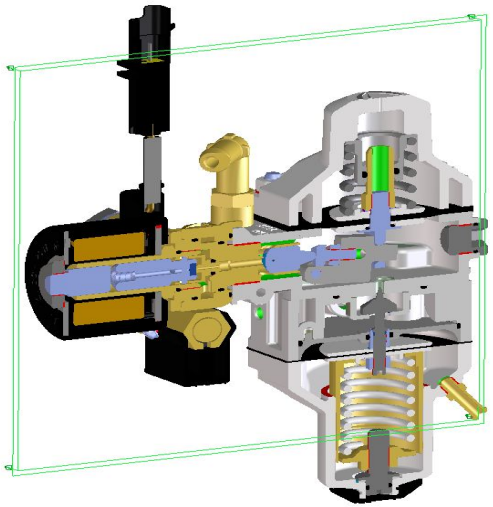
Disadvantages:

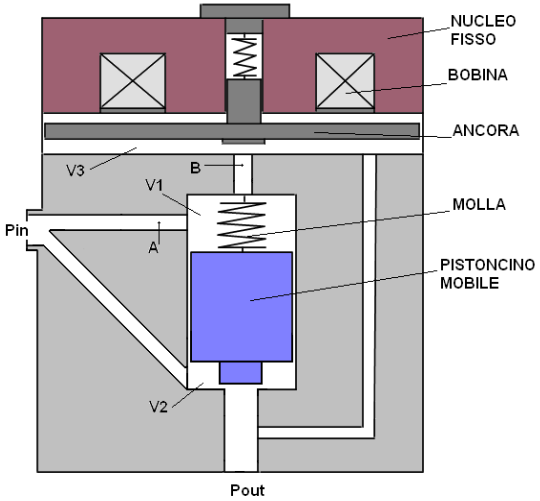
- Fixed Output pressure (set in production)
- The pressure cannot be related to engine operating conditions
- Output pressure reduces for high flows

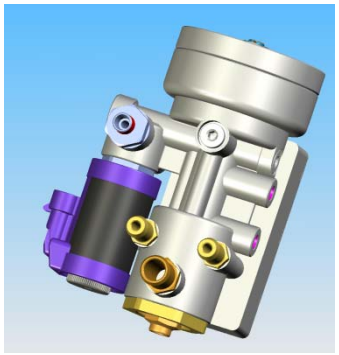
Electronic Pressure Regulator

Characteristics:

- Output pressure electronic controlled, as function of engine operating conditions
- Very suitable for downsized turbo engines
- Autoadapting strategy for ageing conditions
- Monitoring functions and recovery actions for failures
- Without diaphragm







Electronic Pressure Regulator

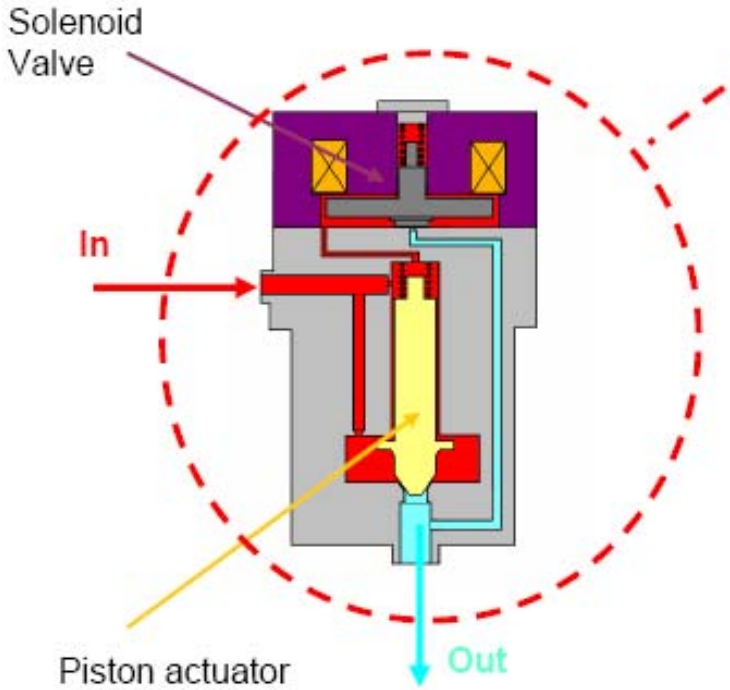
EPR installed in vehicle

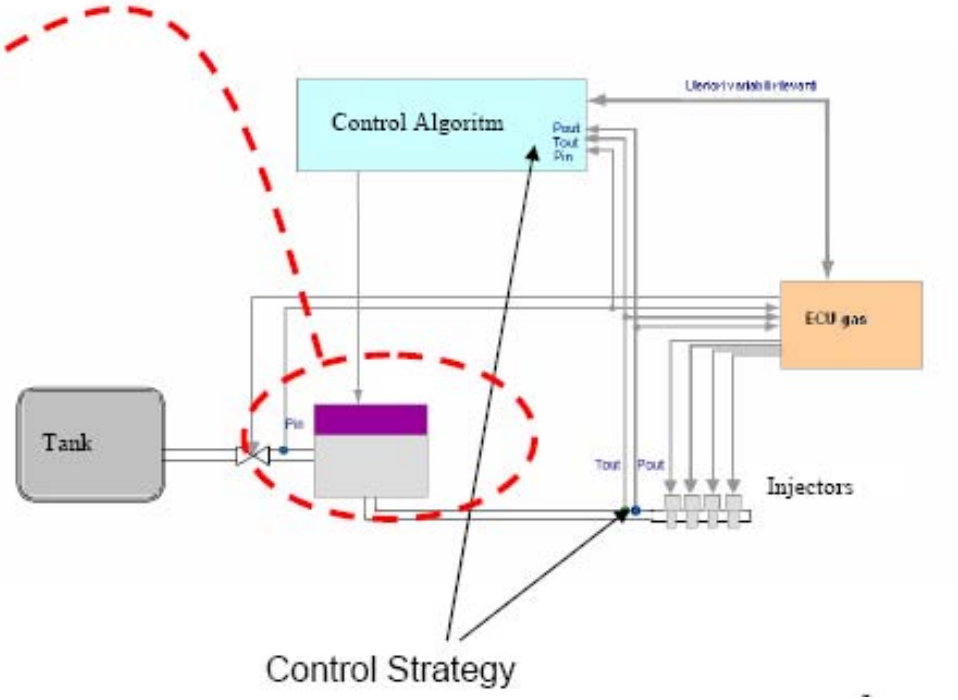
Electronic Pressure Regulator

Electronic Pressure Regulator - Working Principle

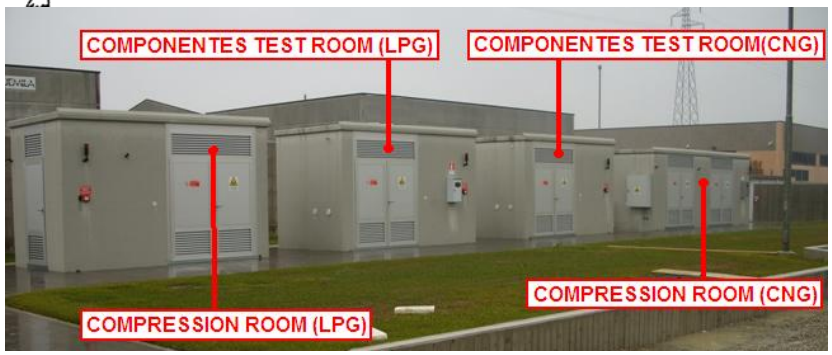
EPR:
Electronic Pressure Regulator

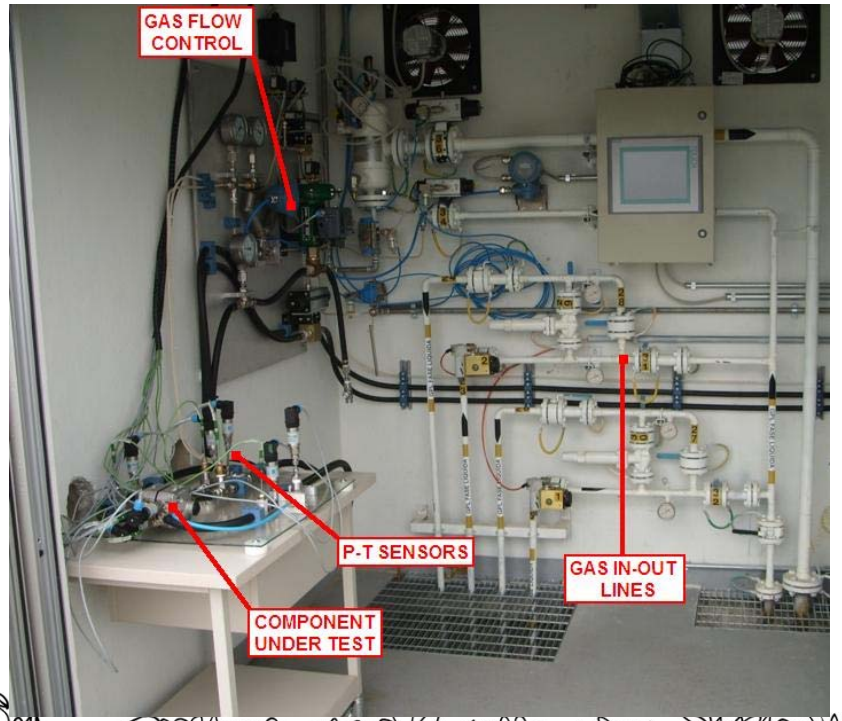
Control System





Components Testing Facilities with real-gas





CNG / LPG COMPONENTS TEST BENCH

Advanced Testing Facilities:

- Components tested with real gas
- Allows for specific gas blends and gas conditioning

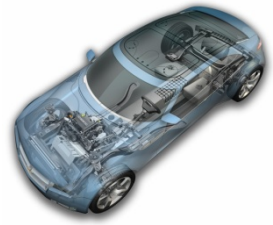
H2 COMPONENTS TEST BENCH

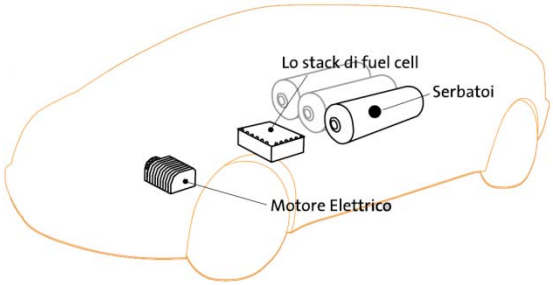
Design available, testing facility to be available along with new tech. center

Agenda

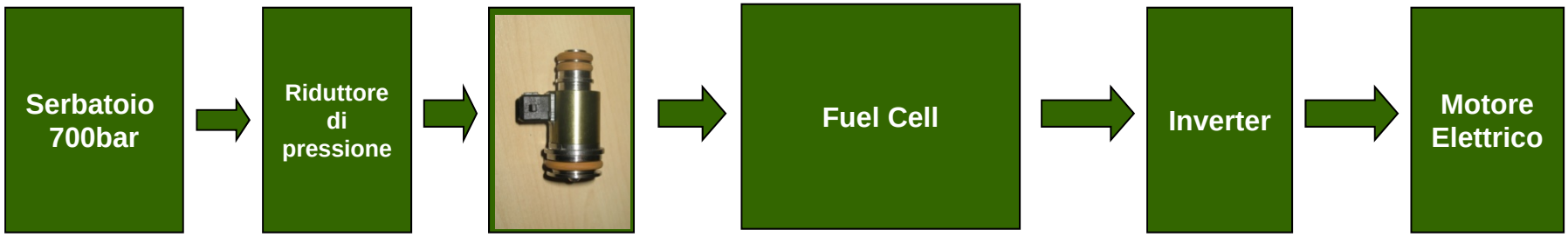
- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- Electronic Pressure Regulator
- **Hydrogen Components**
- Hydromethane

Fuel Cells: Hydrogen Injector Unit





Landi Renzo has been awarded for development of an injector for high pressure Hydrogen in fuel cell from an important manufacturer

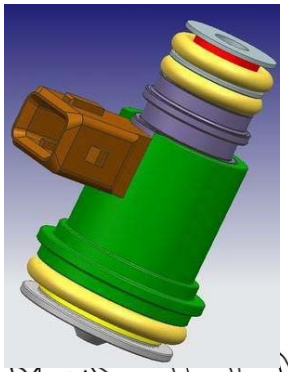


H2 Injector

The system regulates the electrical energy by controlling the H2 flow through the injector

Development of H2 components, by respect to CNG components:

- **Materials compatibility**
- **Safety**
- **Noise**
- **Temperatures**



Agenda

- Landi Renzo Introduction
- Typical CNG system
- Gas Systems Trends
- Dual-Fuel
- Electronic Pressure Regulator
- Hydrogen Components
- Hydromethane

CNG and H2 characteristics

Methane – CH_4

Caratteristiche generali	
Formula bruta o molecolare	CH_4
Massa molecolare (u)	16,04
Aspetto	gas incolore
Fiamma	blu
Numero CAS	74-82-8
Proprietà chimico-fisiche	
Densità (kg·m^{-3}, in c.s.)	0,71682
Temperatura di fusione (K)	90,8 (-182,7 °C)
$\Delta_{fus}H^0$ (kJ·mol^{-1})	1,1
Temperatura di ebollizione (K)	111,8 (-161,4 °C)
$\Delta_{eb}H^0$ (kJ·mol^{-1})	8,17
Punto triplo	90,67 K (-182,48 °C) 1,17 × 10^4 Pa
Punto critico	190,6 K (-82,6 °C) 4,6 MPa
Indicazioni di sicurezza	
Limiti di esplosione	5,3 - 14% vol.
Temperatura di autoignizione (K)	873 (600 °C)
Simboli di rischio chimico	
	frasi R: R 12 **frasi S: S 2-9-16-33**

Hydrogen – H_2

Caratteristiche generali	
Formula bruta o molecolare	H_2
Massa molecolare (u)	2,016
Aspetto	gas incolore
Fiamma	incolore
Numero CAS	1333-74-0
Proprietà chimico-fisiche	
Densità (kg·m^{-3}, in c.s.)	0,08988
Temperatura di fusione (K)	14,01 (-259,14 °C)
$\Delta_{fus}H^0$ (kJ·mol^{-1})	0,117
Temperatura di ebollizione (K)	20,28 (-252,87 °C)
$\Delta_{eb}H^0$ (kJ·mol^{-1})	0,904
Punto triplo	13,8033 K (-259,00 °C) 704,2 × 10^4 Pa
Punto critico	32,9 K (-240,25 °C) 1293 Mpa
Indicazioni di sicurezza	
Limiti di esplosione	4 - 74% vol.
Temperatura di autoignizione (K)	773 (500 °C)
Simboli di rischio chimico	
	frasi R: R 12 **frasi S: S 2-9-16-33**

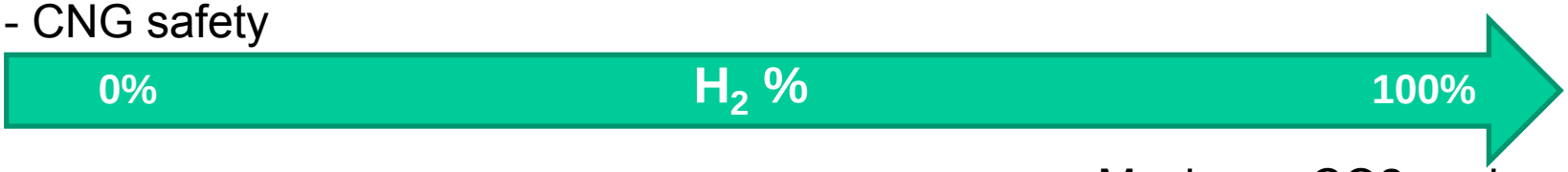
Hydromethane

Hydromethane is a blend of CNG and H_2

It is a way to achieve further CO_2 saving, moving quickly toward H_2 by using today's technologies

H_2 percentage is a trade-off between performances, emissions, costs.

- Range
- CNG specific components - minimum modifications
- CNG safety



- Maximum CO2 saving
- H_2 specific components
- Higher pressures

Hydromethane – System Overview

Use a blends does not require a complete change but only an evolution based on available technology and slightly modification on sw ECU strategies

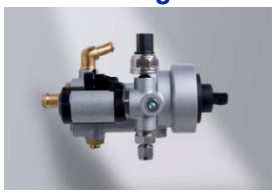
CNG/h2 blends Tank

Switch and Level Indicator

CNG/H2 Injectors

Filter

Pressure regulator



CNG/H2 ECU

Needs Materials with good embrittlement resistance in component

LANDIRENZO®

Thank You

visit us: www.Landi.it