

Measure title: **Large-scale operation of clean bus fleets in Toulouse and preparation of sustainable supply structures for alternative fuels**

City: **TOULOUSE**

Project: **MOBILIS**

Measure number: **5.1**

A Introduction

During the MOBILIS project, Toulouse aims to execute a large deployment of CNG solution. With the objective to get a 100% clean public transport fleet in 2008, Toulouse will purchase 53 CNG buses, will put in place a GNV filling station and will launch the so-called “CNG at home” solution for private households.



A1 Objectives

The global objective of this measure is a shift towards clean PT fleets by substituting diesel with CNG engines and launch of a commercial offer of compressed natural gas (CNG) for private households. For public transport Toulouse aims to have a 100% clean vehicle fleet by 2008. A dedicated evaluation plan will estimate (ex-ante) the potential environmental gains, while (ex-post) the real gains will be defined.

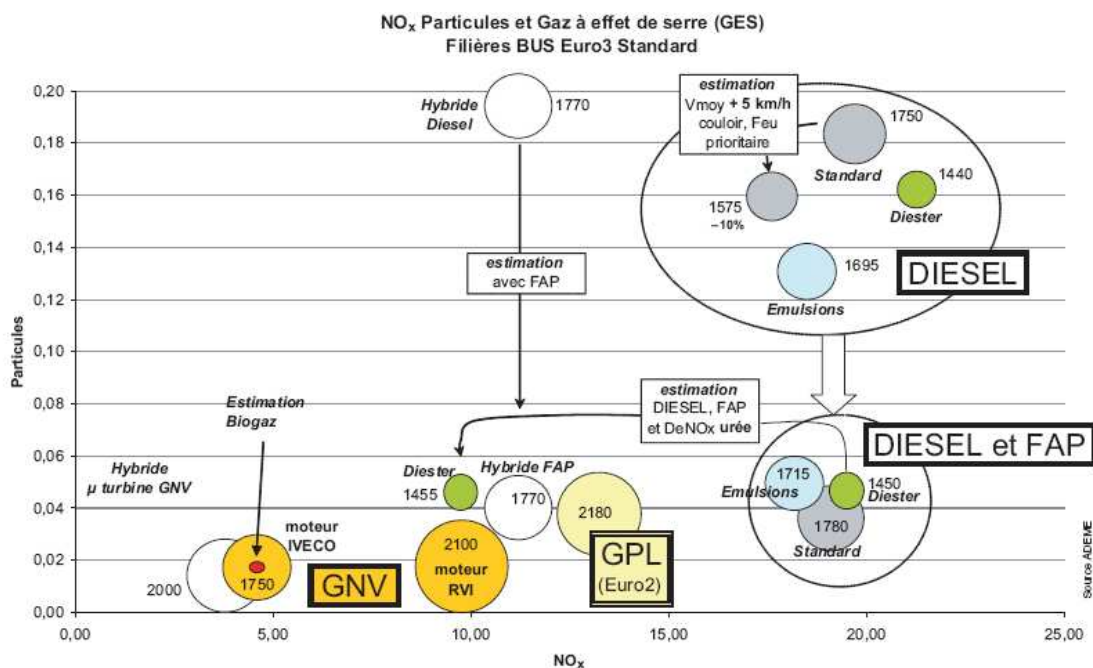


Table 5.1 Comparison of bus propulsion technologies in terms of Particules and NOx emissions

The present table shows a clear gain when using GNV buses and (M5.2) equipping all diesel buses with Soot filters (FAP)

Large scale implementation of CNG vehicle fleets

- Build a second CNG filling station located in the new depot that should be opened in the beginning of 2008.
- Acquire new CNG buses that would mainly be operated in priority areas like High Quality Corridors and city centre bus lines.
- Improve the operation of CNG engines together with the natural gas quality.
- Develop training and extend associated competencies in the CNG engine domain.

This work will be called “CNG vehicles fleets” in the following.

CNG at home (demonstration of CNG micro compressor stations and framework conditions for deployment)

Deploy CNG use for individual passenger cars based on small CNG compressor units for decentralised use (at home):

- Establish a new “CNG at home” offer based on the use of home refuelling units
- Create a customer base of households in the Toulouse area as customers
- Develop a European reference case for this new type of CNG supply
- Based on this first experience :
 - Identify the economic relevance and sustainability of the “CNG at Home” offer
 - Understand the market behaviour in reaction to the “CNG at Home” offer
 - Understand satisfaction criteria of the “CNG at Home” customers
 - Build up a technical and commercial context that enables the future

deployment of the “CNG at Home” offer in France and in Europe

This work will be called “CNG at home” in the following.

A2 Description

CNG vehicles fleet

The development in Toulouse of a large fleet of clean vehicles has concretely begun with the decision, in 2002, of renewing the whole bus fleet with CNG buses. The choice of this technology relies on a large scale and a long term use of CNG technology, that permits to reduce considerably the operational costs, generally considered as a brake to this kind of decision.

In 2002, following the AZF factory explosion (21st of September 2001), the public transport authority Tisséo-SMTC, has decided to renew the fleet of buses, only with CNG buses. Considering the damage by the disaster, efforts have been necessary to replace the bus damaged by the explosion (the main depot was in front of the factory and has been destroyed). At the end of 2003, there were 75 CNG buses running on the network and a dedicated gas station has been opened in the beginning of 2003. This effort is still going on for 2004, and in the beginning of the MOBILIS project (beginning of 2005), there will be 100 CNG buses running on the urban public transport network (note the complete urban buses fleet was at the end of 2003 around 430 buses).

Within the MOBILIS project, this policy would be reinforced by the acquisition of new CNG buses in place of the old diesel bus and the building of a new filling gas station in the new depot that should be built for 2007 (in the place of the one that has been destroyed).

The CNG vehicles fleet in the Toulouse area is not only composed of Tisséo buses. Indeed, there is a real involvement of the regional agency of GDF (Gaz de France - national Gas producer), with a permanent contact with the local authorities that are using CNG vehicles, but also with the Universities and Lycées Professionnels where training are performed in order to develop new competencies on this kind of technologies.

Moreover, the Combustion Research Group in IMFT (member of the INPT High Schools) owns a ten years experience in Natural Gas Vehicle study (experiments, technology and physical analysis):

- Experimental studies on air and gaseous fuels mixing problems in internal combustion engines (injection optimization and aerodynamics). Numerical simulations are also led on the same subject.
- Global combustion studies of CNG in spark-ignition (SI) engine (engine test-bench, pollution and performance measurements).
- These studies were mainly realized with industrial partnership (Siemens, GDF, PSA Peugeot-Citroën, Renault) and Région Midi-Pyrénées.

Within the MOBILIS project, the main development will particularly concern the impact of the natural gas composition on the lean-burn combustion in spark-ignition engines.

CNG at home

CNG development started in France in 1998 with the bus market. This development was followed by the development of CNG garbage trucks. Almost no vehicles were running in 1998. More than 1500 buses and almost 200 Garbage Trucks are now running in France.

The success of CNG development on heavy duty vehicles can be spread out to the passenger cars market. The vehicle technology is ready: most of the major European cars manufacturers have passenger cars vehicle offers.

But the development of CNG for passenger cars raises some investment questions. The development of a public refuelling station network would need a very large investment.

A new small compressor has been developed to be installed in home garages connected to the natural gas network. This small compressor enables the refuelling of the vehicle during the night. The compressor is being tested by Gaz de France at the R&D Division for the French application. In parallel, it is being tested by Canadian for the North American market.

This compressor will probably be available in 2005 for the French market: it is being developed to satisfy the European and national regulations by the compressor manufacturer together with Gaz de France.

Some preliminary studies show that the CNG at Home concept is well accepted by the public. It will permit to initiate the development of CNG use for passengers' cars with acceptable investments.

Description of work

Research and Technical Development related activities:

CNG vehicles fleet

This work is an experimental study on the effect of the gas quality or composition on operating conditions of CNG engines.

In fact natural gas, mainly composed of methane, shows a wide variability in composition according to its production area. This variability affects the running conditions of the so fuelled engines. The first part of the work is about defining the gaseous fuel being representative of the natural gas the provider can offer: pure methane, a mixture of methane and hydrogen (with hydrogen fraction between 15 and 25 %), and a mixture of methane and nitrogen (14% fraction of nitrogen).

Then a wide range of engine tests will be made at the IMFT test bench:

- Steady conditions with fixed engine speed (low and intermediate rotational speed) at partial and full load.
- Transient operating conditions by varying the engine speed.
- The different measurements operated are:
 - Instantaneous cylinder pressure for the use of thermodynamical models of engine combustion.
 - Characterization of mechanical performances: torque, power, efficiency.
 - Pollutants: Unburned Hydrocarbons (methanic, MHC and non methanic NMHC), Nitric Oxides (NO_x), carbon monoxide (CO), Green House Gases (carbon dioxide, CO₂ and methane, CH₄).

The data and physical analysis are made in parallel of the tests and experiments.

CNG at home

No R&D activities.

Demonstration activities:

CNG vehicles fleet

The demonstration activities will concern two main tasks:

- The acquisition of 60 new CNG buses and their affectation / exploitation on high quality bus lines, especially the lines that will use the HQC that should be developed to connect peripheral area to the subway network.
- The building of a new CNG filling station, located in the new bus depot that should be built for the beginning of 2008. That would permit to extend consequently the CNG fleet (around 200 buses) that suffers of the lack of place and of the temporary situation (since the AZF disaster – September 2001). Indeed, one of the bus depots – Atlanta – is now under extension, but for a limited number of buses (close to the full capacity), while the other bus depot – Grande Bretagne – is a temporary depot waiting for the re-construction of the new depot – Langlade. One of the main tasks within the MOBILIS project (first part of the project) would also be the transition management.

The main aim of this measure is to renew the bus fleet by using CNG buses. These new buses would permit to improve the image of the surface public transports towards final users (and non users). This objective would be also reached through a dedicated awareness campaign (internal and external).

Moreover, this measure will consequently contribute to the overall goal of Tisséo, within the MOBILIS project, to obtain a 100% clean vehicles fleet at the end of 2008. A dedicated study of pollutants emission and fuel / gas consumption would be proceeded in order to qualify the whole fleet.

CNG vehicles fleet

In relation to the results that would be obtained within the engine optimisation research works, a dedicated training program would be organised in order to reinforce the operating and maintenance knowledge of the bus operator.

Moreover, the gas engine technologies promotion would be emphasized by GDF through a dedicated training plan in relation with the other measures, especially the one concerning the micro-compressor.

CNG at home

- Develop the content of the commercial offer together with the car manufacturers and gas professionals
- Develop some communication strategies and communication tools to sell the offer
- Evaluate the satisfaction of CNG Customers with satisfaction studies
- Evaluate the profitability of the CNG at Home offer by market segment
- Develop some communications tools to communicate in France and in Europe about the MOBILIS project results

Training Activities

CNG vehicles fleet

In relation to the results that would be obtained within the engine optimisation research works, a dedicated training program would be organised in order to reinforce the operating and maintenance knowledge of the bus operator.

Moreover, the gas engine technologies promotion would be emphasized by GDF through a dedicated training plan in relation with the other measures, especially the one concerning the micro-compressor.

CNG at home

As the offer will be new, training will be one of the key tasks of the project.

Some dedicated trainings will be developed for:

- Professionals (gas professionals, automotive professionals...)
- Customers
- Other peripheral actors (fire fighters...)

Each training developed will then be used at national level.

B Measure implementation

B1 Innovative aspects

Innovative Aspects:

- New conceptual approach
- New mode of transport exploited
- Targeting specific user groups
- New policy instrument

The innovative aspects of the measure are:

- CNG vehicles fleet

At the local level, the particular interest of this measure consists in the clean and energy-efficient image that will be given to the bus network with the deployment of CNG buses.

At the national & European level, the CNG engines optimisation research works would be reused through a dedicated implementation plan. This research activity is to be carried out to achieve pollutant emission reduction obtaining both good mechanical performances and efficiency of the CNG vehicles of the urban bus fleet.

- CNG at home

The concept of CNG at home is entirely new in Europe. It is based on the use of a small compressor unit installed in houses (garages) that are connected to the natural gas network. Targeted marketing and communication activities will be necessary to ensure the commercial success of this new refuelling concept.

Expected results and targets

CNG vehicles fleet

The main targets of this measure are:

- To build a new gas filling station with a capacity of 200 buses.
- To extend the CNG bus fleet from 125 to 185 vehicles.
- To reduce the pollutant emission of the bus fleet.

The main expected results of the research activity are:

- To understand the effects of the gas composition on the engine combustion phenomenon observed both in vehicle and laboratory conditions.
- To optimize and define, with the gas provider and the city bus company, the better gas quality for the CNG bus fleet.

CNG at home

The main result of this measure is to develop a first reference in Europe. The Toulouse demonstration program will be a means to develop and test the “CNG At Home” offer and to communicate about it. It will also be a means to build some new technical, marketing, commercial tools that will be then spread out to the French and European market.

The key target is to have 1.000 homes equipped with the small compressor at the end of the project in the Toulouse Area.

B2 Situation before CIVITAS

CNG vehicles fleet

At the end of 2004 (before the start of CIVITAS MOBILIS project), the public transport bus fleet was composed of 514 buses of which 100 were CNG buses. The rest was composed of diesel buses with different Euro standards (156 Euro 0 buses, 137 Euro 1 buses, 89 Euro 2 buses and 32 Euro 3 buses).

CNG at home

Being an experimentation launched in the frame of the CIVITAS MOBILIS project, there were no specific previous experiences dealing with CNG micro-compressors in France before CIVITAS. Nevertheless, some feasibility works have been performed by GDF (national gas provider and supplier of the CNG micro-compressor) before the start of the MOBILIS project in order to permit a commercial development within the CIVITAS MOBILIS timeframe.

B3 Actual implementation of the measure

The measure was implemented in the following stages:

CNG vehicles fleet

Step 1 : Procurement of 28 CNG buses (February 2005) – In relation to the start of the CIVITAS MOBILIS project, Tisséo has purchased 28 new CNG buses at the beginning of 2005. With this procurement, total CNG buses reached the number of 128.

Step 2: Opening of a second CNG filling station (January 2008) – In the frame of the inauguration of the new bus depot of Langlade (destroyed in 2001 in the explosion of the nearby AZF factory), Tisséo has opened a second CNG filling station permitting some further developments of the CNG fleet (capacity was limited to the filling capacity of the only existing filling station (125 buses)).

Step 3: Procurement of 40 new CNG buses (October 2008) – Tisséo has ordered 40 new CNG buses in the frame of the CIVITAS MOBILIS project however and for fabrication delays, these buses will not be delivered within the MOBILIS timeframe (the 40 buses should be delivered in summer 2009).

CNG at home

Step 1: Launch of the « CNG at home » offer (October 2005) – In October 2005, GDF has launched an important communication campaign dealing the promotion of the CNG micro-compressor.

Step 2: Launch of the commercial offer (January 2006) – GDF has obtained the regulations in order to start the commercial development of the CNG micro-compressor.

Step 3: Commercialisation and training (January 2006 to March 2008) – GDF markets its CNG micro-compressor and realises several training sessions with the objective to provide the technical knowledge to people installing the micro-compressors and ensuring their maintenance.

Step 4: Stop of the commercialisation (March 2008) – In regards to commercial results (58 micro-compressors have been installed two years after official launch), GDF decided to stop the commercialisation of the CNG micro-compressor.

An in-depth Process Evaluation Report gives more details about the actual implementation of the measure.

B4 Deviations from the original plan

The deviations from the original plan comprised:

- Modification of the planning for the construction of the new CNG filling station (from June 2007 to January 2008) and impact on the CNG bus procurement (envisaged end of the MOBILIS project 28 CNG new buses + 25 in 2009 + 25 in 2010),
- Slight modification of the budget (due to some readjustments to actual costs),
- Minor modification of the R&D activities performed by INPT (adaptation to real activities). Among others, is has been decided not to renew the engine bench for the CNG tests (tests results would be the same than with the current engine bench). Its related milestone has been removed.
- Stop of the commercial development of the CNG at home offer by Gaz de France in March 2008.

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

| No. | Measure title | Relation |
|-------|--|---|
| 5.1.T | Large-scale operation of clean bus fleets in Toulouse and preparation of sustainable supply structures for | Integrate the results obtained with the engine optimisation study. Use of the feasibility analysis in the new gas |

| | | |
|--------|---|--|
| | alternative fuels. | filling station building. Link with the training program that aims to develop dedicated knowledge on the CNG engine area. Integrate the results obtained with the bio-diesel analysis study. |
| 5.3.D | Operation of bio-fuel and CNG vehicles and framework conditions for alternative fuel use in Debrecen. | Share of Experience and Results with other MOBILIS sites that would work on the development of CNG Bus fleet. |
| 5.4.L | Operation of bio-diesel and redeployment of bio-diesel and CNG fleets in Ljubljana. | |
| 5.5.V | Deployment of CNG buses and LPG boats in Venice. | |
| 6.3.T | High-quality bus corridors in Toulouse and development of PT segregated and secured lanes in the city centre. | Propose a high quality service on the bus lines using the 3 new HQC. |
| 8.1.T | Improving quality and structure of PT services in Toulouse. | Integrate CNG buses in the global PT service scheme. |
| 11.1.T | Awareness campaign for changing mobility behaviour Toulouse | Give a new image to the bus network and promote clean vehicles. |

C Evaluation – methodology and results

C1 Measurement methodology

CNG at home: Measurement does not call an evaluation in a strict sense of the term. Acting of a demonstrator, the conclusions of measurement (and in particular results of the public opinion and sales) will constitute an auto-evaluation. An in-depth process evaluation report is annexed to the Final Evaluation Report. This report provides with conclusions, feasibility, potential and barriers issues.

For CNG buses, the evaluation has been carried out by measuring the environmental and economical gains between CNG Euro 3 buses and Euro 3 diesel buses. The evaluation has been carried out by taking into account the arrival of the new 28 CNG buses which have been purchased in the frame of the CIVITAS MOBILIS project.

C1.1 Impacts and Indicators

Table of Indicators.

| No. | Impact | Indicator |
|-----|-------------------------|---|
| 1 | Environment | Emissions of HC, CO, Nox and particulates per 1000 km |
| 2 | Environment | Emissions of HC, CO, Nox and particulates for the new 28 CNG buses |
| 3 | Environment | Emissions of HC, CO, Nox and particulates at the level of the whole bus fleet |
| 4 | Economy | Fuel consumption |
| 5 | Economy | Maintenance Cost |
| 6 | Economy | Overall operation costs analysis |
| 7 | Environment and Economy | CBA analysis |

Detailed description of the indicator methodologies:

- Indicator 1** (Emissions of HC, CO, Nox and particulates per vehicle and per 1000 km)

A comparison of emissions of the here above mentioned pollutants will be realized between Euro 3 CNG buses and Euro 3 diesel buses in order to determine the associated environmental gains.

The measurements have been performed according real-time measurements for particulates and manufacturer instruction manuals for HC, CO and Nox.
- Indicator 2** (Emissions of HC, CO, Nox and particulates at the level of the 28 CNG buses)

This indicator is related to the comparison of environmental emissions by taking into account the 28 new Euro 3 CNG buses vs 28 Euro 3 diesel buses.
- Indicator 3** (Emissions of HC, CO, Nox and particulates at the level of the whole bus fleet)

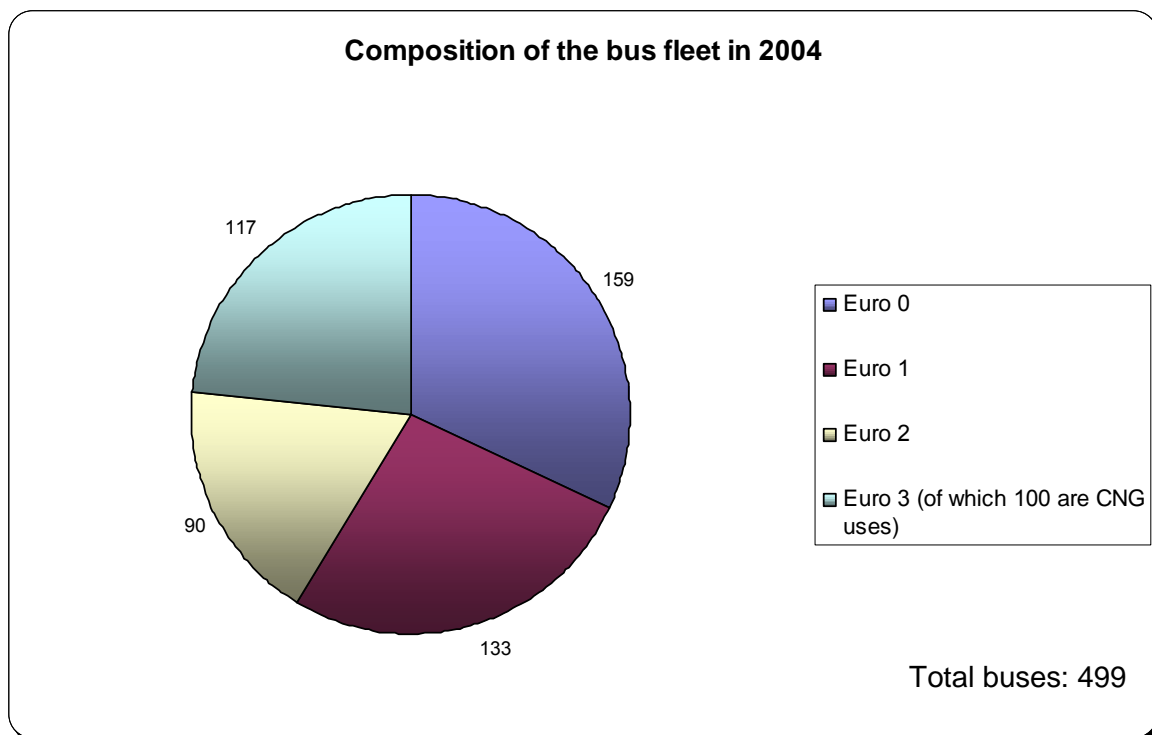
In order to have an overview of the overall environmental gains at the level of the whole bus fleet, it has to underlined that the substitution of diesel buses with CNG buses does not consist an isolated action but is a part of an integrated clean vehicles policy which is also considering the introduction of soot filters on former

and new diesel buses as well as the launch of a biodiesel experimentation (measure 5.2 of the CIVITAS MOBILIS project). The results which will be presented in relation to this indicators battery are the same as for the measure 5.2.

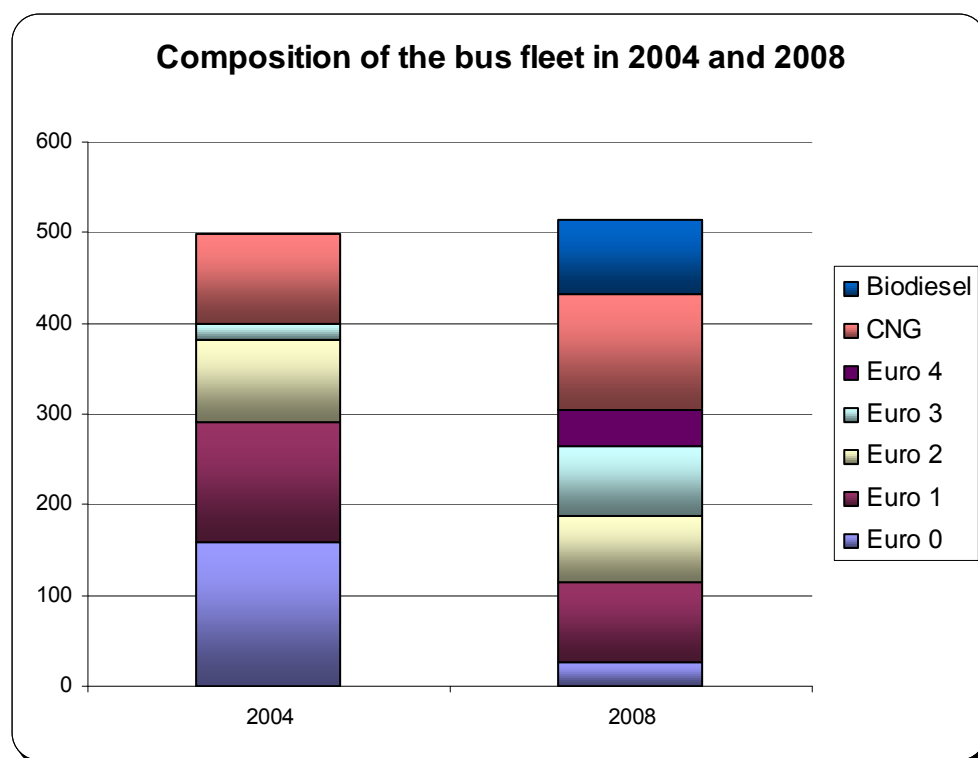
- **Indicator 4** (Fuel consumption costs)
 A comparison of fuel consumption costs will be realized between CNG buses and diesel buses.
- **Indicator 5** (Maintenance costs)
 A comparison of maintenance costs will be realized between CNG buses and diesel buses.
- **Indicator 6** (Overall operation costs)
 A comparison of overall operation costs will be realized between CNG buses and diesel buses by taking into account the whole set of parameter enabling a relevant comparison of operational costs.
- **Indicator 7** (Costs- Benefit Analysis)
 A Costs- Benefit Analysis will be performed by taking into account both environmental and economical indicators.

C1.2 Establishing a baseline

The baseline refers to the composition of the bus fleet at the moment when the CIVITAS MOBILIS started (1st of February 2005). At this period, the fleet was composed of 414 diesel buses and 100 CNG buses (see graph).



The following graph and table show how the bus fleet has evolved throughout the project:



| | 2004 | 2008 |
|--------------|------------|------------|
| Euro 0 | 159 | 27 |
| Euro 1 | 133 | 88 |
| Euro 2 | 90 | 72 |
| Euro 3 | 17 | 77 |
| Euro 4 | 0 | 41 |
| CNG | 100 | 128 |
| Biodiesel | 0 | 81 |
| total | 499 | 514 |

C1.3 Building the business-as-usual scenario

In the CIVITAS MOBILIS project, Tisséo-SMTC made the choice of continuing its investments in the field of GNV. Beyond the buses acquired in the framework of the project (28 to start with +25 ordered at the end), the decision which was of prime importance for the continuity of this policy, rests in the construction of a second GNV compression station in the newly built bus depot of Langlade. Thus the decision taken in the framework of the MOBILIS project results in the possibility of considerably increasing the GNV bus fleet (the two compression stations now allow filling 250 buses each night) and confirm a policy decision announced already in 2002.

Besides, it must be considered that the acquisition of GNV buses is not an isolated policy since it is accompanied (still in the framework of MOBILIS) by the generalization of particle filters and the beginning of a biodiesel experimentation on a major part of the oldest buses of the fleet.

To conclude, it must be indicated that the commitments made in the framework of MOBILIS allowed Tisséo-SMTC to confirm its determination to continue its acquisitions in the field of clean vehicles and particularly in that of GNV.

C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

Fuel consumption costs

The following table shows the fuel consumption costs of CNG buses comparing to diesel buses for the years 2006 and 2007 and average 2006/2007.

| | CNG bus consumption (€ / 100 km) | Diesel bus consumption (€ / 100 km) | Difference between diesel and CNG (€ / 100 km) | Difference between CNG and diesel (in %) |
|-------------------|----------------------------------|-------------------------------------|--|--|
| Year 2006 | 24,48 | 40,37 | -15,89 | - 39,4 |
| Year 2007 | 21,59 | 36,40 | -14,81 | - 40,7 |
| Average 2006/2007 | 23,01 | 38,07 | - 15,06 | - 39,56 |

The comparison of the cost of fuel between GNV and diesel shows a large decrease in the fuel bill in the case of GNV buses (40% on an average for the years 2006 and 2007). Nevertheless it must be considered that the GNV buses require costly infrastructures (compression station and filling system) and that the maintenance costs tend to be higher in the case of GNV buses (see below).

It is thus necessary to make a comparison taking into account all the direct and indirect costs in order to be able to evaluate if, in addition, GNV buses are more profitable than diesel buses (see below).

Maintenance costs

The following table shows the maintenance costs of CNG buses comparing to diesel buses for the years 2006 and 2007. Maintenance costs include workforce costs and new vehicles parts costs.

As maintenance costs are depending on various factors (such as the unexpected breakdowns), it has been decided to compare costs for the years 2006 and 2007 and average 2006/2007.

| | CNG bus maintenance (€ / 100 km) | Diesel bus maintenance (€ / 100 km) | Difference between diesel and CNG (€ / 100 km) | Difference between CNG and diesel (in %) |
|-------------------|----------------------------------|-------------------------------------|--|--|
| Year 2006 | 27,07 | 18,57 | + 8,5 | + 45,77 |
| Year 2007 | 41,07 | 21,80 | + 19,27 | + 88,39 |
| Average 2006/2007 | 34,15 | 20,44 | + 13,71 | + 67,07 |

Overall operation costs

Overall operation costs are being calculating by adding fuel costs, maintenance costs and the over costs for CNG buses which are related to the construction of a CNG filling station. Filling station costs have been calculated according filling station maximal capacity and local depreciation rules. Bus investments costs have been calculated according local depreciation rules.

| | Bus investment costs (€ / 100 km) for 2006/2007* | Fuel costs (€ / 100 km) for 2006/2007 | Maintenance costs (€ / 100 km) for 2006/2007 | Extra CNG costs (€ / 100 km) for 2006/2007 | Total costs (€ / 100 km) for 2006/2007 |
|------------|--|---------------------------------------|--|--|--|
| CNG bus | 52,03 | 23,01 | 34,15 | 2,99 | 112,18 |
| Diesel bus | 32,51 | 38,07 | 20,44 | 0 | 91,02 |

** for bus investment, only the year 2007 has been considered, this is due to the impossibility to estimate depreciation costs of the diesel buses which have started to run along the year 2006*

According to the table and for the cumulated 2006 and 2007, operation costs for CNG buses are 23,25% higher than for diesel buses.

Nevertheless, it has to be stated that:

- the difference in bus investment costs is almost covered by the difference in fuel costs, giving as such a similarity when adding these two types of costs**,
- the maintenance costs for CNG buses are higher but are tending to decrease along the years,
- there is an extra cost for CNG which is linked to the construction of a CNG filling station but which is not that important in regards with the total operation costs.

** As CNG buses have run individually fewer kilometres than diesel buses (respectively 34 444 km / CNG bus in 2007 and 45 554 km / diesel bus in 2007), it has to be noticed that the gap in investment costs should normally be reduced and that the difference in overall exploitation costs should also be reduced in regards to this basic analysis condition.

C2.2 Energy

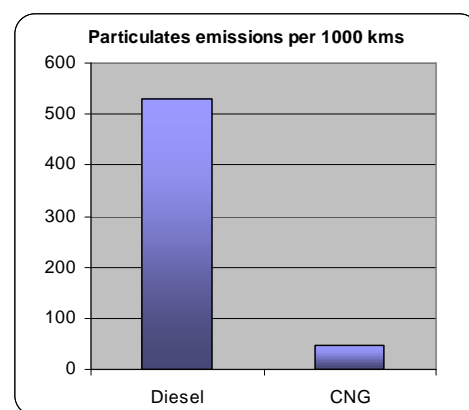
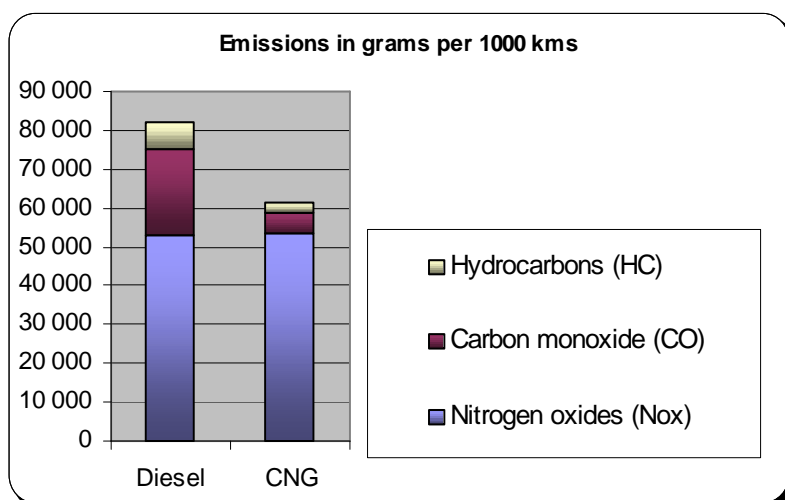
Energy related issues are indirectly being addressed in the “environment section”.

C2.3 Environment

Emissions of HC, CO, Nox and particulates per 1000 km

The following graphs and tables compare the emissions of HC, CO, Nox and particulates per 1000 km between a CNG Euro 3 bus and a diesel Euro 3 bus.

| g / 1000kms of operation | Diesel | CNG |
|--------------------------|--------|--------|
| Nitrogen oxides (Nox) | 52 911 | 53 404 |
| Carbon monoxide (CO) | 22 223 | 5 516 |
| Hydrocarbons (HC) | 6 984 | 2 688 |
| Particulates | 529 | 47 |



The comparison of the emission of Nox, CO, HC and particles show the following:

- GNV buses emit slightly more Nox than diesel buses (+ 0.9%),
- GNV buses emit much less CO than diesel buses (- 75.2%),
- GNV buses emit much less HC than diesel buses (- 61.5%),
- GNV buses emit much less particles than diesel buses (-91.1%).

Emissions of HC, CO, Nox and particulates for the new 28 CNG buses

The following table compares the emissions of HC, CO, Nox and particulates at the level of the 28 CNG buses which have been purchased within the MOBILIS project.

The following data take into account the kilometric volume of production of the 28 GNV buses for the year 2008 (i.e. 1 003 526 kilometers) when compared with an equivalent kilometric volume for 28 diesel buses. This data presents the emissions in tons for the defined production volume.

| Emissions for year 2008 (in tons) | Diesel | CNG |
|-----------------------------------|--------|-------|
| Nitrogen oxides (Nox) | 53,10 | 53,59 |

| | | |
|----------------------|-------|------|
| Carbon monoxide (CO) | 22,30 | 5,54 |
| Hydrocarbons (HC) | 7,01 | 2,70 |
| Particulates | 0,53 | 0,05 |

The interest of this table is in the comparative measurement of the pollutants quantities emitted by a fleet of 28 GNV buses when compared with a fleet of 28 diesel buses over one year (kilometric production volume for 2008).
 Thus for the year 2008, the operation of 28 GNV buses instead of 28 diesel buses, i.e. the production of 1 003 526 kilometers resulted in emitting:
 .0.49 ton of Nox more,
 .16.76 tons of CO less,
 .4.31 tons of HC less and,
 .0.48 ton of particles less.

The valorization of these increases / decreases in emission of pollutants (see section C2.1) gives a saving of 57 345 Euros for the year of operation 2008 of the 28 GNV buses.

Cost-benefit analysis for measure 5.1 (concerning only the CNG bus fleet part)

In relation to the hereunder table and through the external costs calculation methodology coming from the ExternE and Cleaner Driver (www.cleaner-drive.com) projects, the cost-benefit analysis of the “CNG public transport fleet” of the measure 5.1 gives the following results :

Calculation of the external costs:

| Emissions for year 2008 (in tons) | Diesel | CNG | difference | value in € |
|-----------------------------------|--------|-------|----------------|---------------|
| Oxydes d'azote (Nox) | 53,10 | 53,59 | -0,49 | -4 057 |
| Monoxyde de carbone (CO) | 22,30 | 5,54 | 16,77 | 59 |
| Hydrocarbures (HC) | 7,01 | 2,70 | 4,31 | 8 623 |
| Particules | 0,53 | 0,05 | 0,48 | 61 402 |
| | | | total : | 57 345 |

Cost-benefit analysis balance:

- Overall operation costs of 28 CNG Euro 3 buses in 2008 = 1.125.755,47€
- Overall operation costs of 28 diesel Euro 3 buses in 2008 = 913.409,37€
- Extra operation costs when using 28 CNG Euro 3 buses instead of 28 diesel Euro 3 buses = 212.346,10€ ***
- External costs to be deducted = 57.345,00€
- Final general extra costs for using 28 CNG Euro 3 buses instead of 28 diesel Euro 3 buses (after deduction of external costs) in the year 2008 = **155.001,10€*****

*** It has to be underlined that the comparison of the extra operation costs is based on equivalent mileage for CNG buses and diesel buses. As, it has been stated before that CNG buses are running less kilometres than diesel buses (this is what happened in the year 2007), difference in investment costs and extra costs should not be as high as it has been calculated here above.

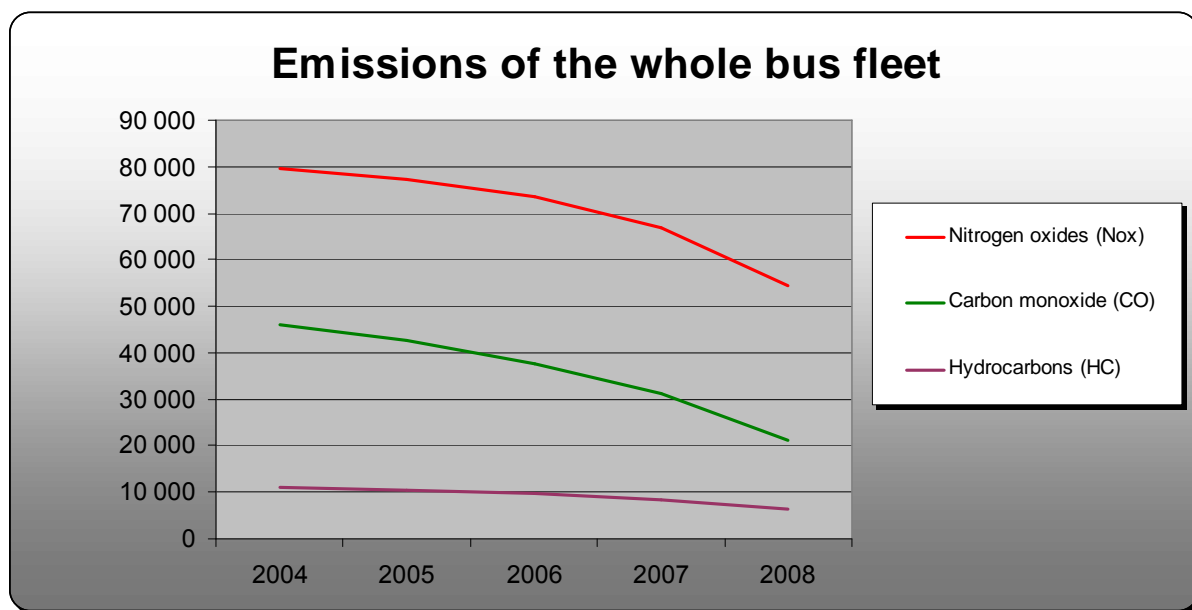
If CNG buses would have the same mileage as diesel buses when calculating operation costs, their investment cost should be **40,31€ / 100 km (instead of 52,03€ / 100 km)** the total extra operation costs for using 28 CNG buses instead of 28 diesel buses should be **94.732,85 €** and final general extra costs for using 28 CNG Euro 3 buses instead of 28 diesel Euro 3 buses (after deduction of external costs) in the year 2008 should be **37.385,85€**

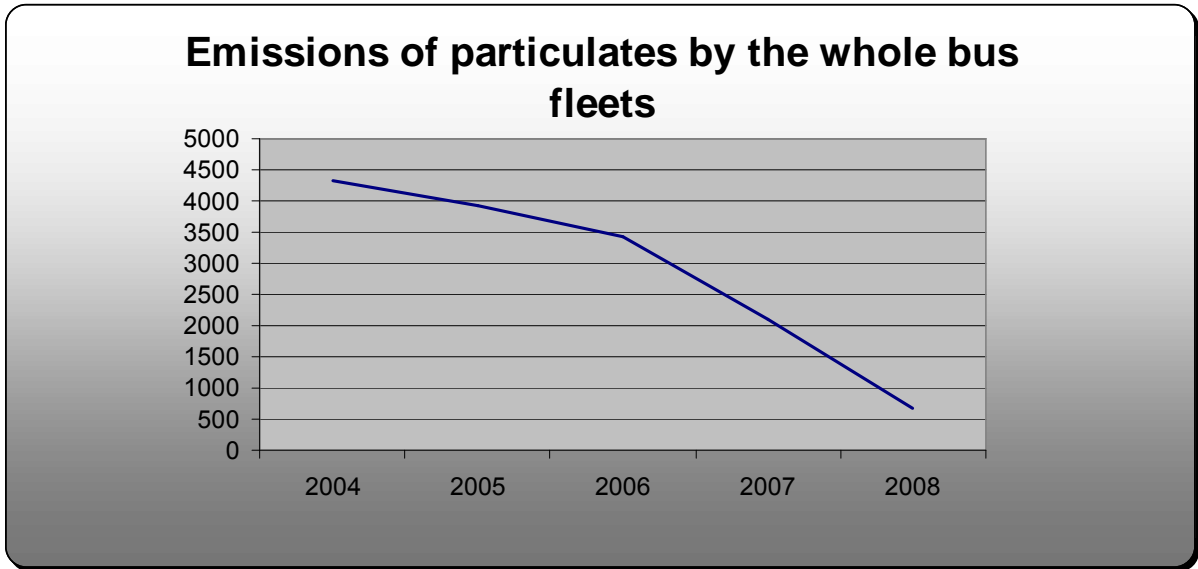
This statement indicates how difficult it is to “compare the comparable”. Therefore, it has to be concluded that the choice “CNG or diesel” is not really a question of costs but is much more a matter of political choice.

Evolution of emissions of HC, CO, Nox and particulates at the level of the whole bus fleet

The following graphics indicate how the emissions of NoX, CO, HC and particulates have evolved throughout the MOBILIS project. It has to be indicated that the evolution is not only due to the two MOBILIS measures but also to the actions which have not been integrated within the MOBILIS project (renewing of the diesel bus fleet with higher Euro standards levels).

Emissions are given in g/1000 km of operation.





Since the beginning of the MOBILIS project (between 2004 and 2008),

- the emissions of Nox have decreased by 31,9%,
- the emissions of CO have decreased by 54,2%;
- the emissions of HC have decreased by 42,8%,
- the emissions of particulates have decreased by 84,4%.

C2.4 Transport

The regulatory and safety constraints impose specific traffic conditions for GNV buses. Since these constraints do not exist for diesel buses, the fact of operating GNV buses makes the definition of bus routes more difficult.

C2.5 Society

The various satisfaction enquiries conducted by Tisséo-SMTC show a positive feedback from the habitants of the Toulouse city since the GNV buses are seen as « more respectful » of the environment.

C3 Achievement of quantifiable targets

| No. | Target | Rating |
|--|---|--------|
| 1 | Continuation through the construction of a second CNG filling station for buses | ** |
| 2 | Procurement of CNG buses | * |
| 3 | Launch of CNG offer for households | * |
| 4 | Understanding of the effects of the gas composition on the engine combustion | NA |
| 5 | Optimize and definition of a the better gas quality for the CNG bus fleet | NA |
| NA = Not Assessed * = Partially achieved ** = Achieved in full *** = Exceeded 0 = Not achieved | | |

C4 Up-scaling of results

Not relevant

C5 Appraisal of evaluation approach

The evaluation of the continuation in the acquisition of GNV buses by Tisséo-SMTC forms part of the general context of development of clean vehicles integrated policy aimed at both diversifying the systems (GNV, particle filters, biodiesel experimentation) and confirming the policy choices made earlier. Thus the acquisition of GNV buses (measure 5.1) cannot be performed without taking into account the actions also taken in measure 5.2 (particle filters, biodiesel) and this in order to give results on the scale of Tisséo-SMTC fleet.

Besides, the GNV buses ordered in October 2008 will meet the Euro 4 standard and consequently will give different energy and environment outcomes. Also, the Euro 3 diesel buses with which the comparison is made are fitted with particle filters and thus limit the difference in emission of particles between the two types of motors.

Nevertheless, by taking into account GNV Euro 3 buses of an equivalent make (Heuliez bus), we were able to calculate the inherent operating costs of the two types of motors and thus evaluate their difference.

Finally, considering the cost-benefit analysis, it must be noted that only the most important pollutants were considered in the external cost calculation method. The additional cost for use of the GNV (after deduction of the external cost) has been calculated without considering the secondary pollutants. Nevertheless, the cost-benefit analysis shows an additional operating cost for the GNV for which the integration of secondary pollutants in the calculation could not change much.

C6 Summary of evaluation results

The key results are as follows:

- **Key result 1** – continuation of the CNG policy for bus fleet (construction of a second filling station and continuation of the procurement of CNG buses)
- **Key result 2** – calculation of the extra operation costs for buses when using CNG instead of diesel and calculation of the decrease of polluting gas
- **Key result 3** – commercial failure of the CNG micro-compressors product within MOBILIS lifetime

D Lessons learned

D1 Barriers and drivers

D1.1 Barriers (CNG bus fleet)

- **Barrier 1** – Unclear figures about real lifetime costs.
- **Barrier 2** – Lack of a local objective comparison of the environmental performances.

D1.1 Barriers (CNG micro-compressors)

- **Barrier 1** – A lack of political support for CNG at the national level between 2005 and 2007.
- **Barrier 2** – Non respect of the development protocol signed in July 2005 by the fuel distributors, especially the opening of 300 public CNG fuelling stations before 2010.
- **Barrier 3** – The absence of market confidence in an offer that promotes a fuel that is not supported.

D1.2 Drivers (CNG bus fleet)

- **Driver 1** – A thorough study of the environmental figures and costs of CNG in comparison to the diesel fuel; it was proved that over a life time the costs are not significantly different.
- **Driver 2** – Political will to continue with the CNG solution, following its environmental gains and public image. Please note that the new generation of diesel vehicles is approaching the CNG vehicles in term of environmental performance.
- **Driver 3** – Strong and open management of the measure showing the real figures, countering a strong lobby (non-figure based) against the CNG solution.
- **Driver 4** – A thorough study of the environmental figures and costs of CNG in comparison to the diesel fuel; it was proved that over a life time the costs are not significantly different.
- **Driver 5** – European and national subsidies to decrease the cost difference between the diesel and the CNG solution.

D1.2 Drivers (CNG micro-compressors)

- **Driver 1** – Strong local political support in order to provide GDF with a suitable place where to launch the CNG micro-compressor.
- **Driver 2** – More developed citizens' awareness in relation to alternative fuel solutions.

D2 Participation of stakeholders (CNG bus fleet)

- **Stakeholder 1** – ADEME (national environment energy) who launched the "CNG pilot sites" project, Toulouse has been chosen as one of the ten pilot sites. Thanks to this "pilot site", several meeting have taken place in order to discuss the CNG benefits.
- **Stakeholder 2** – AFGNV (national association of CNG users) launched together with ADEME the "CNG pilot sites" project.

D2 Participation of stakeholders (CNG micro-compressors)

- **Stakeholder 1** – Local authorities of Toulouse (including some MOBILIS partners) who supported the idea to develop in Toulouse a first reference in Europe.
- **Stakeholder 2** – Car manufacturers who decided to go further in the development and marketing of CNG cars.

- **Stakeholder 3** – National Authorities who did not strongly support the CNG solution during MOBILIS timeframe.
- **Stakeholder 4** – Fuel distributors in the view to develop public CNG fuelling stations.

D3 Recommendations (CNG bus fleet)

- **Recommendation 1** – Real assessment of costs and environmental performances of CNG in order to provide decision makers with clear guidelines in the development of their public transport fleet.
- **Recommendation 2** – Think about long term investments in order to force extra investment costs when renewing the bus fleet.

D3 Recommendations (CNG micro-compressors)

- **Recommendation 1** – Having a long-term vision for developing innovative products such as the CNG micro-compressor.
- **Recommendation 2** – Ensure that the project is politically supported at all levels.
- **Recommendation 3** – Involve all the necessary stakeholders in the project (car manufactures, fuel suppliers, associations, public authorities...).

D4 Future activities relating to the measure

CNG bus fleet

Considering the GNV bus fleet, Tisséo-SMTC has made the choice of continuing its policy of investment in the GNV bus and has signed a contract with IVECO which will supply the next 40 GNV buses (delivered outside the MOBILIS project but ordered within the framework of the MOBILIS project).

Besides, the fact of having built a second compression station at Langlade proves to be a determining factor in the continuation of acquisition of GNV buses.

CNG micro-compressors

The marketing of the CNG micro-compressor has been stopped by Gaz de France but the stop is not definitive. GDF is waiting for a more appropriate context to further develop and market its CNG micro-compressors.

Conclusions of the national debate about mobility (Grenelle de l'Environnement) should give some clarifications about priorities to be pursued in terms of alternative energies.