Expoforum n. 2 *: Fight global pollution – Systems and Synergy for eco-friendly & cost affordable public transportation. - Methane and Hythane Technology paving the way to Hydrogen powered engines*

NATURAL GAS - HYDROGEN BLENDS TECHNOLOGY (HYTHANE ®)

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SOME PEOPLE OPINION

TODAY NATURAL GAS REPRESENTS A REALISTIC AND PRACTICAL WAY TO REDUCE, AT LARGE SCALE ,THE POLLUTION DUE TO ROAD TRANSPORT

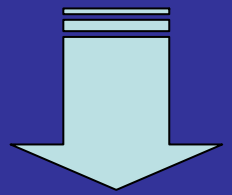
EVEN SO, ACCORDING TO SOME PEOPLE, NATURAL GAS…

- … is a “mature” fuel
- … has no future evolution as transport fuel
- … shall be replaced soon by Hydrogen

CONSEQUENCES …

IF WE TAKE INTO ACCOUNT THAT …..

Natural Gas is a “mature” fuel with no future evolution as it will replaced by Hydrogen



No/low further interest

Very limited technology evolution

No further application spread

BUT SPEAKING ABOUT HYDROGEN …

Even if according to the common thinking the future fuel for transportation will be Hydrogen, it is still a long term option.

"Problems" to be succesfully solved :

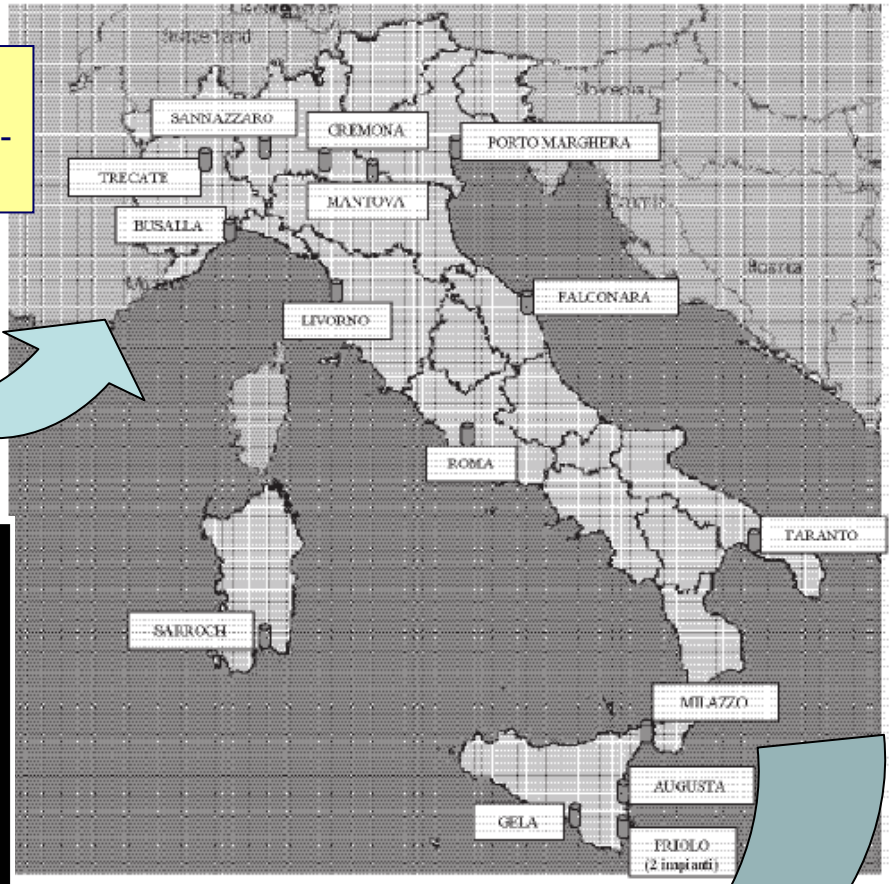
- ❑Production in a not pollutant and energy convenient way
- ❑Distribution network
- ❑Complexity, durability and cost of vehicle peculiar components

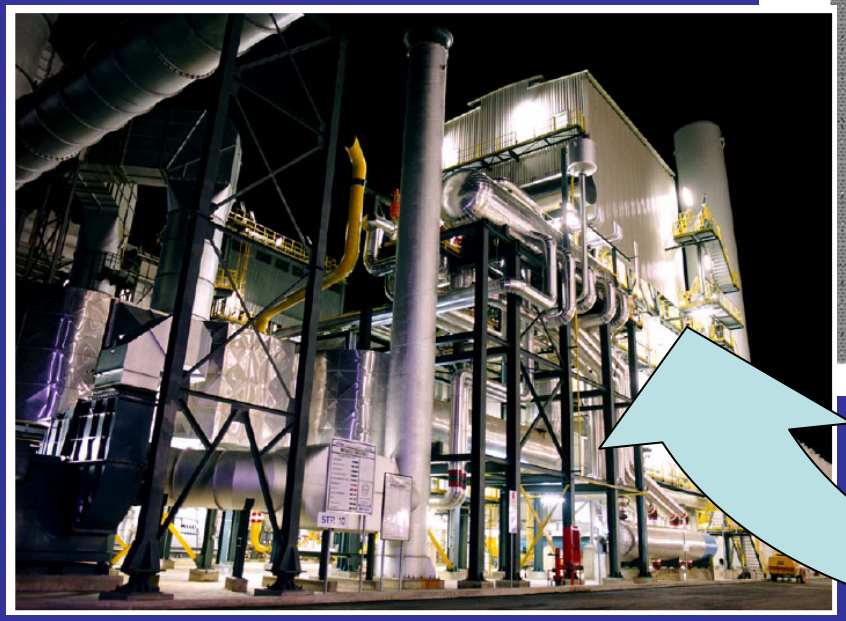
Anyway

- ❖We have to move towards the future
- ❖Some hydrogen production exists

HYDROGEN IS BECOMING A … REALITY

Location of hydrogen İndustrial availability in Italy (Gazzetta Ufficiale 31-05-2007)





Linde “Steam Reformer” plant in Milazzo

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OPTION FOR THE FUTURE

Even if we confirm the present potentiality of natural gas
WE CAN'T DISREGARD HYDROGEN

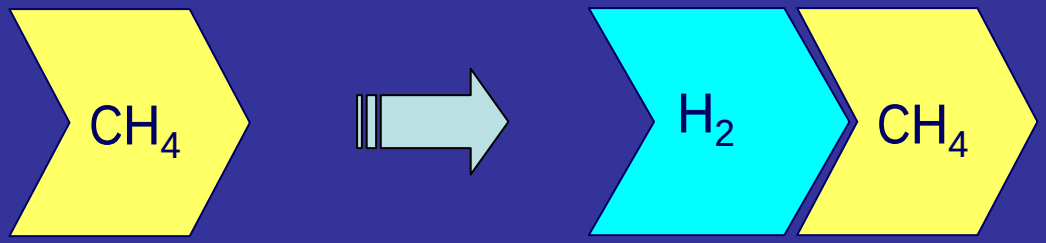
WITHIN THIS FRAME A VEHICLE WITH A POWERTRAIN ABLE

- ❑TO UTILIZE THE HYDROGEN IF AND WHERE IT IS
- ❑TO RUN ALSO WITH A DIFFERENT CLEAN FUEL (NATURAL GAS)
- ❑TO ADOPT AUTOMATICALLY THE "OPTIMIZED" TUNING ACCORDING TO THE "IN USE" FUEL CHARACTERISTICS
- ❑TO COST IN THE SAME RANGE OF THE PRESENT NATURAL GAS TECHNOLOGY

MAY BE AN INTERESTING OPTION!

NATURAL GAS / HYDROGEN BLENDS

All the previous requirements may be satisfied by the introduction of a “new” fuel :
Natural Gas / Hydrogen blends



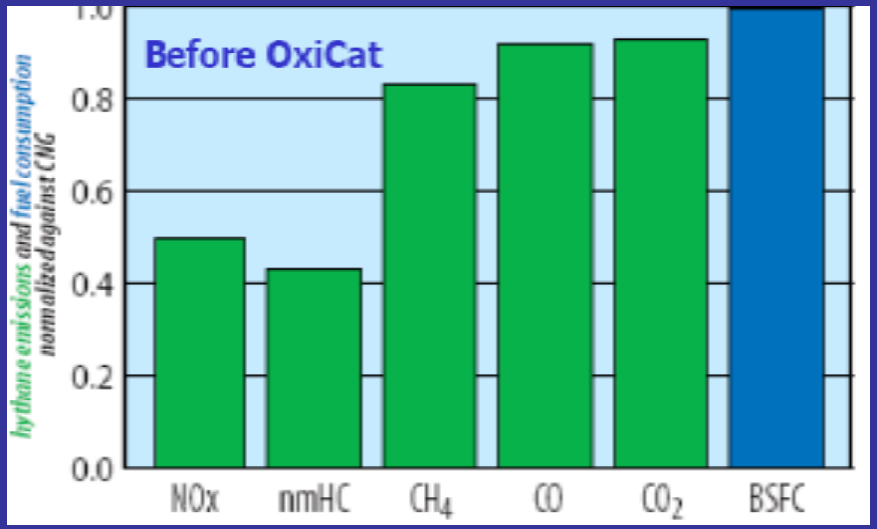
This approach does not require a “revolution” of the engine system, but only an “evolution” based on the Natural Gas technologies already existing.

Moreover mixing a controlled quantity of Hydrogen into Natural Gas provides an additional benefit in terms of emissions reduction.

THE STORY BEGINS……

…. with the birth of Hythane® , blend of 20% hydrogen and 80% natural gas by volume, invented in 1989 by F. Lynch – R. Marmaro and patented in 1992 as a fuel to reduce the NOx emissions (lean limit extension)

Published emission reduction



® Hythane is a trademark of property of Eden Innovations *Ltd* (originally called Brehon Energy PLC), a wholly owned subsidiary of *Eden* Energy *Ltd,* but today is very often used to nominate every methane hydrogen blends

HYTHANE HISTORY IN HD APPLICATIONS

• **1992 – 1995** – Preliminary basic tests by G.M. Canada ,Toronto University, Colorado State University…..

• **1995** – **Canada** : Demonstration in Montreal by Novabus with Cummins/Westport engine.

•**2000/2001** – **California** : Bus demonstrator (Cummins/Westport engine) operated by SunLine Transit Agency

• **2002/2003** – **Sweden** :Hythane Malmö project : basic combustion studies by Lund Institute/Swedish Gas Company on 2 buses (Volvo engines)

• **2005** – **China** : Yuchai 7.9l engine adaptation

• **2006** - **France** : Althytude project : two cities (Dunkirk and Toulouse) with 2 Irisbus busses (Iveco engines)

• **2006** – **India** : Ashok Leyland 6.0 l engine adaptation

Not exhaustive/complete list !

…. AND IN ITALY?

MAIN FOCUS ON PASSENGER CARS/DELIVERY VANS :

- Performances analysis on FIAT Punto Natural Power (Second University of Naples)
- Bong-Hy project on IVECO Daily (ENEA)
- Regione Lombardia project on 20 Panda Natural Power "ad hoc" modified (Centro Rcerche Fiat, Agip, Sapio, NCT, FAST)

…..BUT SOME EXPERIENCE ALSO ON HEAVY DUTY VEHICLE

- Study for the use of hydrogen-natural gas on bus in urban context (ENEA with Regione Emilia Romagna)

WHY NATURAL GAS / HYDROGEN BLENDS (HCNG) ?

"HYTHANE" IS A TRADE MARK FOR A SPECIFIC COMPOSITION

FOR A MORE GENERAL COMPOSITION IT SHOULD BE DESIRABLE A NEW DEFINITION : e.g. HYDROMETHANE (HCNG)

If HCNG contains 10 ÷ 40 % by volume of Hydrogen in Natural gas

- ENVIRONMENTAL BENEFITS
- MINIMUM IMPACT ON VEHICLE/POWERTRAIN TECHNOLOGY

HYDROGEN CHARACTERISTICS vs METHANE

With reference to methane hydrogen is characterized by :

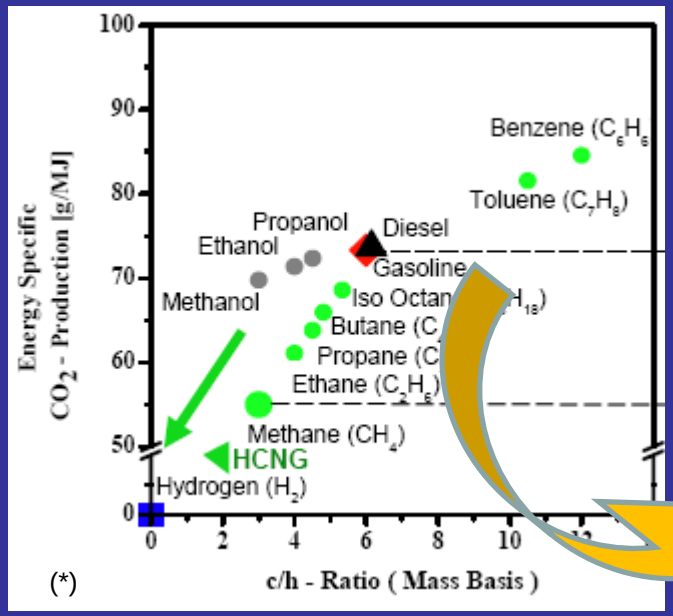
- ❑ higher H/C ratio
- ❑ higher combustion velocity;
- ❑ Less ignition energy;

which implies

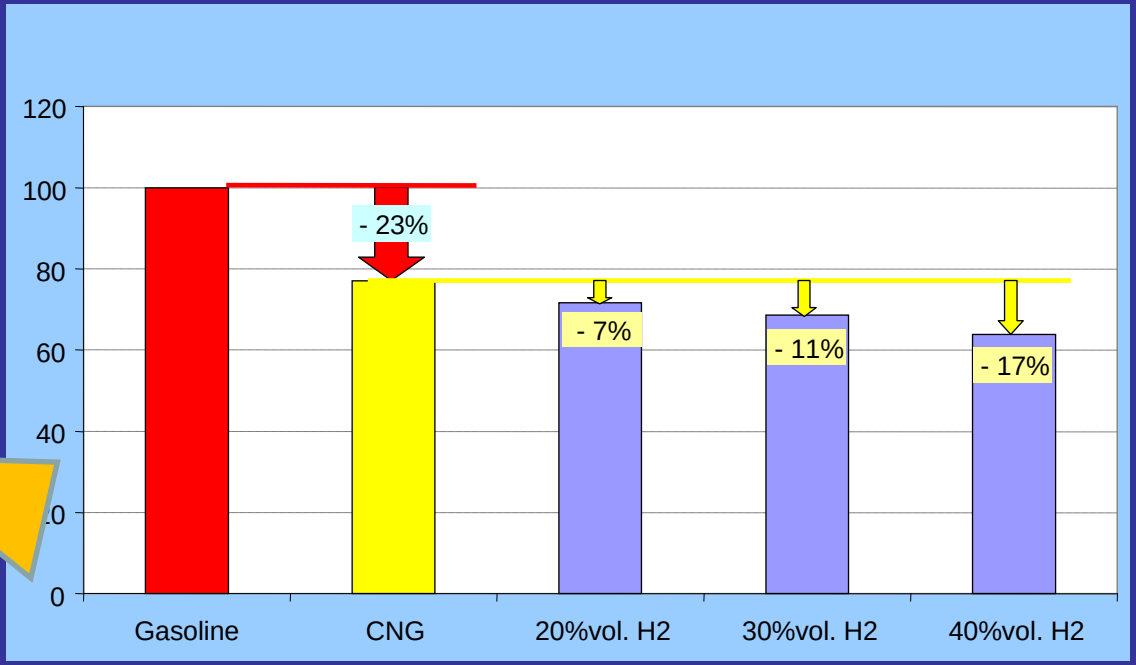
- ➢ more complete combustion reactions;
- ➢ less engine cyclic variation;
- ➢ increased speed of flame front in combustion chamber.

ENVIRONMENTAL BENEFITS

- Additional reduction in CO_2 emissions



(*) From : D. S. Khatri - Harit Energy Solutions Pvt. Ltd India



- Reduction in THC and CO emissions (higher H/C ratio, reduction in flame quenching phenomena)
- Potential increasing in engine efficiency (higher combustion speed)

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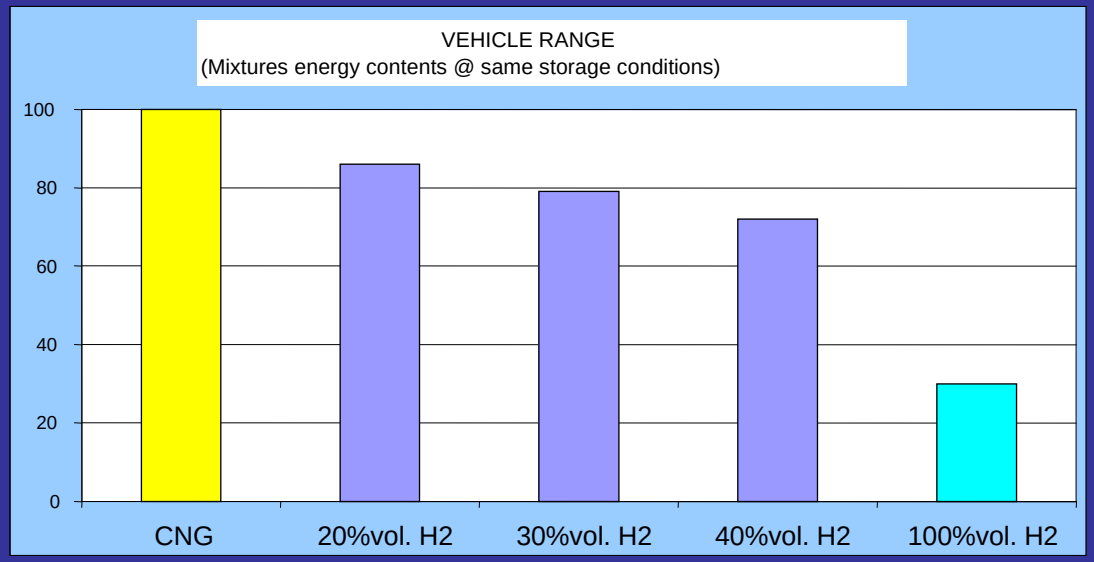
MINIMUM IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(1)

- Acceptable reduction of the vehicle range compared to CNG and pure Hydrogen



- Engine control system & exhaust gas aftertreatment derived from CNG applications

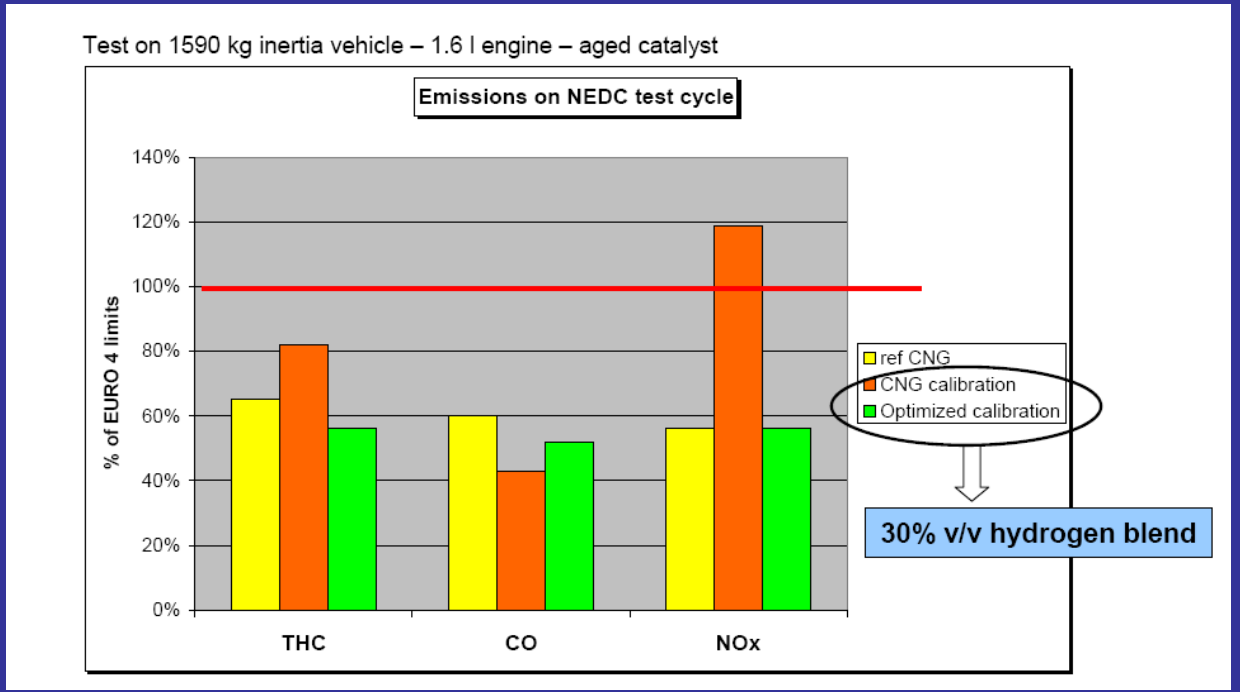
- Limited upgrade of the CNG component materials for compatibility to Hydrogen

MINIMUM IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(2)

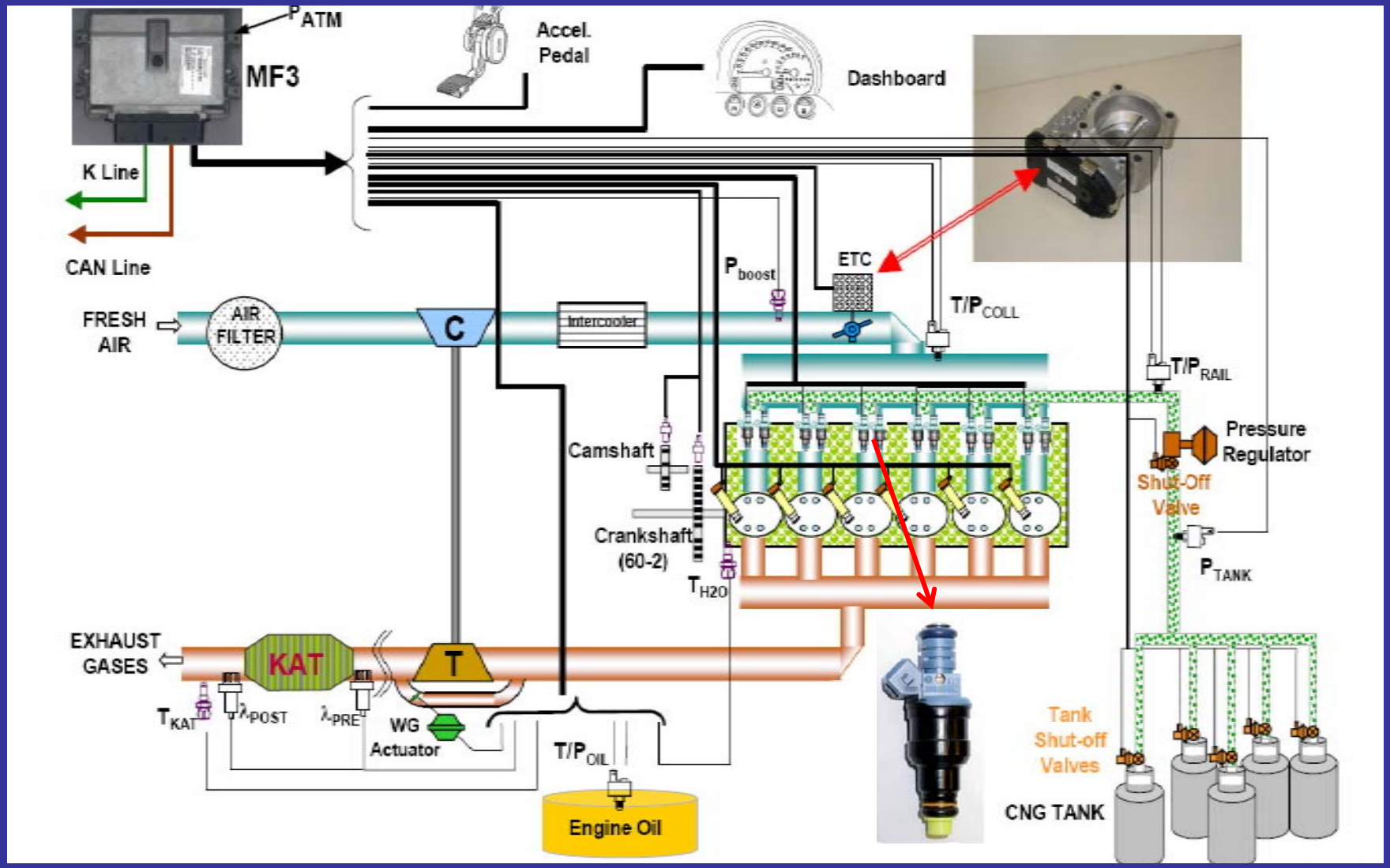
Engine control system & exhaust gas aftertreatment derived from CNG applications

But

- Slightly modification to the SW of electronic engine control
- Optimization of engine parameters calibrations



CNG ENGINE ELECTRONIC CONTROL



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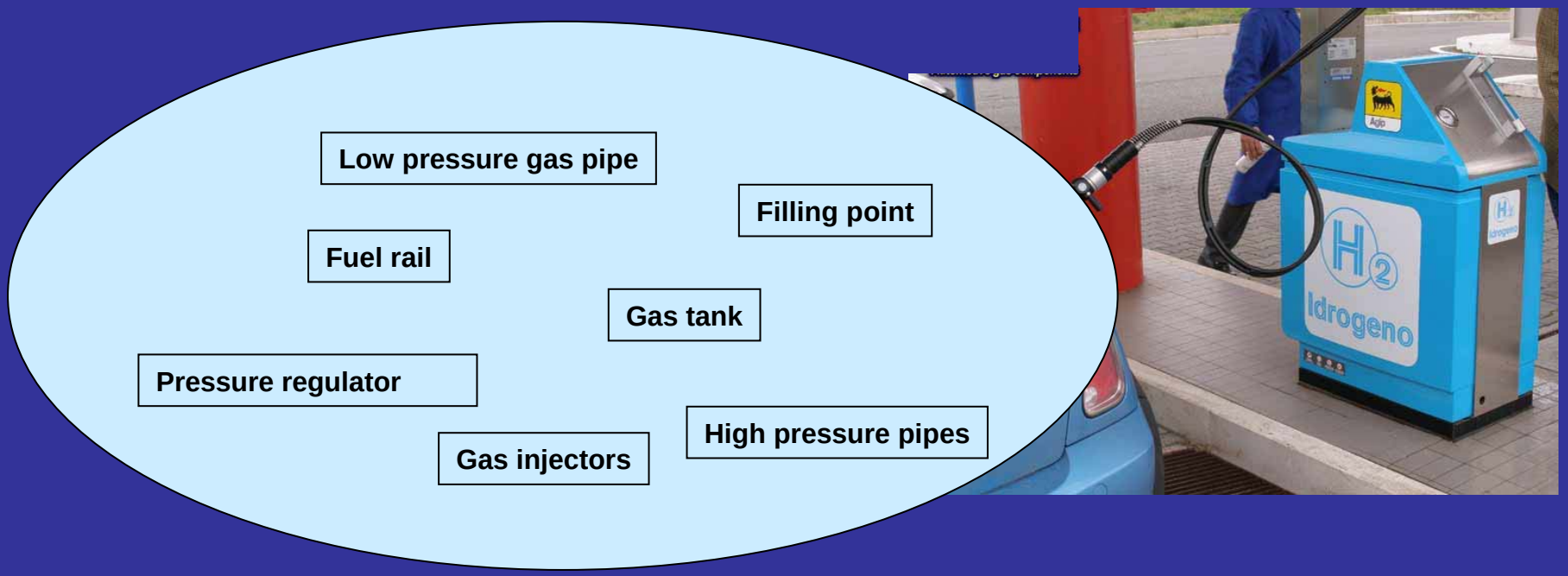
IMPACTS ON VEHICLE/POWERTRAIN TECHNOLOGY(3)

Because of hydrogen, materials with good resistance to embrittlement phenomena “should” be used



More durability tests are still needed in order to evaluate engine & components aging in presence of Hydrogen blends

SAFETY

Main properties of the base gases

	methane	hydrogen
Molecular weight	16,043	2,016
Fuel density (@ std cond)	0,717	0,089
Flammability limit in air - lower (% volume)	5	4
Flammability limit in air - upper (% volume)	15	74
Minimum autoignition temperature (°C)	580	570
Minimum ignition energy (mJ)	0,29	0,02
Laminar flame speed (m/s)	0,4	2,65
Diffusivity in air (dm3/s)	95	1636
Flame colour	blue	colourless

Which differences using HCNG mixtures compared to pure hydrogen ?

1) in case of leakage into atmosphere a demixing of the fuel occurs and the hydrogen fraction diffuses into air with its own properties: in closed room the flammability interval of pure hydrogen has to be considered;

2) a mixture leakage can be identified through the odour from the natural gas fraction (pure hydrogen is completely odourless);

3) the minimum value of the ignition energy is increased, thus allowing more safety to the mixture distribution operations; in case of leakage the same considerations as in item 1) have to be done;

4) the combustion flame is optically detected.

GENERAL REMARKS

1- Mixing Hydrogen in CNG is profitable from the environmental point of view as H/C ratio of the fuel increases (effect on CO2, THC & CO) and combustion process is speed up (effect on thermodynamic efficiency);

3 – Compared to pure Hydrogen, HCNG mixtures have no dramatic influence on vehicle range and engine performance potential;

2 – The right balance between Hydrogen and CNG must be determined taking into account vehicle range and engine combustion parameters (emissions & efficiency);

4 - Concerning safety aspect no major problems are expected

5 – For mixtures with less than 40% vol. Hydrogen minor changes seem necessary to ensure full compatibility of the employed materials but more durability test are still needed;

6 – Finally, the introduction of HCNG blends could play an important role in boosting the process of diffusion of the technologies and of the infrastructures needed for pure Hydrogen in a longer term approach, thus representing a really sustainable "bridge" solution.

TO CONCLUDE : TODAY …

GASOLINE … DIESEL FUEL

TO CONCLUDE : TOMORROW ...

H_2

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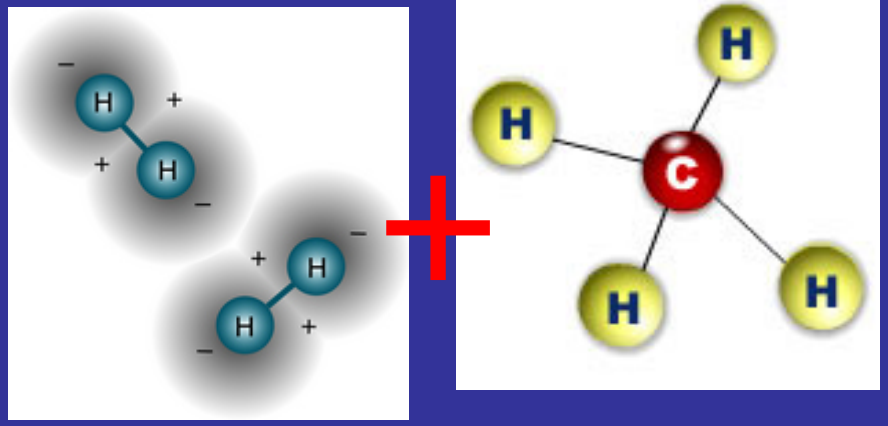
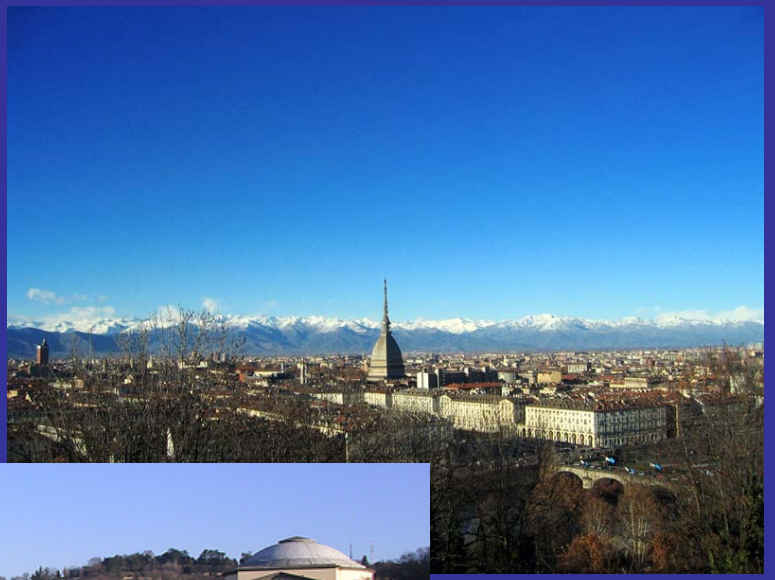
TO CONCLUDE : **HCNG** MAY BE THE BRIDGE





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