

INNOVHUB

STAZIONI SPERIMENTALI PER L'INDUSTRIA

Divisione Stazione Sperimentale per i Combustibili

*Biometano e... Divisione  
Combustibili di Innovhub SSI*

*Simone Casadei*



# Indice

---

- **La normazione in Divisione Combustibili**
- **Lo sviluppo di metodi presso la Divisione Combustibili**
- **Una proposta di attività sperimentale: disponibilità di sponsorship / partnership?**



## Partecipazione diretta ed attiva della Divisione Combustibili di Innovhub-SSI a tavoli tecnici di normazione europea CEN

**Project Committée CEN/TC 408 “Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network”**



**prEN16723**

**“Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network”**

**prEN16723-1:2014**

**“Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network  
Part 1: Specifications for biomethane for injection in the natural gas network”**

**prEN16723-2:2014**

**“Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network  
Part 2: Automotive fuel specifications”**

## Partecipazione diretta ed attiva della Divisione Combustibili di Innovhub-SSI a tavoli tecnici di normazione nazionale CIG e CTI

UNI CT 101/GL 02  
'Mandato M475 Biometano'  
CIG



UNI/TR 11537:2014  
Immissione di biometano nelle reti di trasporto e distribuzione di gas naturale

UNI CT 112/GL01  
'Requisiti e controllo dell'odorizzazione'  
CIG



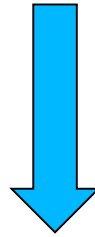
Revisione UNI 7133-2:2014  
Odorizzazione di gas per uso domestico e similare – Parte 2: Requisiti, controllo e gestione

GdL 904  
'Biogas da fermentazione anaerobica e syngas biogenico'  
CTI



UNI/TS 11567:2014  
Linee guida per la qualificazione degli operatori economici (organizzazioni) della filiera di produzione del biometano ai fini della tracciabilità e del bilancio di massa

**Ai Tavoli Normativi sia italiani che europei è emersa, per la matrice biometano, una carenza di metodi dedicati e standardizzati per la determinazione dei composti presenti nella matrice stessa**



**Esigenza di sviluppare metodi analitici ad hoc**

**Cosa si può fare?**

→ **Punto di partenza per la Divisione Combustibili**

**Tradizione consolidata della Divisione Combustibili di Innovhub-SSI di campionamento e analisi riguardanti**

**combustibili gassosi**


**emissioni post combustione**

**autoveicolari**

**da sorgenti fisse**

**e per il biometano?**

Le differenti esperienze pregresse vengono messe a sistema

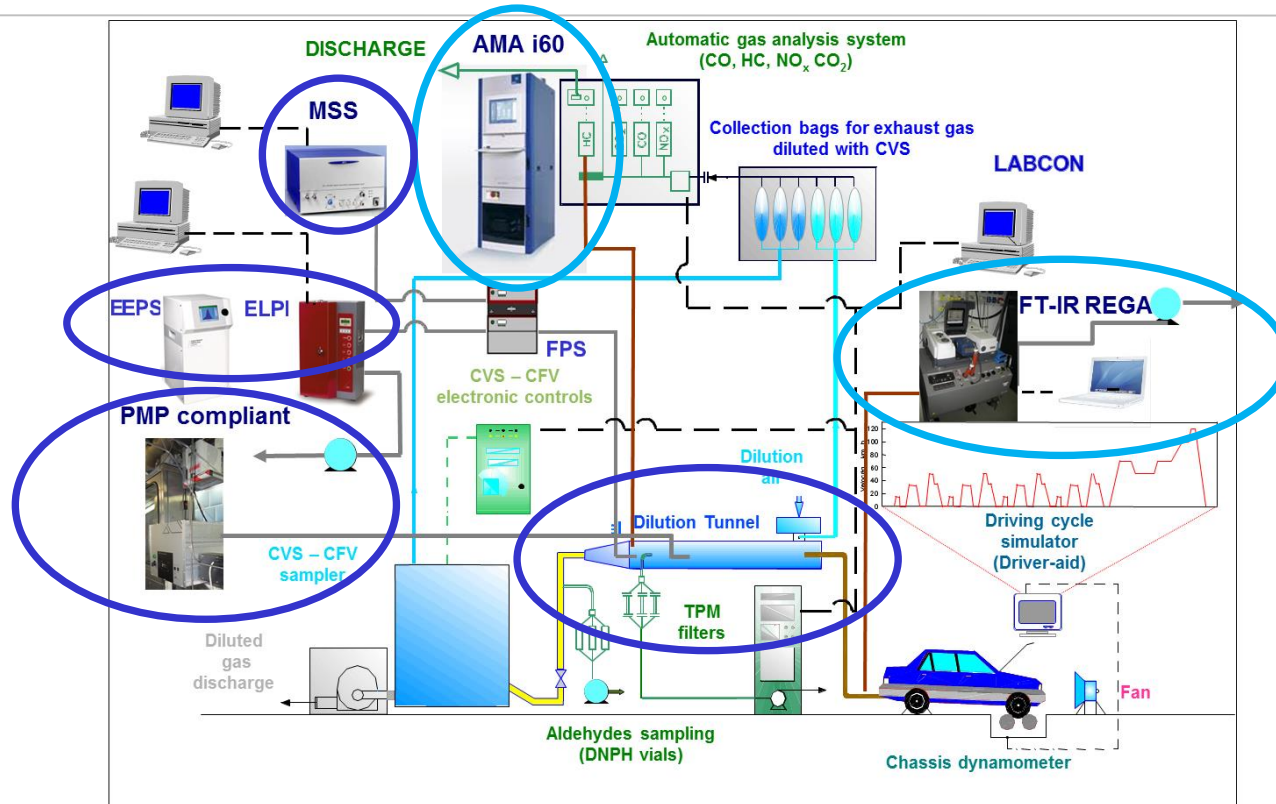


**Sviluppo di metodi analitici per la determinazione di macro ( $\text{CH}_4$ ,  $\text{CO}_2$ , ....) e micro ( $\text{NH}_3$ , silossani, Cl, F, ....) componenti presenti nella matrice biometano a partire da metodi analitici normati per la determinazione di:**

- composizione gas naturale
- composizione gas tecnici
- componenti presenti in emissioni post combustione

**Sono in corso test preliminari di valutazione di sistemi di campionamento e di metodi di analisi in collaborazione con HySyTech e Acea Pinerolese presso l'impianto di produzione di biometano di Pinerolo (TO)**

# Emissioni autoveicolari da biometano – il LEA del Lab. Motori



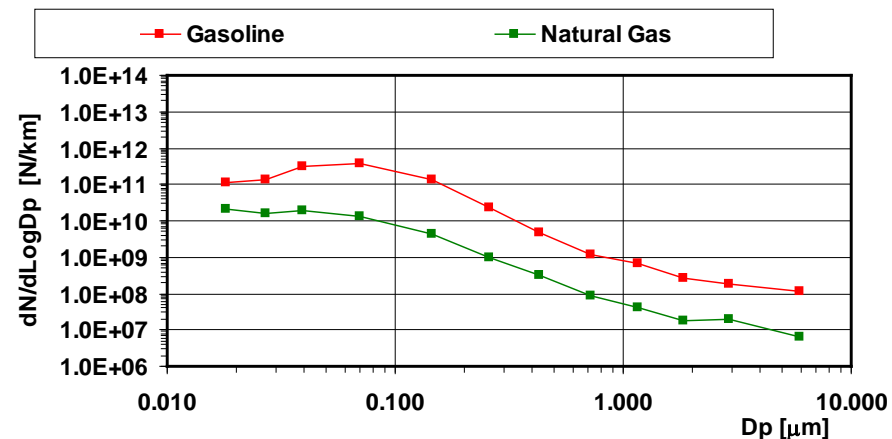
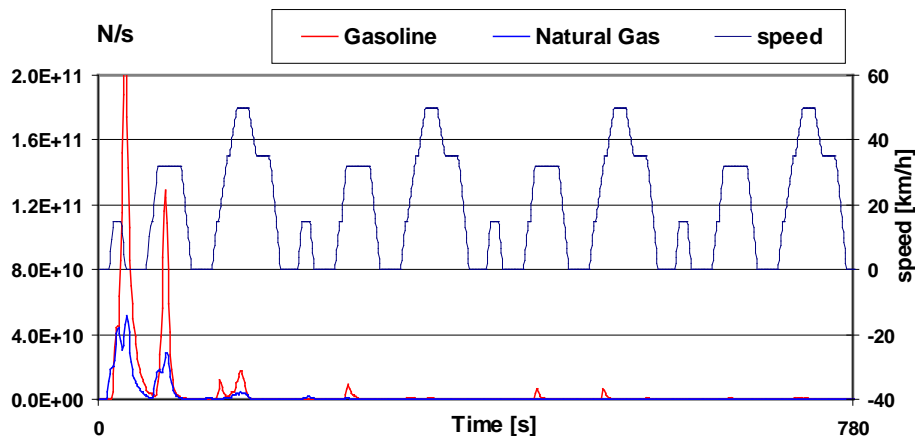
- Particolato - IPA - analisi di caratterizzazione fisico/chimica anche tramite SEM - soot - distribuzione granulometrica particelle solide e totali fino a 5 nm
- Emissioni gassose regolamentate e non: focus su NO<sub>x</sub> , CH<sub>4</sub> e THC
- GHG – Valutazione della riduzione dell’impatto serra tramite alimentazione a biometano (ev. LCA Well-to-tank e/o Tank-to-wheel?)



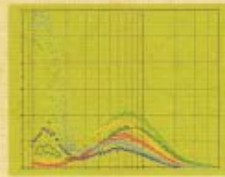
# Il Progetto Auto a metano del LEA

7 autoveicoli bi-fuel (GNC/benzina) sono stati testati per determinare le differenze nell'emissione di PN (numero di particelle) e PM (massa totale e frazione soot) e la distribuzione delle particelle.

Modello autoveettura	Fiat Marea	Fiat Doblò	Fiat Panda	VW Touran	Fiat Doblò	Fiat Multipla	Fiat Grande Punto
codice	A	B	C	D	E	F	G
Omologazione	Euro 2	Euro 3	Euro 4	Euro 4	Euro 4	Euro 4	Euro 5
anno/mese test	feb-05	ott-07	lug-10	ago-10	apr-11	apr-12	ott-11
km	97000	30500	10600	15350	15400	54058	18900
Cilindrata (cc)	1581	1596	1242	1984	1596	1596	1368
Potenza max (kW@rpm) benzina	76 @ 5750	76 @ 5750	44 @ 5000	80 @ 5400	76 @ 5750	76 @ 5750	57 @ 6000
Potenza max (kW@rpm) GN	68 @ 5750	68 @ 5750	38 @ 5000	-	68 @ 5750	68 @ 5750	51 @ 6000
Coppia max (Nm@rpm) benzina	145 @ 4000	145 @ 4000	102 @ 2500	160 @ 3500	145 @ 4000	145 @ 4000	115 @ 3000
Coppia max (Nm@rpm) GN	130 @ 4000	130 @ 4000	88 @ 3000	-	130 @ 4000	130 @ 4000	104 @ 3000
TWC S/N	S	S	S	S	S	S	S



# Riconoscimento ad una prestigiosa Conferenza Internazionale



## 17<sup>th</sup> ETH Conference on Combustion Generated Nanoparticles

23<sup>rd</sup> - 26<sup>th</sup> June, 2013  
ETH Zürich, Switzerland  
www.nanoparticles.ethz.ch

Zürich, 26<sup>th</sup> June 2013

# Certificate

This certificate confirms that the  
**1. Best Poster Award**  
has been offered to

*Simone Casadei*

for the poster entitled

*Nanoparticle Size Distribution, Soot and Ammonia Emissions from a NGVs Fleet*

presented at the  
**17<sup>th</sup> ETH Conference on Combustion Generated Nanoparticles**  
held at the  
ETH Swiss Federal Institutes of Technology  
Zürich, 23<sup>rd</sup> - 26<sup>th</sup> June, 2013

Th. Lutz

Secretary of the  
Organizing Committee

Dr. A. Mayer

Organizing Committee  
Combustion Generated Nanoparticles

17<sup>th</sup> ETH Conference on Combustion Generated Nanoparticles  
ETH Zentrum, Zurich, Switzerland 23<sup>rd</sup> - 26<sup>th</sup> June, 2013

## NANOPARTICLE SIZE DISTRIBUTION, SOOT AND AMMONIA EMISSIONS FROM A NGVS FLEET

Simone Casadei, Davide Reato, Francesco Avella

innovhub - stazione sperimentale per l'industria, Divisione SSC Viale A. De Gasperi 3 - 20097 San Donato Milanese, Milano - Italy

Contact: [casadei@ias.it](mailto:casadei@ias.it)



In Italy natural gas vehicles (NGVs) constitute more than 50% of the European NGVs fleet and recently a significant increase of conventional fuels costs and environmental awareness led to further favorable conditions towards the use of natural gas as automotive fuel. Some scenario analysis predict a significant growth in the European NGVs market (also related to the bio-methane production development) and many vehicles manufacturers have recently produced new natural gas models, in order to meet the European and the other NGVs most successful markets (e.g., Iran, Pakistan, Argentina, Brazil, India, China) demand [1]. In literature only few data are available on particles, PM, soot fraction and ammonia (ammoniac) secondary aerosol precursor exhaust emissions by recent technology engines vehicles and these are mainly related to the comparison between NGVs and conventional fuelled vehicles [2]. In the reported project the gasoline/NG fueling associated emissions were compared.

### Test vehicles and natural gases characteristics

Vehicle	Year	Engine	Power	Max. Speed	Max. Torque	Max. RPM	Max. Torque RPM	Max. Power RPM	Max. Torque (Nm)	Max. Power (kW)	Max. Torque (kgm)	Max. Power (hp)
1	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
2	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
3	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
4	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
5	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
6	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61
7	2012	1.4L	55	160	13	4000	3000	45	13	45	1.3	61

### MATERIALS AND METHODS

- 7 bi-fuel vehicles (from Euro 2 to Euro 5) all with MPI and TWC systems
- Test gasoline samples were all EN 228 specification compliant [3]
- NEOC + CAOC Urban chassis dyno driving sequence
- 95% Student test for statistical significance of gasoline/NG omission variations (4 tests per vehicle/fuel)

### Exhaust sampling and emissions analysis system

### RESULTS: NANOPARTICLES (NP), ULTRAFINE PARTICLES (UFP), SOOT EMISSIONS

#### NP (Dp < 40 nm), UFP (Dp < 144 nm) and soot emissions in UDC warm-up phase - vehicles C (Euro 4) and G (Euro 5)

- In the first seconds after engine starting, particulate emissions were always related to gasoline feeding
- Significant prevalence of NP, UFP and soot with gasoline
- NG fed vehicles omitted particles with Dp mainly < 40 nm
- Lower particulate emissions in 40 + 144 nm Dp range with NG
- A noticeable soot peak after the Euro 5 vehicle cold start, when fuelled with gasoline

#### NP and UFP NGVs fleet emissions and dimensional distribution: NG vs. gasoline UDC warm-up phase

- PN emissions decreased for four vehicles NG fuelled in the Dp full range, measurable by IUP
- PN emission peak at Dp ~ 70 nm for almost all vehicles
- Most of the UFP had Dp < 40 nm with both gasoline and NG feeding
- NP and UFP omission level was visibly lower when five vehicles were fuelled with NG

#### NG vs. gasoline CAOC Urban cycle

- Lower PN emission with NG for vehicles C and E, no significant differences for all the others
- PN emission peak ranged in 70 + 140 nm Dp for almost all vehicles
- Slight decrease of NP/UFP emissions with NG feeding
- Most of the UFP had Dp < 40 nm with both gasoline and NG feeding

### RESULTS: SOOT

- Significant variability of total particulate matter (TPM) and soot emissions (low loads)
- TPM (mostly semi-volatile substances [4]) decreased with NG except for vehicles B and F -> not well-mixed NG exhaust
- Soot emission reduction generally detected with NG feeding
- Very high soot emission in the warm-up phase with gasoline
- Focus on vehicle D: highest soot emissions in warm-up phase and in Urban cycle, gasoline fed

Modal soot fraction emission - vehicle D (Euro 4)

TPM vs soot average emissions for the fleet vehicles

### RESULTS: AMMONIA

Very few informations found in literature [5, 6] suggesting NH<sub>3</sub> generation in catalytic devices during soot emissions (secondary) engine operating conditions, that require a temporary enrichment of the air/fuel mixture. Other possible causes are related to the effects of aging of the lambda probe (air/fuel controller) and of the catalyst itself

- In all driving conditions NH<sub>3</sub> emission level was quite variable between the tested vehicles
- NH<sub>3</sub> emission in UDC was significantly lower with NG for all vehicles except C: reduction range 40% + 95%
- NH<sub>3</sub> emission in EUCC and CAOC Urban cycles increased with NG feeding, except vehicle D
- Due to the strong variability of measures (no statistical significance), more tests were found to be necessary

Ammonia average emission for the fleet vehicles

### CONCLUSION

With a suitable engine set-up in urban driving conditions the natural gas feeding, compared to the gasoline one, was shown to have lower emissions in terms of nano- and ultrafine particles, soot and ammonia.

The research was developed through institutional funding (Italian and gas industries) of InnovHub (SSC Division, Aspetti speciali gas-to-100% Cometa, AIRC) contracted through AIRC, and to ENI Gas & Power for providing three vehicles of the fleet. ENI Gas & Power kindly provided also the natural gas vehicle reports.

1) The SUV - Gas Vehicle Report (May 2010) - <http://www.gpl.com>  
 2) D. Schreiber et al. - "Particle Characterization of a Modern GHD, Gasoline and Diesel Passenger Car" - SAE 2007-24-0122  
 3) European Standard EN 228 - Automotive Fuels - Unleaded petrol (vacuum in force at time of testing)  
 4) "Characterization of Exhaust Particulate Emissions from Road Vehicle - PARTICULATE" - EU Research Programme - Final Report (2005)  
 5) T. Hsu et al. - "Investigation of NH<sub>3</sub> Emissions from Low Technology Vehicles as a Function of Vehicle Operating Conditions" - Environ. Sci. Technol., 37, (2003)  
 6) F. Avella - "Characterization of gas/air and diesel passenger cars unconventional pollutants emissions" - PARTIC, Project - P02, Final Report (2008)

### *Biomethane & dual fuel: climate change / air quality win-win approach?*

Tematica e prospettive di elevato interesse per stakeholders pubblici  
→ implementazione politiche ambientali su traffico / qualità dell'aria / climate change

- es. Regione Lombardia: problema dei mezzi diesel circolanti senza DPF (elevate emissioni di particolato)

➤ Disponibilità biometano (HySyTech e ACEA Pinerolese)

➤ Disponibilità impianto/veicolo dual-fuel (?)

- Target ideale: LDV (furgoni) Euro 2-3-4

### *Biomethane & dual fuel: climate change / air quality win-win approach?*

- **Facilities e know-how per il testing (Divisione SSC):**
  - LEA del Lab. Motori
  - strumentazione on-board, PEMS (disponibile da gennaio 2016)
  - caratterizzazione combustibili – Area Analitica e Area Ambiente
  - protocollo consolidato e referenziato (Min. Ambiente) per la determinazione dell'efficacia di dispositivi/combustibili innovativi nell'abbattimento di consumi ed emissioni allo scarico
  
- **Avvio progetto: entro i primi 6 mesi del 2016**
  
- **Durata (dall'avvio alla relazione finale): 6÷12 mesi → *f* (# autoveicoli)**

## Proposta progetto di ricerca (3/3)

### Diesel EURO 1-2-3



>> 1 mg !

### Diesel EURO 4 w/o DPF



~ 1 mg

### Cold start Urban Driving Cycle (UDC)

~ 3000 l/h isokinetic air flow sampling

Dual fuel diesel / biomethane ?



<< 1 mg ?

**GRAZIE PER  
L'ATTENZIONE!**

*simone.casadei@mi.camcom.it*

