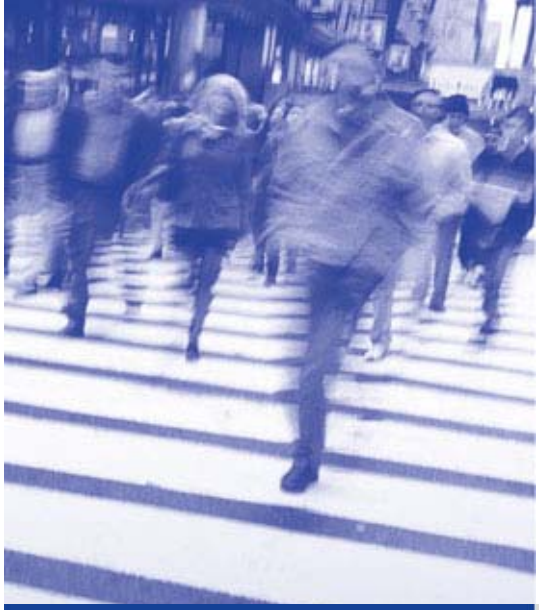


CiViTAS
Cleaner and better transport in cities

MIMOSA
BOLOGNA • FUNCHAL • GDAŃSK • TALLINN • UTRECHT

Measure Evaluation Results

BOL 1.2 Cleaner Private Vehicles

Valentino Zanin
Giorgia De Chiara
Davide Rossi
(TeMA Territorio Mobilità Ambiente S.r.l., municipality of Bologna consultant for the measure evaluation)

Date: February 2013
Revised version April 2013

THE CIVITAS INITIATIVE
IS CO-FINANCED BY THE
EUROPEAN UNION

Executive Summary

The measure 'Cleaner Private Vehicles' belonged to the wide range of measures covering environmental and sustainable mobility issues in Bologna. The idea behind the measure was to encourage those citizens who are strongly depending of their private vehicle to use cleaner fuels for their vehicles. In 2007 Bologna made the promotion of renewal of pollutant private vehicles by clean vehicles a priority part of its urban traffic plan. The CIVITAS MIMOSA gave Bologna the opportunity to boost this effort.

The objectives of the MIMOSA measures were to support car owners to switch to clean vehicles, to anchor and make visible the role of public administration as manager and facilitator between the several stakeholders involved in the field of clean vehicles and energy and to check the overall efficiency of vehicle renewal concepts. Therefore the city of Bologna focused on promoting the use of all types of clean vehicles, on fundraising and fund management in order to efficiently implement the measures. Thereby the MIMOSA measure was a crucial support to appoint experts to carry out in-depth studies to maximise the effectiveness of national and regional funds.

The present measure is strongly interdependent with three other MIMOSA measures in Bologna which shared the same high level objective of improving air quality. The four measures were identified as bundled measures: BOL 1.2 'Cleaner Private Vehicles', BOL 3.1 'Road Pricing Policies', BOL 4.1 'Mobility Managers' and BOL 7.1 'City Freight Delivery Plan'. This measure was implemented in the following parts:

Part 1: Data collection (October 2008 - 2012) During the entire measure process, the opinions, requests and proposals of car owners and vehicles suppliers were collected to elaborate and adapt the incentive procedures to the specific need and expectations of consumers and suppliers.

Part 2: Review and supervision of incentives funding system (October 2008 - 2012) Since the beginning of the MIMOSA project, a team of the Municipality of Bologna was in charge of networking and negotiating activities with the partners involved in vehicles conversion and clean energy technologies as well as of public fundraisings on the regional and national level. In close cooperation with these partners and with the available public budget, the MIMOSA team coordinated incentive pilot projects. Incentive actions were established for conversion of private car filter, purchases of electric bicycle or motorcycle and scrap page program for pollutant vehicles. The recharging system of the existing fleet of car sharing vehicles was improved and a common regional tariff system was implemented in Bologna and four neighbouring cities for recharging clean vehicles. This later project was launched in a special public inauguration ceremony during the Mobility Week 2011 in the presence of the Mayor of Bologna and the President of the Emilia Romagna Region.

Part 3: Implementation of traffic management measures (October 2008 to 2012) Different activities were conducted: analysis of the feasibility of the measure were carried out, communication campaigns and action days such as "Thursdays without cars" were organized and new tariff regulation and special benefits and facilities for clean vehicles were implemented such as allowing clean vehicles to circulate in the traffic restricted areas and granting other circulation/parking facilities to methane/LPG and electric vehicles.

This measure was selected as focused measure and in addition to the impact and process evaluation a cost-benefit analysis (CBA) was conducted. The impact evaluation of the measure was based on a number of environmental indicators and the number of converted vehicles.

The **key-results** of the evaluation showed that the activities carried out by the Municipality were successful: the percentage of LPG or methane powered vehicles registered in Bologna reached 16% in 2011 compared to 8.4% in 2007. Over 10% of methane-fuelled vehicles have been counted in the urban area which fulfilled the European Union White Paper recommendation. Another positive key result was a decrease of 22% of CO emissions and a general decrease in emissions compared to the levels between 2007 and 2011 were measured.

The CBA pointed out that a break-even is achieved after 12 years. This means that the investment did not make a loss, but also the air quality improvements were not too onerous within the considered time span. The CBA showed the difficulty in comparing costs/benefits of different magnitudes, such as those undertaken by Public Administrations for renewals, lower tax revenues due to the lower fuel consumption or monetization of environmental benefits. The reason could be linked to the randomness of some cost items which have varied greatly during recent years and were therefore very hard to predict in the long-term.

Due to the economic crisis in Italy, the main **barrier** encountered during the measure was the national and local budget cuts in 2011 which implied that financial incentives for the vehicle conversion were abandoned. Nevertheless the variety of activities conducted by the Municipality of Bologna during the MIMOSA measure let assume that the positive trend observed in the field of clean vehicle promotion will continue in the future years.

It is highly recommended to replicate this measure in cities which want to overcome the challenge posed by slow car renewal. However, it is important to be aware that the success of the measure is not necessarily linked to the availability of public incentives for vehicle owners. Instead it is recommended to make sure that a common political interest and willingness to address environmental issues is expressed and to have political support for the implementation of the measure.

The activities conducted in the frame of MIMOSA measure contributed to give drivers the **possibility** to choose cleaner as valid alternative. Bologna took a leading role in Italy in the field of clean vehicle recharging system. Indeed, the electric vehicle recharging system planned in the frame of the regional plan was implemented in Italy for the first time and the installation of a liquid methane recharging station contributed to extent the innovative methane and LPG vehicles recharging network in Italy. The success of these efforts makes Bologna an Italian pioneer which will hopefully be followed by many others.

A Introduction

A1 Objectives

The Measure's objectives were:

(A) High level / longer term:

- To reduce pollutant emissions in the urban area and
- To save energy in the transport sector

(B) Strategic level:

- To improve the use of alternative fuels & clean vehicles

(C) Measure level:

(1) To support the renewal of private vehicles by encouraging a switch to new environmentally-friendly engines, and to promote the purchase of new vehicles with eco-sustainable technology to reach the target of 10% clean fuel vehicles in 4 years;

(2) To demonstrate the effectiveness of the Administration's management and supervisory activities for facilitating the relationship with stakeholders involved in private vehicle renewals

(3) To verify the benefits of private vehicle renewal, in order to fine tune the City Administration's policy by measuring the decrease in pollution.

A2 Description

The Measure supported and refined Bologna's policy on boosting and encouraging private vehicle renewal, by confirming and developing the two strategies adopted: financial incentives and priority traffic facilities for cleaner vehicles for residents of the Municipality of Bologna.

As part of the Mimosa project, specialist personnel carried out in-depth studies on how to maximise national and regional funds.

Therefore, **the whole incentive funding system was reviewed**, and the Administration's management and supervision activities were optimized. Firstly, the procedure giving vehicle owners incentives for the costs of installing/purchasing methane/LPG technology (the co-funding repaid about 25% of the full cost) was fine tuned and updated almost annually. Feedback and requests were collected from vehicle owners, garages and other stakeholders. Secondly, the Administration's technicians supervised the relationship between vehicle owners and garages to guarantee the regularity of the service. Thirdly, a continuous monitoring activity was carried out in order to find further economic resources to support this measure.

Facilitations were introduced for less polluting vehicles, including free access to the Limited Traffic Zone (LTZ), discount on parking tariffs. On the other hand, restrictions were introduced for polluting vehicles according to their combusted gas emission category. LPG and methane vehicles were exempt from these provisions.

B Measure Implementation

B1 Innovative Aspects

The innovative aspect of the Measure was:

- **New economic instrument** - The implementation of a comprehensive (dis-)incentive system based on the eco-friendliness of vehicles (e.g. parking fare differentiation based on vehicle pollution levels - see also measure 3.2).

B2 Research and Technology Development

The RTD activity consisted of a preliminary in-depth analysis and information gathering to obtain a comprehensive description of the scenario. The following preliminary activities were carried out:

1. Start data collection and scenario analysis:
   - analysis of data on the number of cleaner vehicles (and trend) in the overall fleet in circulation;
   - compilation of the measures favouring cleaner vehicles, in order to obtain a comprehensive description of the current scenario.
2. Legal/Administrative framework definition:
   - examination of the agreements between the Municipality and garages favouring private vehicle renewal;
3. Initial research activity and implementation plan:
   - initial research and monitoring activities on the current scenario to identify the most effective ways for the Administration to favour environmentally-friendly vehicles;
   - an examination of sources of funding for vehicle renewal at regional, national and European level;
   - preliminary research was done by the Municipality of Bologna and the Emilia Romagna Region to check the feasibility of promoting cleaner lorries. Following this preliminary research, categories of potential beneficiary vehicles and an appropriate level of financial contribution were identified.

Through the findings of the research activity, the Administration realized the importance of taking into account not only financial contributions to converting vehicles to LPG/methane, but also enforcing mobility management policies and strategies.

B3 Situation before CIVITAS

The policy of encouraging private vehicle renewal used two different aspects: financial incentives and circulation facilities prioritising cleaner vehicles. Thanks to national and regional funds, financial incentives were offered to help shift engine technology away from traditional fossil fuels to Liquefied Petroleum Gas - LPG - and Compressed Natural Gas - CNG (Methane).

At the same time the conversion of private vehicles was boosted by facilitating less polluting vehicles (see measure 3.1 “Road pricing policies” for details) and discounting parking tariffs (i.e. up to 100% in favour of hybrid and electric vehicles - see measure 3.2 ‘Pricing and monitoring policies for parking’ for details). Moreover, vehicles with low/very low environmental impact or zero emissions were not subject to traffic restrictions. These

restrictions were planned in accordance with Regional air quality agreements and were annually updated and signed by the Administration. In order to guarantee the continuity of the process, the whole incentive funding system needed to be improved and new initiatives to encourage private vehicle renewal had to be found.

B4 Actual Implementation of the Measure

The city of Bologna adopted different complementary approaches with this Measure. These included: i) **promoting the use of all types of clean vehicles** (either newly purchased clean vehicles or converted vehicles, through the allocation of further public funds), by prioritising traffic facilities for clean vehicles through access to the LTZ and by parking policies; ii) **fund raising and fund management**, review and supervision of incentive funding system, for the conversion of private vehicle fleets to methane and LPG, iii) **supervision of the procedures** to keep continuity in the reservation list for conversions.

A dedicated **office** carried out research and monitored activities, aiming to: firstly, identify funding sources for vehicle renewal at regional, national and European level; secondly, to maintain the continuity of the reservation list regarding vehicle renewals when funding schemes had changed over time; thirdly to collect recommendations and requests for clarifications on incentive procedures from vehicle owners and equipment installers. The office aimed also to check and demonstrate to what extent management and supervision of the process of vehicle renewal was effective.

The Measure was implemented in the following parts:

Part 1 – data collection *(from October 2008 to 2012)*

- Collection of recommendations and requests for clarification on incentive procedures from vehicle owners and of feedback from installers and other stakeholders. During the process the Municipality included a provision for answering questions. This was necessary in order to continuously improve the actions put into practice.

Part 2 – review and supervision of incentive funding system *(from October 2008 to 2012)*

- Negotiations with Trade Associations such as Confartigianato, the association of Italian craft businesses, representing the mechanics involved in vehicle conversions, and ECOGAS, a consortium of gas and methane dealers (2008-2009).
- The Emilia Romagna Region contributed € 665,000 (independent of the Mimosa project) to support methane and LPG conversion incentives for private vehicle fleets. This fund was integrated with the others and was made available to car owners (2009-2010).
- The Municipality of Bologna launched an experimental Project on FAP, anti particulate filters, in conjunction with the Emilia Romagna Region. All commercial vehicles were offered the chance to install FAP filters, allowing them to pollute less, passing from Euro 1 to Euro 3 category, for which they would receive a refund of up to 50% of the installation cost (2009-2010). The project was not successful. Only 3 commercial vehicles installed FAP filters.
- In September 2011 the Municipality of Bologna launched a project in conjunction with Federmetano and ATC, with financial support from the Italian Environment Ministry, to create a methane car sharing fleet. As part of this project all car- sharing vehicles were equipped with a recharging card provided by FederMetano, enabling cars to be recharged throughout the whole of the Bologna District Area.

- The recharging network for methane and LPG vehicles increased significantly. The Emilia Romagna Region opened its first liquid methane recharging station in Calderara, a town close to Bologna; there are only eight such stations in the whole of Italy.
- On 16th September 2011, as part of European Mobility Week 2011, Enel, power and gas company, and Hera, water and energy services multiutility, presented a regional plan for recharging systems for electric vehicles. The President of the Emilia Romagna Region and the Mayor of Bologna attended the inauguration ceremony for the first electric recharging column, which was also the first one in Italy. Through the agreement between Enel, Hera and the regional authorities, residents of Bologna, Reggio Emilia, Rimini, Imola and Modena can recharge their electric vehicles in any of these five cities. They can pay their energy bills at the same cost agreed with their energy supplier, or through the integration of the contract into the regional 'Mi Muovo elettrico' card.
- Thanks to a regional fund of € 300,000 Euros, since September 2011 Bologna's residents have been eligible for:
  - an incentive of 300 Euros to purchase an electric bicycle or an electric motorcycle,
  - an incentive of 600 Euros if, at the time of purchase, they scrapped an old motorcycle (Euro 0 or Euro 1 category).
- Regarding these incentives (September 2011), 57% of funding was used to purchase electric bicycles and motorcycles (data to May 2012): 492 electric bicycles and 14 electric motorcycles have been purchased in all.
- 32% of the funding was used, also taking advantage of the further incentive for scrapping old motorcycles.

Part 3 – Implementation of traffic management measure (from October 2008 to 2012)

- The incentive campaign for the conversion or purchase of methane, LPG or electric vehicles was launched in 2008; it continued during the implementation of the Measure.
- Clean vehicles benefitted from free access to restricted areas, received a discount on parking and were authorized to enter the city on days when more polluting vehicles were prohibited.
- The regional agreement on air quality and traffic provisions was signed (2009). LPG and methane vehicles were excluded from traffic restrictions.
- A detailed analysis was carried out on the demand and trend for permits for the LTZ area and city centre parking (October-December 2010).
- On 3rd October 2011, the Municipality of Bologna signed its 2011-2012 agreement on "Air Quality" with RER. It included restrictions for polluting vehicles, according to their combusted gas emission category, between 3rd October 2011 and 30th March 2012.
- 9th January 2011 saw the launch of "Thursdays without cars", during which polluting vehicles, according to their combusted gas emission category, were not allowed to circulate. This ended on 30th March 2012.
- a specific flyer on Air Quality provisions was published in 2011 (please refer to measure 4.2).
- by the end of 2011 the Municipality of Bologna had procured 41 methane and LPG vehicles, increasing its lower-emission fleet share to 50%.

B5 Inter-Relationships with Other Measures

The Measure was interrelated with measure 3.1 ‘Road pricing policies’ and with measure 3.2 ‘Pricing and monitoring policies for parking’. Bundling was not evaluated, however, since the measures had their own target and domain, as follows:

- **with reference to measure 3.1**: the road pricing policy was aimed at limiting access to the LTZ area to all vehicles, excluding particular categories requiring access, as explained in the related MRT; measure 1.2 included all vehicles registered in Bologna,
- **with reference to measure 3.2**: ‘clean vehicles’ could obtain parking facilities by purchasing a subscription; they were required to display a sticker on their windscreen. Considering the small number of stickers requested compared to the number of vehicles registered in Bologna, the bundling was not considered.

It should be noted that measures 3.1 ‘Road pricing policies’, 4.1 ‘Mobility managers’ and 7.1 ‘City freight delivery plan’ pursued the same high-level objective as measure 1.2, improving air quality, even though they have their own targets and domain of application. For this reason, a bundled indicator for these 4 measures was the level of particulate 10 and particulate 2.5 recorded throughout the Municipality, even when no Mimosa measures were applied. Average values were obtained and collected from fixed points every day.

Obviously this value was influenced by other factors which were not always linked to the Mimosa project. However, changes in polluting emissions could be considered linked to traffic conditions and changes in driver behaviour.

C Impact Evaluation Findings

C1 Measurement Methodology

C1.1 Impacts and Indicators

The objective of the Measure was to bring down polluting emissions in the Municipality of Bologna in order to improve the residents' quality of life. The Municipality tried to reach the target of new or converted vehicles by encouraging the renewal of the existing fleet, using financial incentives and traffic and parking facilities. For these reasons the following indicators, all included in the environment evaluation area, were selected,

TABLE C1.1.1: 1.2 Measure Indicators

Indicator	Evaluation area	Core Indicator	Impact	Indicator	Source of data
1	Environment	Core Indicator 8	Emissions	CO_2 emissions	COPERT estimation
2	Environment	Core indicator 9	Emissions	CO emissions	
3	Environment	Core Indicator 10	Emissions	NO_x emissions	
4	Environment	Core Indicator 11	Emissions	particulate emissions	
5	Environment	Local indicator	Emissions	CNG/LPG conversions	Number of cars converted to methane (CNG) or liquid gas (LPG) engine
6	Environment	Local indicator	Emissions	circulation facilities	See detail

TABLE C1.1.2: Bundled indicator -7.1-3.1-4.1-1.2

Indicator	Evaluation area	Typology	Impact	Indicator	Source of data
7*	Environment	Core Indicator 7	Emissions	Particulate emissions	Data recorded at fixed stations in the centre of Bologna

* Indicator 7 was chosen to monitor and check polluting emissions throughout the whole of the Municipality

The Municipality of Bologna planned to base the evaluation on the actual running fleet. However, this was not measurable because of the impossibility of counting it electronically. Therefore, the registered car fleet was included in the analysis. It included part of the vehicles registered in Bologna and a small number of vehicles registered outside Bologna. The dimension and the composition of the Bologna **registered fleet** was considered in order to:

- value polluting emissions (indicators 1 to 4);
- quantify the number of converted/new vehicles and evaluate the Measure's effects on registered fleet renewal (indicator 5);
- quantify Municipality circulation facilities to boost running fleet renewal (indicator 6).

Indicators 1 - 4 'Environment evaluation area': The impact was calculated using an estimate. Using the COPERT methodology, the emissions' impact was calculated .based on the changes to the fleet's composition.

COPERT is a software program aiming at the calculation of air pollutant emissions from road transport. The technical development of COPERT is financed by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre on Air and

Climate Change. Since 2007, the European Commission's Joint Research Centre has been coordinating the further scientific development of the model. In principle, COPERT has been developed for use from the National Experts to estimate emissions from road transport to be included in official annual national inventories. The COPERT 4 methodology is also part of the EMEP/CORINAIR Emission Inventory Guidebook. The COPERT 4 methodology is fully consistent with the Road Transport chapter of the Guidebook. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation. For more details on the COPERT running fleet classification, see table (1) in the references of this MRT.

Calculations were made after the Measure had been in place for a year to check on the results. The unit was g/vkm (emissions weight/distance) and ton/years. The domain of the analysis was the registered car fleet of Bologna city.

In order to apply the COPERT methodology, the following assumptions were made:

- average daily urban trip length: 9.6 km/car,
- urban mean mileages (distances covered) of cars divided into classes of emissions (2): studies show that older vehicles cover a lower annual distance than newer ones,
- average urban speed: 23 km/h,
- cars are used on 365 days per year,
- Bologna's running car fleet has the same composition as the fleet registered in the city.

Indicator 5 'Number of cars converted to methane (CNG) or liquid gas (LPG) engines' The indicator was influenced by several factors, not always dependent on Mimosa policies. These included the availability of funds, residents' spending power and the cost of living. In order to provide an overall impression, it is necessary to consider the Bologna car fleet's composition according to fuel types. This component is also used for estimating emissions using COPERT methodology, as explained previously for indicators 1-4). Follow-up measurements were taken once a year to check on the results. The term of reference for the quantification of renewals was the registered fleet of Bologna and the unit is the number of vehicles per fuel type.

Indicator 6 'Circulation facilities' This indicator monitored the number of vehicles benefitting from the Municipality's exemptions from limited traffic areas. The indicator is made up of two different sub indicators as follows:

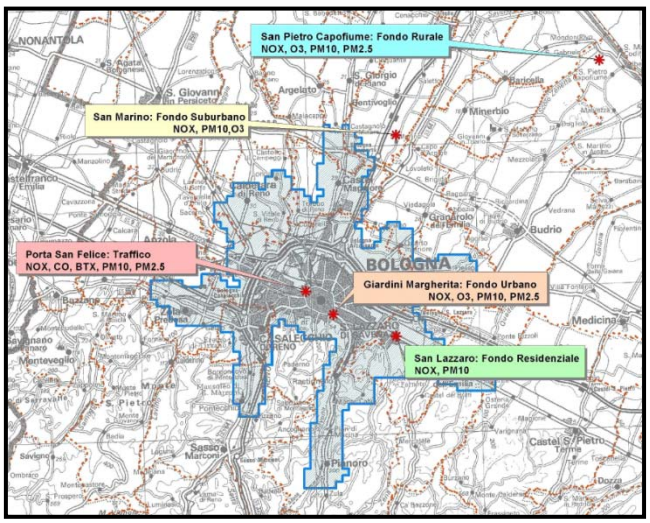
TABLE C1.1.3: Circulation facilities - indicator detail

Number	Unit	Frequency	Domain
6.1	N. of car windscreen stickers (separate data for each initiative: sticker for hybrid and electrical vehicles and n. of stickers requested for Methane vehicles). These vehicles benefit from free parking in charged car parks	Follow-up measurements were taken once a year (October/November) to check on the results	Bologna city clean running vehicles
6.2	N. of ecological operating markers to get to LTZ (for clean vehicles including methane/LPG/European standard emissions vehicles) given to: Commercial Agents, own account freight operators, third party freight operators, fitters, Limited Traffic Zone shops	Measurements were taken after Measure implementation	Bologna city clean running vehicles

Indicator 7 'Particulate emission' recorded at fixed stations

Indicator 7 was chosen to monitor and check the development of polluting emissions throughout the Municipal, in connection with measures 3.1, 4.1 and 7.1. The map below shows the location of fixed stations (in 2011) and their capacity for recording polluting emissions. The Porta San Felice station was chosen because an historical trend was available for PM 10 and PM 2.5 data.

FIGURE C1.1.1: Location of fixed stations in and around Bologna



Source: ARPA Regional Agency for the Environment

Frequency: data was collected every day. Data given in this document is the average value of 365 data entries recorded over a year.

Unit: $\mu g/m^3$ (average daily production). Domain: data was collected at a fixed station located in the centre of Bologna.

C1.2 Establishing a Baseline

The Measure came into force in 2008. The baseline included data from 2005 to 2007. 2008 data, when the Measure was introduced, thus a transitional year, was considered part of Mimosa results, because high numbers of conversions were registered in the later months of 2008, presumably thanks to the Municipality's work at the beginning of the project.

Indicator 1 - 4 'Emissions': The tables in the results section show emissions of the four indicators CO_2, CO, PM, NO_X, obtained by applying the COPERT methodology from 2005 to 2007. Data analysis shows how the renewal of vehicles, which began before the Mimosa project, helped lower emissions in the Municipality of Bologna. For instance, CO_2 emissions fell from approximately 189,000 tons in 2005 to 186,000 tons in 2007 (a reduction of 1.5%).

In order to complete the evaluation, emission variations are reported both in g/vkm (grams per vehicle kilometre) and in absolute values (tons per year).

Before Mimosa, Bologna Municipality policies already supported the private choice towards less polluting vehicles. Between 2005 and 2007 there was a 35% decrease in CO emissions.

Reported values were calculated considering the distances covered inside the Municipality of Bologna only (cf. hypothesis: average daily urban trip). The amount of emissions avoided in the entire territory was probably greater.

Indicator 5 'Number of cars converted to methane (CNG) or liquid gas (LPG) engine': At the end of 2009, 10,000 vehicles were converted to methane/LPG. 6,337 of those were directly managed by the Municipality of Bologna (source: Municipality of Bologna).

Indicator 6.1 'Number of car windscreen stickers': (separate data for each initiative: sticker for hybrid, electrical vehicles and methane vehicles).

With reference to indicators 5 and 6.1, data comes from different sources which are not immediately comparable. For example, indicator 6.1 may include windscreen stickers given to vehicles registered in other cities. The measure evaluation was made considering each indicator trend separately in different years.

Indicator 6.2 'Number of ecological operating markers': for clean vehicles including methane/LPG/European emissions standards vehicles. Given to: Commercial Agents, own account freight operators third party freight operators, fitters, Limited Traffic Zone shops.

Indicator 7 'Particulate emission recorded at fixed stations':PM 10 and PM 2.5 values recorded at a measuring station in Porta San Felice during the years before Mimosa will be reported in the result section. Data is available from 2003 for PM10, and from 2004 for PM 2.5.

C1.3 Building the Business-As-Usual Scenario

Indicators 1 - 4 'Emissions' and **Indicator 5 'Number of cars converted to methane (CNG) or liquid gas (LPG) engine'**

The Business-as-Usual case is designed considering any accompanying incentives and simulating a 'non cleaner' fleet renewal and the relative impact indicators.

The Business-as-Usual scenario is built using the actual total number of registered vehicles per year (no variation in total registered car fleet). However, the registered fleet's *composition* was modified with reference to methane and LPG vehicles. For these categories of vehicles an upward trend within the BaU scenario is assumed, with *a lower rate of increase than the actual one recorded* between 2008 and 2011 (see following tables and graph C.1.3.1 and C.1.3.2).

This approach is based on the following hypotheses:

- the total number of vehicles remains unchanged when the actual scenario (MIMOSA) and BaU scenario are compared; all vehicles up to Euro 3 in the Bologna registered fleet with a decreasing or constant trend remain the same in MIMOSA and BaU, since the reduction is not due to the MIMOSA project. By contrast, the number of Euro 4 and Euro 5 vehicles is assumed to be lower than MIMOSA, following the trend recorded before 2008;
- with reference to Methane vehicles: categories where there is a decrease or with small amounts remain the same in the two scenarios for the reasons reported above;
- the trend of LPG and Methane vehicles is lower in the BaU scenario than in MIMOSA. Assuming the total number of vehicles is the same in MIMOSA and BaU, the difference for gasoline-methane vehicles is put into gasoline of the same cc; in the case of LPG vehicles, it is distributed by percentage between diesel and gasoline and per cc.

FIGURE C1.3.1: BaU LPG vehicles (euro 4)

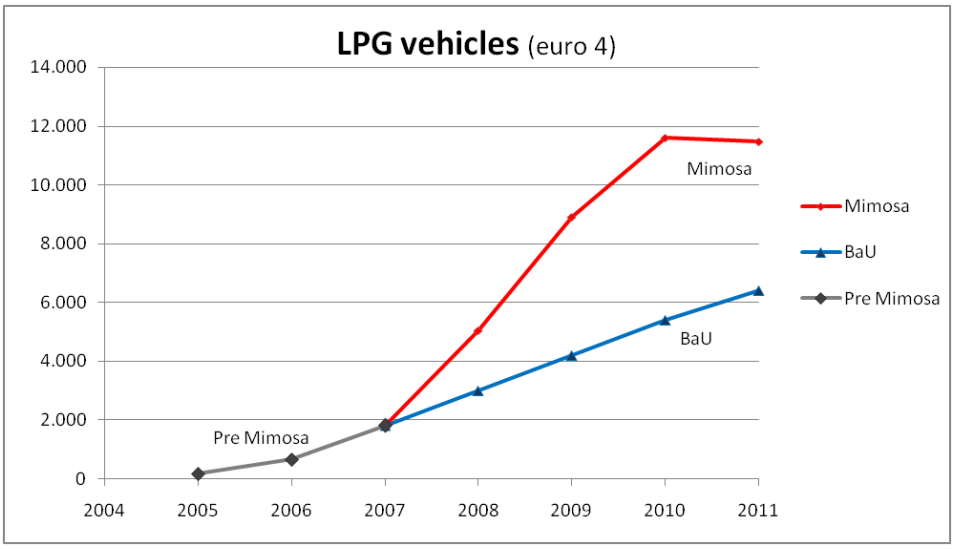
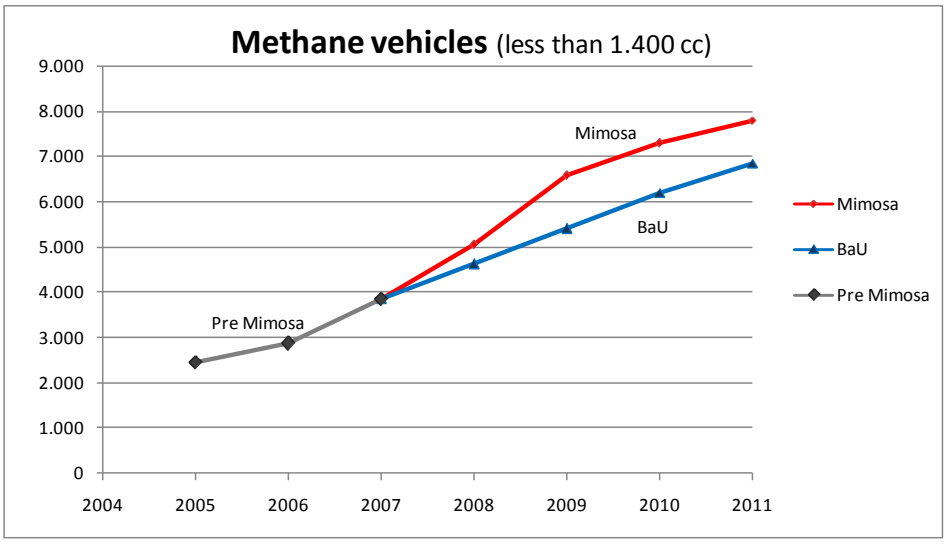


FIGURE C1.3.2: BaU methane vehicles (less than 1.400 cc)



All other hypotheses referring to the COPERT method remain unchanged (please see C.1.1).

Indicator 6 'Circulation facilities'

Requests for windscreen stickers and ecological operating markers depend on residents' needs and these vary during the years. A BaU scenario for these kinds of indicators is therefore inappropriate when evaluating the effects and effectiveness of the Measure.

Indicator 7 'Particulate emission recorded at fixed stations'

The BaU hypothesis for indicator 7 was calculated using the average value of five years (where possible) before the Mimosa project.

C2 Measure Results

C2.1 Economy

Not applicable

C2.2 Energy

Not applicable

C2.3 Environment

The following tables show emission results after the Mimosa project and the results of the Business-as-Usual scenario. The baseline data was taken from the registered fleet in Bologna available at the end of 2011. Data was collected and processed by ACI, the Italian Automobile Club.

As reported above, the environmental policy started before Mimosa. Results after the Measure was implemented confirm the positive trend in emission reduction with particular reference to CO and No_x emissions.

TABLE C2.3.1: Indicators 1- 4 emissions [ton]

Indicator/year (ton)	**Pre Mimosa (baseline)**			**Mimosa**			
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
CO_2	**189.155**	**186.406**	**186.292**	**183.426**	**181.973**	**181.097**	**183.016***
Δ *year before*	-	-2.749	-144	-2.866	-1.453	-876	+1.919
CO	**5.272**	**4.373**	**3.398**	**3.063**	**2.807**	**2.615**	**2.516**
Δ *year before*	-	-899	-975	-335	-256	-192	-99
NO_X	**444,54**	**409,68**	**369,44**	**351,88**	**336,6**	**326,8**	**323,5**
Δ *year before*	-	-34,86	-40.24	-17.56	-15,28	-9,8	-3,3
$PM_{2.5}$	**20,662**	**20,482**	**20,272**	**20,075**	**19,75**	**19,52**	**18,88**
Δ *year before*	-	-0,180	-0,210	-0,197	-0,325	-0,23	-0,64
PM_{10}	**28,222**	**28,006**	**27,832**	**27,607**	**27,292**	**27,074**	**26,542**
Δ *year before*	-	-0,216	-0,174	-0,225	-0,315	-0,218	-0,532

Source: COPERT applied to the Bologna car fleet composition by fuel types

** The increase in Bologna registered fleet between 2010-2011 explains the growth in tons emitted during 2011.*

TABLE C2.3.2: Indicators 1- 4 emissions [g/vkm]

Indicator/year	Pre Mimosa (baseline)				Mimosa		
	2005	2006	2007	2008	2009	2010	2011
CO_2	**264,618**	**264,569**	**266,921**	**265,079**	**263,839**	**263,085**	**262,639**
Δ *year before*	-	-0,049	+2,352	-1,842	-1,240	-0,754	**-0,446**
CO	**7,375**	**6,206**	**4,868**	**4,426**	**4,070**	**3,799**	**3,685**
Δ *year before*	-	-1,169	-1,338	-0,042	-0,356	0,271	**-0,114**
NO_X	**0,622**	**0,581**	**0,529**	**0,509**	**0,488**	**0,475**	**0.471**
Δ *year before*	-	-0,041	-0,052	-0,020	-0,02	-0,013	**-0,004**
$PM_{2.5}$	**0,0289**	**0,0291**	**0,0290**	**0,0290**	**0,0286**	**0,0283**	**0,0281**
Δ *year before*	-	+0,002	-0,001	0	-0,0004	-0,0003	**-0,0002**
PM_{10}	**0,0395**	**0,0397**	**0,0399**	**0,0399**	**0,0396**	**0,0393**	**0,0389**
Δ *year before*	-	+0,0002	+0,0002	+0,0000	-0,0003	-0,0003	**-0,0004**

Source: COPERT applied to the Bologna car fleet composition by fuel types

A comparison of pre and post Mimosa data shows a decrease in all emissions. As reported above, benefits are more evident when data is calculated in tons since data in g/vkm is spread over the entire fleet. This is particularly evident considering differences between the BaU and post Mimosa data.

TABLE C2.3.3: Environment results, Indicators 1 – 4 [ton/year]

Indicator		Pre Mimosa (baseline 2007)	Mimosa (2011)	BaU (2011)	Mimosa (2011) vs Baseline (2007)		Mimosa (2011) vs BaU (2011)	
					Δ	Δ%	Δ	Δ%
1	CO_2	186.292	183.016	185.184	-3.276	-1,8%	-1.108	-0,5%
2	CO	3.398	2.516	2.523	-882	-30,0%	-875	- 25,8 %
3	NO_X	369,44	323,50	328,60	-45,94	-12,4%	-40,84	-11,1%
4	$PM_{2.5}$	20,272	18,880	19,800	-1,392	-6,9%	-0,472	-2,3%
	PM_{10}	27,831	26,542	27,459	-1,289	-4,6%	-0,372	-1,3%

Source: COPERT applied to the Bologna car fleet composition by fuel types

TABLE C2.3.4: Environment results, Indicators 1 – 4 [g/vkm]

Indicator		Pre Mimosa (baseline 2007)	Mimosa (2011)	BaU (2011)	Mimosa (2011) vs Baseline (2007)		Mimosa (2011) vs BaU (2011)	
					Δ	Δ%	Δ	Δ%
1	CO_2	266,921	**262,639**	**264,750**	-4,282	-1,6%	-2,171	-0,8%
2	CO	4,868	**3,675**	**3,695**	-1,193	-24,5%	-1,173	-24,1%
3	NO_X	0,529	**0.471**	**0,478**	-0,058	-10,9%	-0,051	-9,6%
4	$PM_{2.5}$	0,0290	**0,0281**	**0,0285**	-0,0009	-3,1%	-0,0005	-1,7%
	PM_{10}	0,0399	**0,0389**	**0,0395**	-0,001	-2,5%	-0,0004	-1%

Source: COPERT applied to the Bologna car fleet composition by fuel types

Indicator 5 'Number of cars converted to methane (CNG) or liquid gas (LPG) engine': Between 2005 and the end of 2009, 10,000 vehicles were converted to methane/LPG, of which 6,337 were directly managed by the Municipality of Bologna (source: Municipality of Bologna). The Municipality counted an average of 750 converted vehicles each year. During 2010 national and local incentives were stopped for six months. There were 350 converted vehicles, 50% compared of the annual average. During 2011 national and local incentives were stopped, thus no more vehicles were converted through financial incentives.

However, the Municipality's activities in years when the Measure was in force mean that the share of vehicles fuelled by LPG or methane circulating Bologna already reached 15.84% in 2011. The Municipality of Bologna surpassed the 10% of methane-fuelled vehicles in its urban area, as recommended by the European Union White Paper.

TABLE C2.3.5: Overall composition of fleet registered in Bologna city by fuel type

	Year	Petrol	Diesel	Methane	LPG	Other	Total	methane + LPG	Percentage of Methane and LPG
Pre Mimosa	2005	147.394	44.862	5.750	6.141	30	204.177	11.891	5,82%
	2006	139.909	46.452	6.546	8.331	37	201.275	14.877	7,39%
	2007	134.087	48.305	7.836	8.987	39	199.254	16.823	8,44%
Mimosa	2008	125.524	48.672	9.337	13.993	35	197.561	23.330	11,81%
	2009	119.375	49.130	10.843	17.537	34	196.919	28.380	14,41%
	2010	114.727	50.350	11.485	19.887	32	196.481	31.372	15,97%
	2011	113.375	53.691	11.766	19.685	30	198.547	31.451	15,84%

Based on ACI data (registered cars in the Municipality of Bologna)

TABLE C2.3.6: Environment results, Indicator 5 [vehicles LPG + Methane]

Pre Mimosa (baseline 2007)	Mimosa (2011)	BaU (2011)	Mimosa (2011) vs Baseline (2007)		Mimosa (2011) vs BaU (2011)	
			Δ	Δ%	Δ	Δ%
16.823	31.451	25.453	+14.628	+87,0%	+8.630	+51,3%

The wide range of action undertaken by the Administration had a strong impact on the number of cleaner vehicles circulating in Bologna, converted and newly purchased ones. Considering the BaU scenario, processed as reported above using historical data from 2005 onwards, the number is particularly high.

Indicator 6.1 'Number of car windscreen stickers': The number of requests increased by 61% compared to the pre-Mimosa period. This policy was a significant incentive for residents.

TABLE C2.3.7: Number of car windscreen stickers

Fuel type	Pre Mimosa	Mimosa				TOTAL	Δ % (2011 vs 2007)
	2007	2008	2009	2010	2011		
Methane	339	460	597	416	509	2.321	50%
LPG	326	483	725	648	753	2.935	131%
Electric vehicle	354	245	384	333	379	1.695	7%
Total	**1.019**	**1.188**	**1.706**	**1.397**	**1.641**	**6.951**	**61%**

Source: Municipality of Bologna

Indicator 6.2 'Number of ecological operating markers': Markers are used in order to access the LTZ and to benefit from parking possibilities. They were issued for clean commercial vehicles including methane/LPG/European standard emissions vehicles, with particular reference to Commercial Agents, own account transport operators, third party transport operators, Limited Traffic Zone shops' vehicles. Thanks to the Measure, they increased from 645 before the MIMOSA project to 2,725 afterwards (data at the end of 2010).

Indicator 7 "Particulate emissions" recorded at fixed stations

Concerning the bundled indicators, PM 10 and PM 2.5 values were recorded at a measuring station in Porta San Felice. They are shown in the following table.

TABLE C2.3.8: Average PM_x daily emissions (µg/m3)

PORTA SAN FELICE	2003	2004	2005	2006	2007	2008	2009	2010	2011
PM 10 (µg/m^3)	45	40	42	45	42	37	34	34	37
PM 2.5(µg/m^3)	-	28	30	31	28	25	22	21	23,1

(*)Threshold Limit (Pm10): 40 µg/m3

Threshold Limit (Pm2.5): 25 µg/m3 to be met by 2015 (Decree 155/2010)

Source: ARPA Regional Agency for the Environment

A comparison of data from 2003 to 2011 shows an overall trend of decreasing pollution, with only a slight increase during 2011.

FIGURE C2.3.1: average PM_x daily emissions (µg/m3)

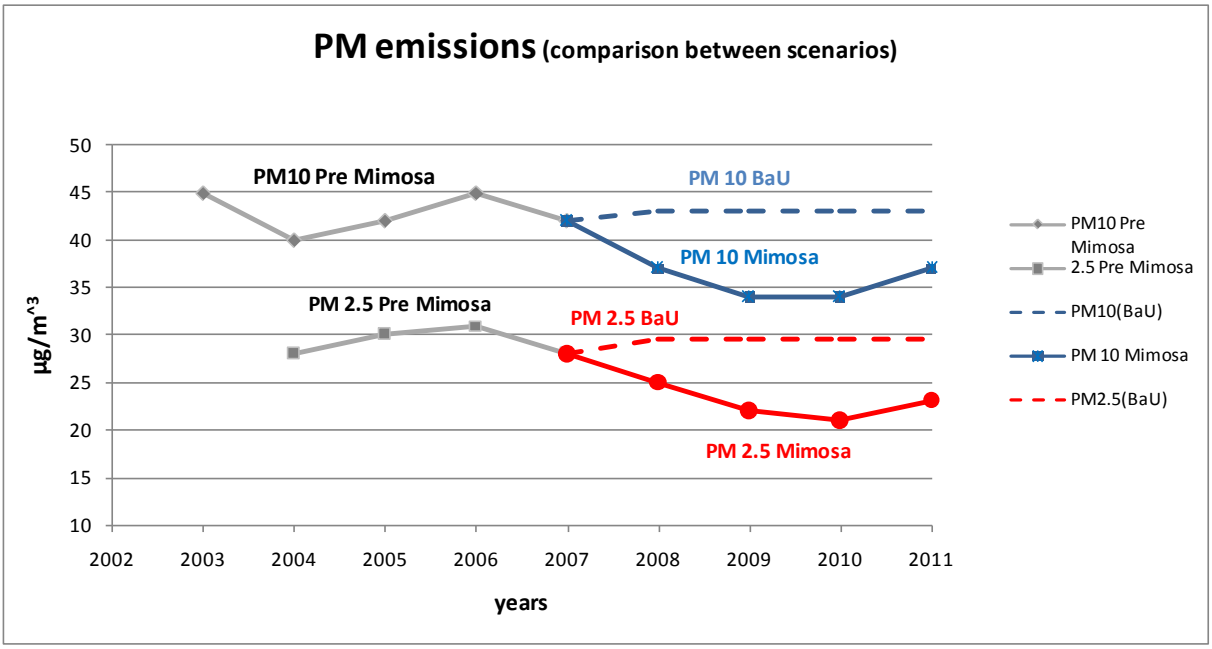


TABLE C2.3.9: PM_x emissions, comparison between scenarios (µg/m^3)

Average daily value (µg/m^3)	Pre Mimosa (baseline 2007)	BaU (average of 3 years before)	Mimosa (2011)	Mimosa VS. baseline	Mimosa VS. baseline	Mimosa VS. BaU	Mimosa VS. BaU
PM 10	42	43	37	-5	-12%	-6	-14%
PM 2.5	28	29,6	23,1	-4,9	-17,5%	-6,5	-22%

C2.4 Transport

Not applicable

C2.5 Society

Not applicable

C2.6 Cost-Benefit Analysis

As this was a focused Measure, a CBA was carried out. It considered the following stakeholders: the Municipality of Bologna and users of the Measure (residents, beneficiaries) with their own costs and benefits. Using the "net present value" formula to calculate the overall gain for society, the following costs and benefits were selected:

- Costs: annually assigned investment funds from the public administrations (conversion funds and incentives for private users for car fleet renewal), various fuel taxes, discounts offered to cleaner vehicles (parking prices and circulation facilities) and private investments.
- Benefits concerning the reduction of pollutions emitted in the city by new cars, assuming no changes in users' behavior, and private benefits from the use of different fuels.

TABLE C2.6.1: NPV calculation elements

Element	Detail
Bologna registered fleet	Vehicles classified following COPERT methodology
Converted vehicles	Converted vehicles classified following COPERT methodology
Investment costs (Municipality of Bologna)	Annual incentives paid by the Municipality
Investment costs (residents)	Renewal costs
Circulation costs	Blue coupons (3) costs for vehicle type
Emissions (CO_2, NO_2, SO_2, $PM_{2,5}$)	COPERT estimate
Fuel consumption	Average consumption per vehicle type (urban area)
Tax revenues	VAT and other excise taxes per fuel type
Parking revenues	Subscriptions sold (in total and to clean vehicles)

The detailed costs and benefits are shown in the references (4)

The following hypotheses were made:

- the scope was restricted to registered cars with methane or LPG systems installed through the Municipality's incentives,
- the financial incentive for methane or LPG system installation applies to each family's most frequently used car,
- no differences in maintenance cost between green vehicles and traditional ones,
- working days/year: 230,
- the environmental benefits of different kinds of vehicles and different euro standards expected after 2012 were calculated exclusively using the lower emissions produced through Mimosa (renewals obtained between 2008-2011, projected until 2020). This hypothesis is simplistic because it overlooks all aspects connected to residents' 'awareness' in future decisions.
- discount rates: 3,5%, 2%, 5,5%.

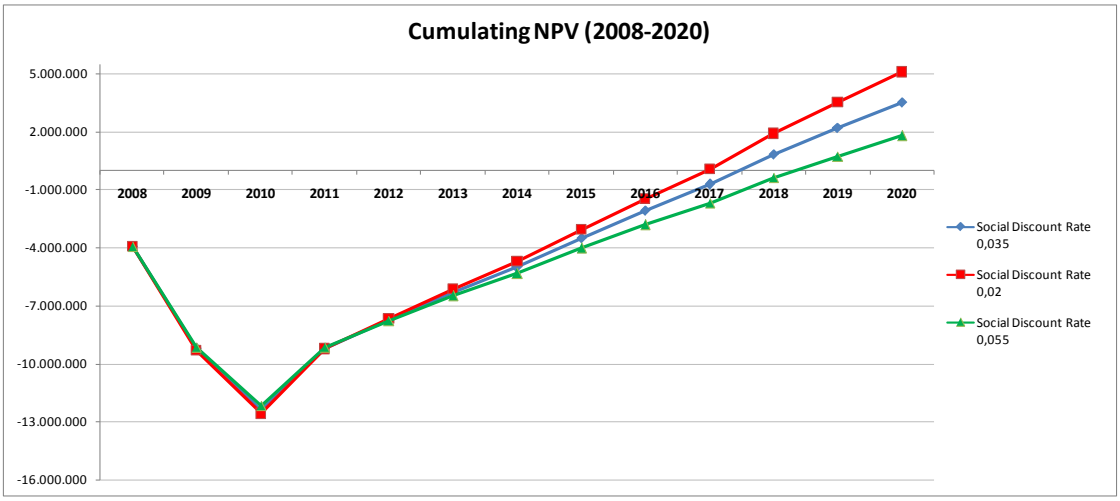
TABLE C2.6.2: Net present Value

Net Present Value	**SdR 0,035**	**3.529.190**
	SdR 0,02	**5.082.491**
	SdR 0,055	**1.781.283**

Source: CBA

Figure C.2.6.1 shows the Net Present Value trend during the twelve years of the study.

FIGURE C2.6.1: Cumulating NPV



The results show a substantial benefit between the vehicle renewal expenditure and the results of 12 years of evaluation. This means that improving air quality in Bologna was not too onerous within the considered time span. As often occurs, it will take many years to reach the breakeven point, which would be in 2017, nine years after the Measure started.

Overall, the CBA demonstrates a general benefit for residents with a largely positive net present value. The results therefore justify the investment, especially considering that measure 1.2 concerned residents' health.

The evaluation showed the difficulties of comparing costs/benefits of different magnitudes, such as those sustained by public administrations for renewals, lower tax revenues due to lower fuel consumption and the monetization of environmental benefits. Another important aspect is the strong randomness which characterized most of the cost/benefit variables. Many elements showed great variations in the past; for example, unleaded fuel costs increased by 13% in Italy last year. In addition, in many cases the considered costs were 'lost earnings' for the Public Administrations with a lesser impact than the direct costs would have.

C3 Achievement of Quantifiable Targets and Objectives

No.	Target	Rating
1	To support the renewal of private vehicles by encouraging a switch to new environmentally-friendly engines, and to promote the purchase of new vehicles with eco-sustainable technology The measure focused expressly on purchased and converted vehicles registered in Bologna, with particular reference to the older ones that are hard to convert.	★★
2	To demonstrate the effectiveness of the Administration's management and supervisory activities for regulating the relationship with stakeholders involved in private vehicle renewals.	★
3	To verify the benefits of private vehicle renewal, in order to fine tune the City Administration's policy by measuring the decrease in pollution.	★
NA = Not Assessed; **O** = Not Achieved; ★ = Substantially achieved (at least 50%) ★★ = Achieved in full; ★★★ = Exceeded		

Considering the results of the impact evaluation, the first objective was achieved in full. Great efforts were made by the Municipality both to support residents and manage funding. The high number of conversions helped replace the oldest part of the registered fleet.

The Municipality's activities were successful: the share of vehicles fuelled by LPG or methane registered in Bologna reached 16% in 2011.

The Municipality of Bologna achieved more than 10% of methane-fuelled vehicles in the urban area, and thus matched the European Union White Paper recommendation. The percentage may be higher considering that measurement took place over three years (2009, 2010 and 2011) and 2012 data is not available.

From the impact evaluation it was difficult to demonstrate whether the second objective had been achieved. This is because the process itself was not analysed in detail. However, it was possible to show its effects in terms of result achievement, considering the number of converted vehicles and the makeup of the overall registered fleet.

The benefits of private vehicle renewal, both from converted vehicles and newly purchased ones, were evaluated with *estimates*, by applying the COPERT methodology under specific statements. Even if data had not been collected through monitoring stations, we could still assert that the third objective was substantially achieved.

C4 Up-Scaling of Results

The measure already involved all residents; up-scaling was not applicable for the city level.

Similar policies were implemented at regional and national level (incentives were given by Italy's national Ministry), but the whole implementation also took other introductory factors into account which were not always applicable in other areas (i.e. the availability of methane refilling stations).

C5 Appraisal of Evaluation Approach

The evaluation approach gave good results. Emissions were evaluated by considering data in tons rather than in g/vkm, as decided at the beginning of the project, to outline better the

results of the analysis. The evaluation approach was based on data collected by ACI (Bologna registered fleet) that was issued many months later.

As reported above, the evaluation approach focused on vehicles registered in Bologna and not on the actual running fleet in Bologna. This included part of the fleet registered in Bologna and a small number of vehicles registered outside Bologna). This bias, hard to overcome, was due to the fact that the actual running fleet was not identifiable. However, differences between the two kinds of fleets had little importance in terms of their overall composition.

The evaluation approach could be improved by considering data on actual traffic in the LTZ or the whole of the Bologna city area. Finally, the analysis could be ameliorated by considering differences in average daily urban trip lengths depending on vehicle types and sizes, based on specific surveys.

C6 Summary of Evaluation Results

The key results were as follows:

Key result 1 – reduction of CO production by 25.8% and a general fall in emissions comparing 2007/2011.

Key result 2 – 87% increase in the number of clean vehicles (Methane and LPG) comparing 2007 and 2011. The high percentage of methane and LPG vehicles in Bologna showed the success of the Municipality's commitment.

C7 Future Activities Relating to the Measure

Future activities relating to the Measure will be to:

- continue all the activities carried out during the last year of the project,
- maintain and improve traffic and mobility policies in favour of less polluting vehicles.

D Process Evaluation Findings

D0 Focused Measure

Measure 1.2 has been evaluated as a focused measure. The three most important reasons are given in the box below in order of importance.

7	Most important reason
10	Second most important reason
1	Third most important reason

These choices take reference from the checklist below.

1	**The measure fits into the EU policy towards clean urban transport (five pillars of the EU Green Paper)**
2	The measure fits into the city policy towards sustainable urban transport and / or towards sustainability in general
3	The expected impact on the transport system, environment, economy and/ or society / people is very high
4	The high level of innovativeness of the measure with respect to technique, consortium, process, learning etc
5	The measure is typical for a group of measures or a specific context
6	The possibility of carrying out a good Cost Benefit Analysis
7	**Participation of a range of different actors**
8	The high degree of complexity of managing the measure
9	The measure is regarded as an example measure
10	**Others: The measure aims to promote and stimulate a new market for cleaner vehicles**

D1 Deviations from the Original Plan

None

D2 Barriers and Drivers

D2.1 Barriers

Overall Barriers

Discontinuity in funding availability –Until 2011, despite Italy's weak economy, funding availability was guaranteed with a bureaucratic effort. During 2011 the funding stopped, slowing down the number of cars converted to methane/LPG.

Public funds (where available) needed to be harmonized – while funds were still available until the end of 2010, there were differences between the amount, terms and conditions

requested by National funds and Regional ones, with the risk of confusing users. Specific communication campaigns targeting each new fund's requirements were always necessary.

D2.2 Drivers

Overall Drivers

Strong political support: environmental issues were always taken into strong consideration by political institutions in Bologna. This commitment provided technical offices with good help during all management activities. Moreover, local politicians participated in many initiatives, making clean vehicle initiatives more noticeable. For example, as part of European Mobility week 2011, the President of the Emilia Romagna Region and the Mayor of Bologna attended the inauguration ceremony for the first electric recharging column.

Car producers included environmental issues in marketing strategies: advertisements by several car producers included the topic of clean vehicles. This helped to promote a clean vehicle culture, increasing awareness of environmental issues and the importance of these topics with regard to car purchasing.

D2.3 Activities

Overall activities

The reported activities were aimed at tackling the two barriers described above in order to successfully implement the Measure:

Investment in organizational internal work: This action was taken in order to provide people not only with communication campaigns to avoid confusion, but also continuous support on demand, improving the initiatives and optimizing available resources. Thanks to these efforts, Bologna residents benefited from a long incentive period, which allowed the city of Bologna to significantly increase the number of clean vehicles.

Clean vehicle initiatives, even with a lack of public funds: the Municipality continued to invest in low impact policies and activities, addressing clean vehicles, even when it was not possible to guarantee financial support for car owners.

D3 Participation

D3.1 Measure Partners

- The **Municipality of Bologna – COBO – was** directly responsible for coordinating and implementing the Measure.
- The **Emilia Romagna Region** supported the Municipality of Bologna with implementation and evaluation tasks, especially with respect to (dis-)incentives, based both on financial and traffic management, supporting private vehicle renewals.

D3.2 Stakeholders

- **Car drivers –** with particular reference to those who ‘can’t do without a car’ (e.g. because they cannot reach their destinations by PT, because of work needs, have mobility disadvantages or are in general ‘non persuadable’ drivers) so that they *at least* use cleaner fuels.

- **Residents –** of the city's central areas, those who were expected to obtain several advantages from the Measure implementation in terms of quality of life.

D4 Recommendations

D4.1 Recommendations: Measure Replication

This Measure modernizes the city's vehicle fleet: this Measure can and *must* be replicated in those cities facing the problem of an old car fleet to be replaced. However, it is important to note that the success of the Measure is not necessarily linked to the availability of public incentives for vehicle owners. Instead it depends on the presence of a general political and common interest in environmental issues. This measure design, focusing on limited access and innovative parking policies as incentives to owning clean cars, *also influences* public provisions aimed at giving citizens the **real possibility** of choosing lower impact fuels. Bologna is one of the Italian cities where the recharging network for methane, LPG and electric vehicles increased significantly during the years of when the Measure was in force. The choice of a clean car represents an absolutely valid and tempting alternative for the city's residents.

D4.2 Recommendations: Process (Related to Barrier-, Driver- and Action Fields)

To follow complementary different strategies at the same time as:

a) Resources: fund raising and management, operational activities and communication to the general public allowing for continuity and effectiveness,

b) Residents' Incentives: the internal organisation's work made it possible to target and allocate the available funds for the best. After the funds ran out, the Municipality of Bologna maintained and strengthened the presence of tangible benefits for cleaner vehicle users, providing exclusive circulation facilities for cleaner vehicles.

To count on shared interests between headquarters: achieving the objectives of the Measure is strongly dependent on political will. Local government commitment was decisive for the success of the measure.

F Annex

(1) COPERT registered fleet classification (passenger cars)

Type	Legislation/technology
Gasoline < 1.4 l	PRE ECE
	ECE 15/00-01
	ECE 15/02
	ECE 15/03
	ECE 15/04
	Improved conventional
	Open loop
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007
Gasoline 1.4–2.0 l	PRE ECE
	ECE 15/00-01
	ECE 15/02
	ECE 15/03
	ECE 15/04
	Improved conventional
	Open loop
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007
Gasoline > 2.0 l	PRE ECE
	ECE 15/00-01
	ECE 15/02
	ECE 15/03
	ECE 15/04
	Improved conventional
	Open loop
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007

Type	Legislation/technology
Diesel < 2.0 l	Conventional
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007
Diesel > 2.0 l	Conventional
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007
LPG	Conventional
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
2-stroke	Conventional
Hybrids < 1.6 l	Euro 4 — 98/69/EC Stage 2005

Source: European Environment Agency, "Emission inventory guidebook 2009"

(2) Mean car mileages by class of emission

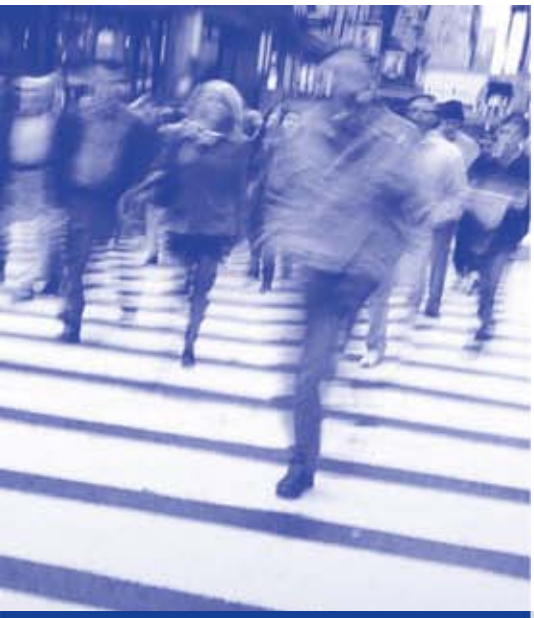
Petrol	Km	Diesel	km
Pre ECE	2.850	Pre EURO	1.890
ECE 15.00 15.01	3.570	EURO I	2.910
ECE 15.02	3.330	EURO II	3.680
ECE 15.03	3.540	EURO III	4.080
ECE 15.04	3.370	EURO IV *	4.080
EURO I	3.300	EURO V *	4.080
EURO II	3.690		
EURO III	3.880		
EURO IV *	3.880		
EURO V *	3.880		

Source: TeMA calculations using Genoa University data (M. Capobianco, G. Zamboni, Università di Genova, "Valutazione del parco circolante, delle percorrenze urbane e dei fattori emissivi dei veicoli stradali nella città di Genova", VII Expert panel Emissioni da Trasporto Stradale, Rome 16th January 2003)

(3) The blue coupon is the vehicle's annual exhaust fumes check. To show the test has been passed, the client receives a numbered certificate with the date of the check, licence plate number and emission values (this must be kept on board), and a blue coupon sticker with the year of the check. The sticker must be displayed on the vehicle windshield . The Exhaust fumes check is compulsory for all cars, motorcycles and scooters 12 months after registration. The blue coupon vehicle check must be done every 12 months. It is illegal to drive without a blue coupon, though vehicles registered as historic ones are exempt.

(4) CBA detailed costs and benefits, 2008 to 2011

NPV		YEAR			
		2008	2009	2010	2011
COST	PUBLIC FUNDS	347.000	390.000	247.000	353.000
	PRIVATE INITIAL INVESTMENT	3.296.010	4.545.340	3.708.270	-1.951.160
	PARKING SUBSCRIPTIONS	14.435	54.968	133.121	120.000
	DIFFERENT FUEL CONSUMPTIONS	864.411	2.479.549	2.500.000	2.500.000
BENEFIT	PRIVATE CONSUMPTION OF CHEAPER FUELS	571.403	1.968.113	3.171.090	3.807.188
	AIR QUALITY	4	96	101	101
	GREENHOUSE GASES	3.151	27.338	27.547	40.623



CiViTAS
Cleaner and better transport in cities

MIMOSA
BOLOGNA • FUNCHAL • GDAŃSK • TALLINN • UTRECHT

Bologna 1.2 Cleaner Private Vehicles

Annex

Cost-benefit analysis

Authors: Valentino Zanin - Davide Rossi- Giorgia De Chiara – (TeMA Territorio Mobilità Ambiente S.r.l.)

Date: 13 February 2013

THE CIVITAS INITIATIVE
IS CO-FINANCED BY THE
EUROPEAN UNION

I. Table of Content

List of Abbreviations

BaU	Business-as-usual
BOL	Bologna
CBA	Cost-Benefit Analysis
CO	Carbon monoxide
DCF	Discounted Cash Flow
EC	European Commission
et seq.	et sequentes
GDP	Gross Domestic Product
HFC	Hydro fluorocarbons
HGV	Heavy Goods Vehicle
NMVOC	non-methane volatile organic compounds
NO_2	Nitrogen oxide
NPV	Net Present Value
Pb	Lead
PM10	Coarse particles
PM2.5	Fine particles
PT	Public Transport
RTD	Research and Technology Development
SDR	Social Discount Rate
SO_2	Sulphur dioxide
UB	User Benefit
P.A.	Public Administration
ACI	Automobile Club Italia

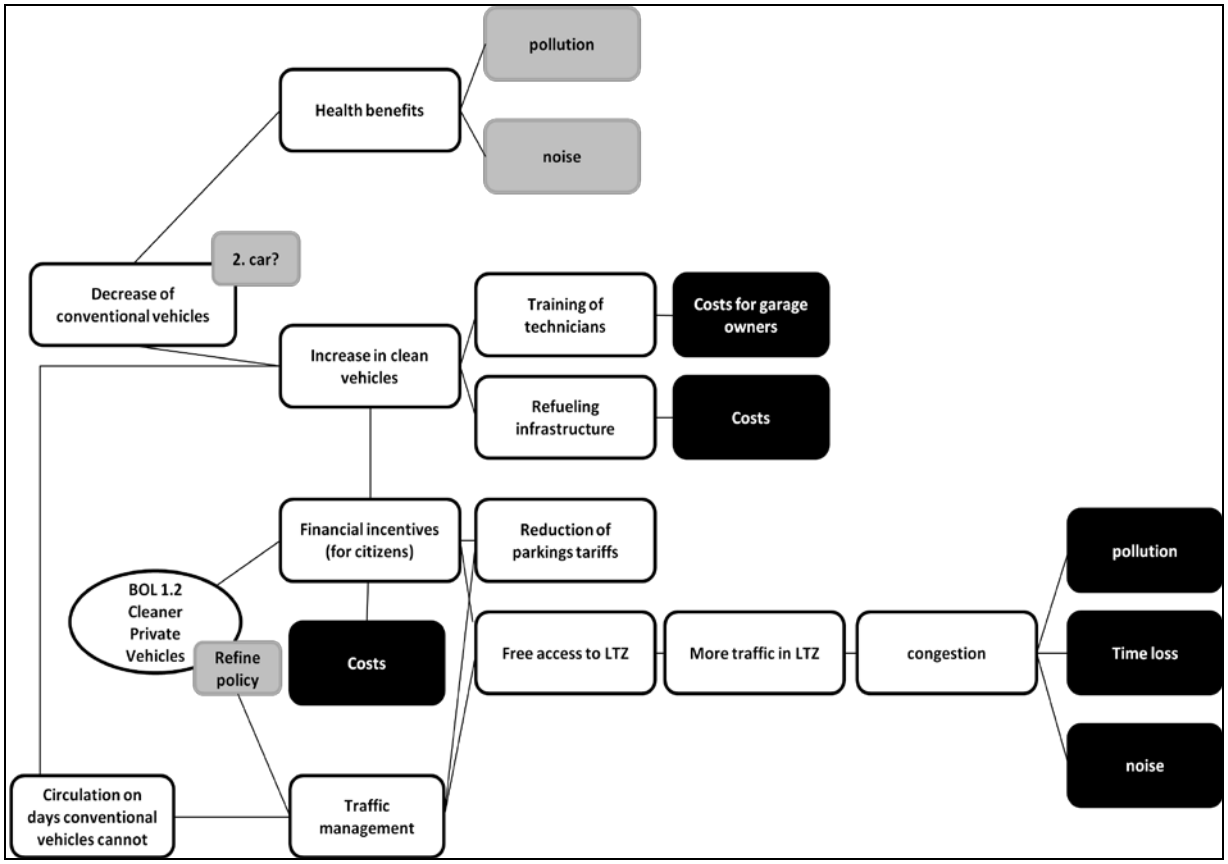
Introduction

Bologna has made the promotion of private vehicles renewal a priority since 2007 as part of its urban traffic plan. With CIVITAS MIMOSA, Bologna wanted to give its efforts a boost. Bologna Municipality wanted to encourage private car owners to shift from petrol to liquefied petroleum gas (LPG) and compressed natural gas (CNG) and to promote the purchase of cleaner vehicles that are equipped with eco-technology.

1 Costs and Benefits

BOL 1.2 Cost benefit analysis studied the elaborate relationships between all aspects related to the renewal/substitution of Bologna registered park. These connections are extremely complex and often difficult to study because of them interest different life's aspects (e.g. health, money, facilitations in all day life). The figure below underlines the cause and effect chain produced for Measure 1.2. As a first step of the evaluation, it includes all voices of cost/benefit: every single element in the graph has been studied singularly in the pages below. Then, the voices of costs and benefits selected for the analysis have been added in the Net Present Value sum in the end of the Annex.

Figure 1.1: Cause- and effect chain for BOL 1.2 Cleaner Private Vehicles



The table below summarizes costs and benefits for each stakeholder group.

Table 1: costs and benefits for different stakeholder groups of measure BOL 1.2

Stakeholder Group	Cost	Benefit
Authorities	- Financial investment for conversions and purchases of new vehicles - Lower entrances caused by different fuel consumption. - Lower entrances caused by facilitate parking's subscriptions	
Private vehicles users	- Investment for conversions/ purchases of vehicles	Lower cost of clean fuels Facilities in circulations rules Facilities in parking subscriptions
Citizens		Exposure to less air pollutants

Starting from pre-mimosa data and from the costs and benefits differences observed during the three years of the Mimosa project (2008-2012[1]), the NPV has been calculated.

The single voices methodologies are reported as follows.

1.1 Costs

In this paragraph all the main costs of the measure have been considered. Every voices has been identified with the methodology used for its assessment and its order of magnitude.

The following list summarizes all the voices considered, reporting in brackets the subject of heading:

- Public investments for incentives (Public Authorities),
- Refueling cost: consumption of different kind of fuel and infrastructures (Private Users),
- Private investments (Private vehicles' Users),
- Facilitations in parking subscriptions (Public Authorities),
- More flow in LTZ area (Citizens),
- Training of garage's technicians (Public Authorities),
- Circulation of cleaner vehicles on days when conventional ones cannot (Citizens).

[1] Not all data was available for 2011 and 2012.

Public investments for incentives

Public investments are Public Administrations' costs used to contribute to private initial cost for purchase/convert a vehicle. In the analysis two kind of founds have been considered: conversion's ones and money dedicated to new vehicle purchases . P.A. (Emilia Romagna Region and Italian Government) allocated 1.500 euro for every new cleaner car bought and established a contribute of 550 euro for every vehicle converted in LPG during 2009, 2010 (350 euro in 2008) and 650 euro for Methane's commutation (500 euro in 2008).
In this contest, were funds dedicated to cleaner vehicles are from higher institutional administrations, Bologna Municipality used Mimosa's project to support a structure able to manage the National/Regional procedure established for assign money to Municipalities.

Consumption of different kind of fuel

The use of cleaner vehicles implies changes in fuel's consumptions, specifically, an inflection of common fuels sales (unleaded and diesel) and the increasing in methane and LPG sales.
Cleaner fuel are subject to smaller taxes than "traditional" ones, therefore the shift of sales causes a missed gain for P.A.

Private investments

Private citizen's costs for registered running park's renewal are evaluated starting from the number of converted vehicles or purchased, as a difference between the cost of operation (purchase or conversion) and the fund dedicated to private users. The value represents the starting investment of every single user that, multiplied for the number of new vehicles, give the initial private investment.

Facilitations in parking subscriptions

The Municipality of Bologna planned facilitations in parking subscriptions for users who have a cleaner vehicle. This facilitations lie in a discount of 50% of subscription's cost (both annual and monthly). Considering the point of view of the owners of the parking infrastructure (the Public Administration) these facilitations are a cost as missed gain.

More flow in LTZ area

Municipality of Bologna allowed cleaner vehicles to access the LTZ zone during all days. This relief can be considered as a general cost for citizens who live the zone: the growth of flows incoming implies more noise and more pollutions emitted. This voice has been neglected in the analysis considering *the increasing* of cleaner vehicles is not relevant compared to totality of Bologna registered park (about 1%): from an environmental point of view the littleness of distances covered in the restricted zone and the few number of vehicles interested make the cost of the evaluation smaller than the other voices of the analysis. The same assumptions can be applied to noise considerations.

Training of garage's technicians

This voice of cost has been dropped since the training of garage's technicians is a natural dynamic of everyday's work: in all business workers have to increase his/her knowledge if he/she wants update and remain competitive in the market. Moreover cleaner vehicles are fully used and their technologies are already extensively known.

Refueling infrastructure

Same considerations of the previous voice can be applied, renewal of refueling infrastructure is not a cost connected to the measure but a natural development of companies, which have to go towards user's needs.

Circulation of cleaner vehicles during "restricted circulation days"

Municipality of Bologna banned vehicle's regular circulation in about 20 days (Thursday) during all years (2008, 2009, 2010, 2011). These restrictions concerned only a defined-limited zone in the centre of Bologna. Municipality studies appraises only 10% of vehicles' users left his/her car during these days: in 2008 there were 23.000 clean vehicles (LPG + Methane) and the registered running park was 197.500 (cleaner vehicles are 11% of the total registered running park), the "normal" vehicles are about 89% of the total. Considering the estimation of percentage of them who stopped itself during restriction days was about 9% and twenty working days represent roughly 8% of total working days during one year, vehicles taken out from circulation during one year are 9% of the 8%, that is 7‰. This value can be dropped considering its order of magnitude.

1.2 Benefits

In the following paragraph the main benefits are analyzed and evaluated, as follows, reporting in brackets the subject of heading:

- Better air quality in urban areas - exposure to less air pollutants (Citizens),
- Less exposure to greenhouse gases (Citizens),
- Lower cost of "clean" fuels (Private Vehicles Users),
- Less noise exposure (Citizens).

Better air quality in urban areas and less exposure to greenhouse gasses

Benefits are connected to lower pollution's emissions of cleaner vehicles; the growth of methane and LPG cars entails a reduction of pollutions in all city territory. The lower emissions are estimated through Copert Methodology, considering the composition of Bologna registered park, the average daily urban trip equal to all classes of vehicles and the same average urban speed for all vehicles.

Lower cost of "clean" fuels

The lower price of cleaner fuels implies a reduction of private everyday's costs, in the analysis a yearly benefit for users of cleaner cars has been considered.

Benefits are estimated multiplying the annual mileage of vehicles, consumption (litre/km) and differences in customer's cost between unleaded and methane or LPG fuels.

Noise exposure

The noise exposure reduction does not represent the core objective of Measure 1.2, and cleaner vehicles have not acknowledged better noise emissions than "normal" ones[2]. The eventual benefit given by less noise production has been neglected.

2 The only exception is represented by electric vehicles which are not investigated in this Measure.

2 Costs and benefits methodology

The methodology chosen for the evaluation of costs and benefits is reported in the following paragraphs.

2.1 Public investments

Yearly number of new/converted cleaner vehicles are evaluated considering differences in registered running park composition between two consecutive years.
If an increase of cleaner vehicles occurred in categories not longer on sale (euro 0, … , euro 3) these new vehicles have been considered converted. If the growth is in the categories euro 4 or euro 5 on sale since 2005 , these new vehicles have been considered as new purchase or converted vehicles.

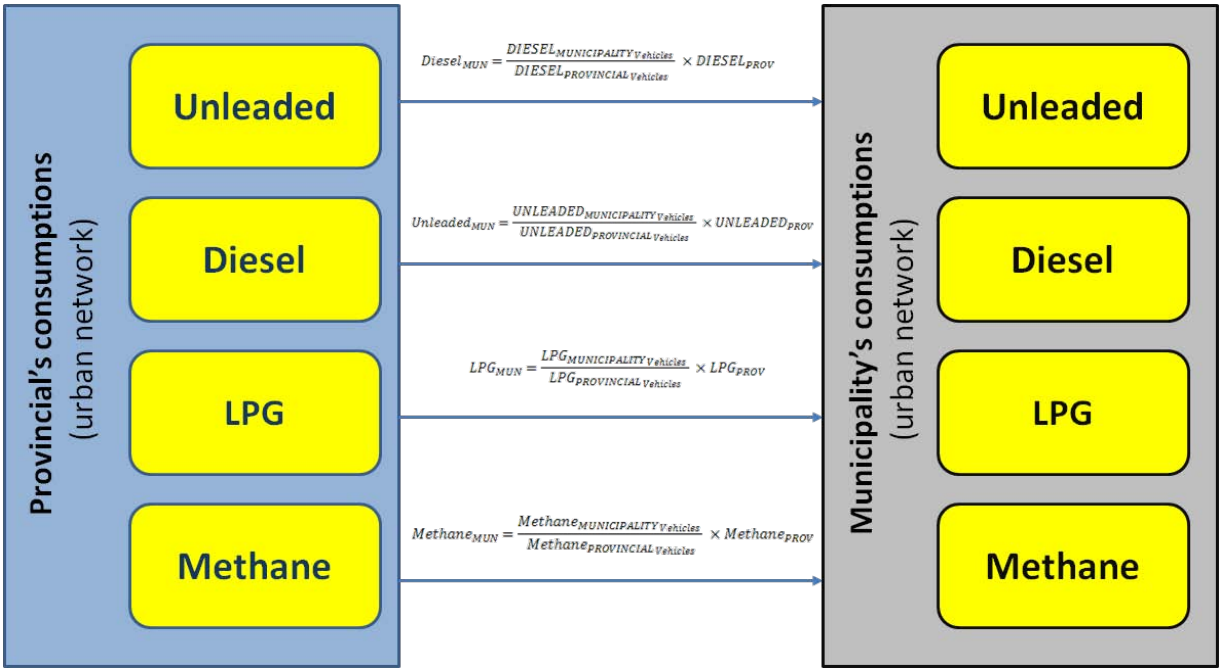
The evaluation of costs sustained from public administration consider all money (national and regional funds) invested during years of Mimosa's project (2008-2011, values of 2012 are not available yet). This value contains both founds for purchasing and for conversions and no disjunction can be done between the two typologies.

2.2 Consumption of different kind of fuel

The average value of the fuel's public price has calculated for every year of analysis, starting from monthly average values of Department of Economic Development. Only VAT and EXCISE TAX were considered as public administration cost.
Municipality's consumption of every kind of fuel are not available: Department of Economic Development publishes *Provincial's sales* divided in ordinary network, highway and other uses.

Starting from consumptions in ordinary network, tones sold are estimated as a proportion of Municipality's vehicles and Provincial's ones, considering separately every alimentation's category (diesel, unleaded, LPG, methane).

Figure 2.2.1 : methodology of appraisal for Municipality's consumptions.



2.3 Private investments

Private investments for conversion/purchase of new vehicles are estimated as a difference between the average cost and the P.A. contribute.

A new cleaner vehicle is more expensive than a "normal" one of about 3.000 euro. With reference to conversions, starting private's investments are 1.680[3] € for LPG cars and 2.280 € for methane's (assumed constant during all years of Mimosa).

Both methane and LPG yearly costs, are estimated as follows:

[3] Source: Ecogas National price list.

2.4 Facilitations in parking subscriptions

Facilitations allowed for parking subscriptions imply a missed gain for the owners of the services.

Subscriptions have different costs with reference to the zone of parking and the period of validity. For the appraisal of the missed gain it has been considered the data contained in the next tables, where, in the first has been reported the single cost of every typology of subscription, in the second one there are numbers of the facilitated subscriptions sold.

Table 2.4.1: Costs of parking subscription between 2008-2011 in BOL Municipality

Parking	Standard Cost (€)			Subsidize Cost (€)		
	1 month	6 months	yearly	1 month	6 months	yearly
CERCHIA DEI MILLE	70	300	0	35	150	
CENTRO STORICO	70	300	0	35	150	
CORONA SEMICIRCOLARE	40	150	0	20	75	
BOLOGNINA ARCOVEGGIO	25	90	0	12,5	45	
ZONA FIERA	40	150	0	20	75	
STAVECO	170	0	0	85		
TANARI	30	0	0	15		
PRATI DI CAPRARA	30	0	0	15		
MARCO POLO 2	30	150	250	15	75	125
FOSCOLO	170	900	1.700	85	450	850
STIASSI	30	150	250	15	75	125
BUTON	30	150	250	15	75	125

Source: ATC Bologna

Table 2.4.2: Number of subsidized subscriptions sold (2008-2011)

SUBSIDIZED Subscriptions sold (Mimosa)	2008	2009	2010	2011
1 MONTH Centro Storico	1.683	2.199	2.577	3.144
1 MONTH Corona Semicentrale	2.972	3.805	4.018	4.502
1 MONTH Bolognina – Arcoveggio	14	422	168	272
6 MONTHS Centro Storico	52	278	118	295
6 MONTHS Semestrale Corona Semicentrale	129	758	1.111	1.534
6 MONTHS Semestrale Bolognina - Arcoveggio	4	187	31	93
	4.854	**7.649**	**8.023**	**9.840**

Source: ATC Bologna

Starting from the subscriptions sold and their related discount, it has been possible to evaluate the missed gain occurred to parking owners as the differences in price multiply for number of facilitate subscriptions.

2.5 Better air quality in urban areas and less exposure to greenhouse gasses

The environmental benefit of renewing the registered running park by increasing cleaner vehicles percentages are estimated on Bologna's Municipality registered park with the support of a pollution calculator adopting COPERT's methodology. The driver for emissions indicators evaluation is Bologna registered park composition (only passenger cars) classified following the COPERT methodology.

Table 2.5.1: COPERT registered registered running park classification (passenger cars)

Type	Legislation/technology
Gasoline < 1.4 l 1.4–2.0 l > 2.0 l	PRE ECE
	ECE 15/00-01
	ECE 15/02
	ECE 15/03
	ECE 15/04
	Improved conventional
	Open loop
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007

Type	Legislation/technology
Diesel < 2.0 l > 2.0 l	Conventional
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
	Euro 5 — EC 715/2007
	Euro 6 — EC 715/2007
LPG	Conventional
	Euro 1 — 91/441/EEC
	Euro 2 — 94/12/EC
	Euro 3 — 98/69/EC Stage 2000
	Euro 4 — 98/69/EC Stage 2005
2-stroke	Conventional
Hybrids < 1.6 l	Euro 4 — 98/69/EC Stage 2005

Source: European Environment Agency, "Emission inventory guidebook 2009"

The COPERT method has been applied to the Bologna car registered running park composition by fuel types associating a level of kilometre's emissions to each vehicle type. Starting from the Bologna registered park data evolution, applying the COPERT method the emissions has been calculated.

In order to apply the COPERT methodology, the average yearly cars mileages have been estimated. It has to be noticed that the methodologies followed for the CBA evaluation it is quite different from the MRT's one. Since Bologna Municipality is the main subject of the Measure

Evaluation Template (MRT) analysis, the mileages considered comprehend only the kilometres covered into urban roads. A different approach is in the CBA where a differentiation in annual mileage for vehicle has been done, in order to evaluate the benefit/cost for the overall society, not only for the Municipality. For pollutions related to air quality the same assumptions taken into the MRT have been maintained: pollution of air quality are dangerous if highly concentrated, for this reason only tons emitted in the city area have been included, considering the emissions produced outside the city area did not have significant implications for the citizen's health. Hypothesis adopted for air pollutant (see also MRT paper) are: as daily urban trip it has been considered an average length of 9,6 km[4], the urban speed equal to 23 km/h[5] and all year's days use of car have been included (this period has been chosen because the literature analysis considerate indicates the value of 9,6 km as an average number obtained considering 365 days of car's use). The assumption can be considered correct because Measure 1.2 works in "everyday life" of citizens and not only in the aspects connected to their working days, so the benefits have to be considered all year long.

Moreover greenhouse gases are dangerous even if they are not produced in high quantity, every gram emitted contributing to damage the atmosphere. For the analysis of this kind of pollutants the mileage average value, has been taken from a study of ISPRA[6]' s Institute. In the study the mileage is estimated for every typology of vehicle depending to vehicle's ages, and to the kind of alimentation. The total mileage is divided in kilometres done in urban areas, 9,6 km daily covered (for 365 with average speed 23 km/h) and the remaining ones (difference between the total of annual value, decreasing every year, and urban mileage, considered constant for the vehicle life).

[4] M. Capobianco, G. Zamboni (Università di Genova), "*Valutazione del parco circolante, delle percorrenze urbane e dei fattori emissivi dei veicoli stradali nella città di Genova*", VII Expert panel Emissioni da Trasporto Stradale, Rome 16 January 2003

[5] M. Capobianco, G. Zamboni, *Op. cit.*

[6] Istituto Superiore per la Protezione e Ricerca Ambientale.

Table 2.5.2: annual mileage for different ages of vehicle's life (passenger cars)

Unleaded vehicles					
Vehicle's age	**Average annual mileage**	**Urban**	**Extra urban**	**% Urban**	**% Extra urban**
>18	4.320	3.504	816	81%	19%
15, 16, 17, 18	9.667	3.504	6.163	36%	64%
11, 12, 13, 14	11.500	3.504	7.996	30%	70%
6, 7, 8, 9, 10	13.167	3.504	9.663	27%	73%
2, 3, 4, 5	14.500	3.504	10.996	24%	76%
1	15.280	3.504	11.776	23%	77%

Source: ISPRA

2.6 Lower cost of "cleaner" fuels

Lower cost of cleaner fuels imply a gain for the private user who uses methane or LPG instead of unleaded or diesel. In the CBA analysis the mileage of a cleaner car is assumed equal to the one covered by a "normal" one; the assumption is reasonable because the kind of alimentation do not change users habits. The benefit from different fuel consumption is calculated starting from the annual average mileage. The average values of mileage, depending to vehicle's ages, are taken from the study of ISPRA Institute, mentioned above.

The appraisal takes into account that new/converted vehicles do not begin their life on the 1st of January of the year considered, and by consequence not all vehicles (new/converted) can cover the same mileage[7] in one year: take into account it, kilometres covered of first year have been halved. The assumption is an simplification of the reality caused by no more specific information about cleaner vehicles selling are available (i.e monthly sales).

The total gain have been obtained multiplying the average mileage covered for the difference and fuel consumption costs. The following formula represents an example used to calculate the gain between LPG and Unleaded vehicles (the same considerations can be followed for methane vehicles).

[7] As an example a car converted in January presumably will have twelve times the mileage of one bought in December.

Fuels consumption are: 14 km/liter for unleaded cars, 12,6 km/liter for LPG and 15,6 km/liter for methane.

Since no predictions can be done for trend on fuel's costs, differences between the three kind of fuels have been considered constant starting from 2012, equal to 2011 spread's values.

3 Computing the Business as usual scenario

BaU's scenario is a prediction of future consequence if this Measure will not applied in the City. Build the BaU implies some assumptions and hypothesis, as follows:

- Bologna's registered running park of BaU has the same number of vehicles than Mimosa's one, changes occurred only in its category's composition.

  Private users purchase/convert a cleaner car only if he/her uses it as first use vehicle because he/her have to return from the initial investment. It is reasonable to suppose there are no differences in number of vehicles between Mimosa and BaU's scenario and Mimosa's measure helps to shift the typology of alimentation but not to change the overall number of units.

- Growth's trend (or decreasing) of vehicles in the registered running park is evaluated as follows: the business as usual scenario has built maintaining equal to Mimosa's scenario the total number of vehicles every year (see point above), modifying the registered running park composition with particular reference to the methane and LPG vehicles.

  For these categories of vehicles it has been assumed a BaU's trend following the years before Mimosa. The number of cleaner vehicles in excess between Mimosa and BaU has then subdivided in "normal" vehicles. This approach previews the following hypothesis:

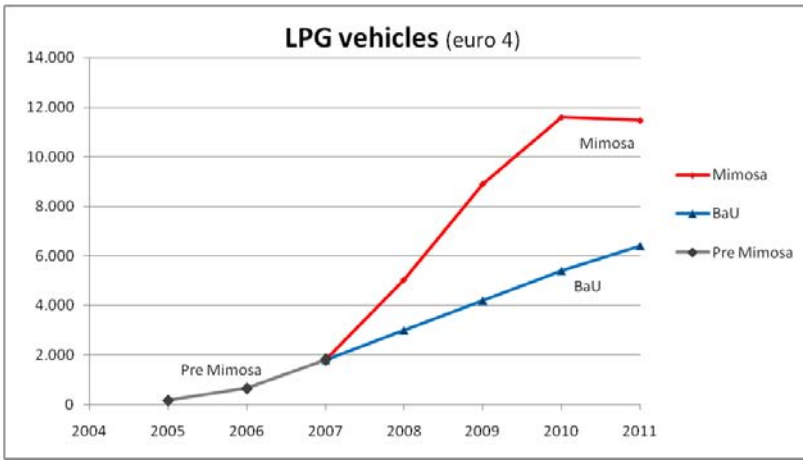
  1) with reference to methane and LPG vehicles, the categories till Euro 3 which registered a decreasing or they have maintained steady values it has assumed they have same units also in the BAU's scenario.
  2) LPG vehicles Euro 4 and Euro 5, have been estimated following the trend of historical data registered before 2008;

Table 3.1: LPG' registered running park composition (2005-2010)

	Pre Mimosa data			BaU				Mimosa			
COPERT class LPG	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**
Euro 0	2.430	2.919	2.450	2.370	2.183	1.999	1.829	2.370	2.183	1.999	1.829
Euro 1	1.375	1.558	1.085	1.299	1.155	1.020	919	1.299	1.155	1.020	919
Euro 2	1.276	1.711	2.406	3.382	3.281	3.030	2.755	3.382	3.281	3.030	2.755
Euro 3	888	1.481	1.240	1.907	1.964	1.922	1.814	1.907	1.964	1.922	1.814
Euro 4	171	661	**1.806**	**2.990**	**4.200**	**5.400**	**6.600**	**5.035**	**8.909**	**11.601**	**11.463**
Euro 5	0	0	0	**0**	**45**	**315**	**585**	**0**	**45**	**315**	**905**
TOTAL	6.140	8.330	8.987	11.948	12.828	13.686	14.302	13.993	17.537	19.887	19.685

Source: ACI, Automobile Club Italia

Figure 3.1: number of LPG vehicles euro 4 in BOL registered running park (pre Mimosa, Mimosa, BaU)



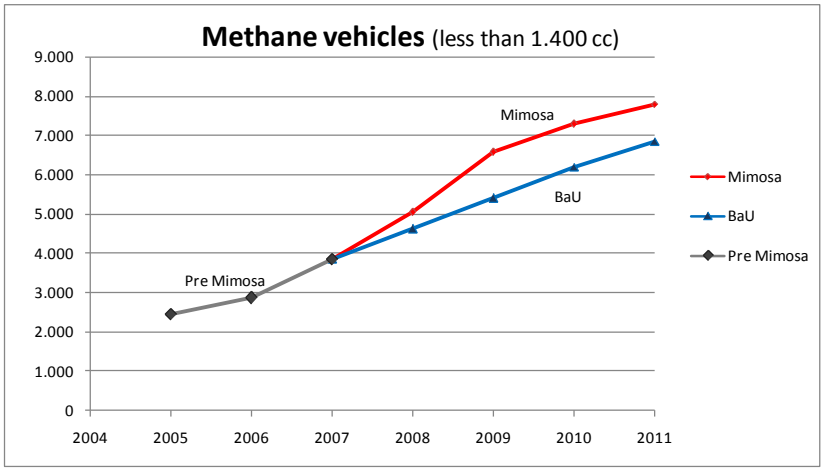
3) Methane vehicles Euro 4 and Euro 5: for engine's class < 1400 cc, vehicles have been assumed to be 5.400 in 2009 (1.171 less than the real values), 6.200 in 2010 (1.083 less than real values) and 6.850 in 2011 (935 less than real values) following the trend registered before 2008;

Table 3.2: methane's registered running park composition (2005-2010)

	Pre Mimosa data			BaU				Mimosa			
COPERT class	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**
less than 1400 cc	2.448	2.860	3.859	4.615	5.400	6.200	6.850	5.043	6.571	7.283	7.785
1401 cc - 2000 cc	3.273	3.645	3.928	4.233	4.181	4.099	3.873	4.233	4.181	4.099	3.873
more than 2000 cc	29	41	49	61	91	103	108	61	91	103	108
Total	**5.750**	**6.546**	**7.836**	**8.909**	**9.672**	**10.402**	**10.831**	**9.337**	**10.843**	**11.485**	**11.766**

Source: ACI, Automobile Club Italia

Figure 3.2: Number of methane vehicles < 1400cc in BOL registered running park



4) "in excess" vehicles between 2009-2010-2011 and BAU scenarios from the two point explained above (2) (3), have been subdivided as follows: gasoline-methane vehicles have been put into gasoline euro 4 category of the same dimension of engine; LPG vehicles have been distributed in percentage between diesel and gasoline and per engine kind.

- Average vehicles mileage in BaU is considered equal to Mimosa's measure;
- Contributes for conversion/purchase were from national and regional funds; Mimosa's project invest its money exclusively in higher strategic level, essential for the improvement of knowledge and awareness of citizens. This doesn't imply the same cost/investment will be done even if no Measure 1.2 was developed: BaU's scenario was built considering funds will be proportionate to number of vehicles converted in the Business as Usual scenario.
- Measure 1.2 helps to improve cleaner registered running park of the city: Mimosa's activities created a gap between the actual scenario and the BaU's one. In the analysis, considering the difficulty to predict what will happen in the future, it's assumed Mimosa helps to change Municipality registered running park only during its five years of activity. This assumption implies that everything done after 2012 would be done also even if Mimosa never existed. Thanks to this assumptions, the future development of registered running park do not change the differences generated between 2008-2012, and the split can be considered constant every strategies will be adopted in the future by Municipality (as example differences of emissions production can be considered constant between Mimosa and BaU scenario after 2012).

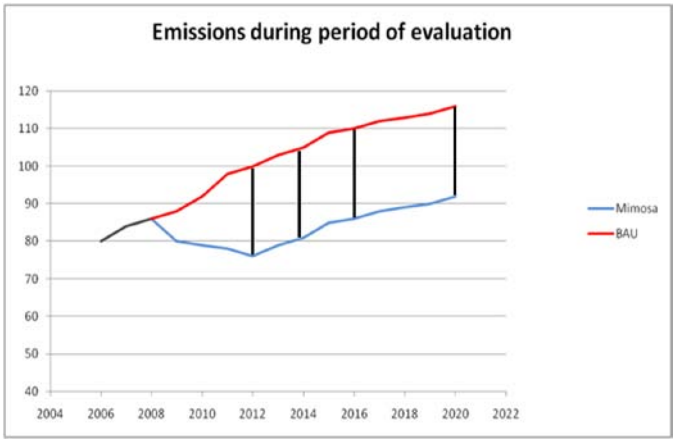
Environmental benefits expected after 2012 were calculated considering exclusively the less emissions produced by the new percentage of cleaner vehicles in registered running park that is the renewals obtained between 2008-2011. This hypothesis is simplistic because it neglects all aspects connected to the growth of "awareness" of citizens caused by Mimosa, which will influence positively future decisions. Mimosa aimed to obtain not only real-concrete results but also wanted to improve the knowledge of inhabitants and their sensibility in relation to heart health. Probably after 2012 (at the end of Mimosa) citizens will be more sensible to environmental problems and sustainable mobility and their choices will reflect that.

Unfortunately this aspect has been missed, but this approximation maybe underestimate future

composition of registered running park, which will have more cleaner vehicles than predicted ones. Registered running park registers a small annual reduction and cleaner vehicles' percentage is in growing.

Considering all these aspects it seems reasonable to take into account Mimosa's benefit/costs during 12 years (2008-2020) but to hypothesize that everything will be done after 2012 will be the same in Mimosa's scenario and in the BaU's one, maintaining the gap of 2012 constant.

Figure 3.3: Example of evaluation approach for the emissions create by Measure 1.2 and its evolution after 2012



Another assumption concerns the percentage of annual new/converted vehicles in BaU. The value of ratio has been considered equal to Mimosa's scenario (same percentage of new nd converted vehicles): the most important difference between the two scenarios is the number of cleaner vehicles and not the percentage of purchased/converted ones.

The estimation of annual consumptions of fuels are from real sales, assuming that the difference in tons sold mostly depends to the number of units in Municipality registered running park (divided into alimentation's categories). BaU's tons consumed are calculated as a ratio between the number of cars in the supposed scenario and the ones in Mimosa multiplied by tons really sold. As example for the unleaded evaluation:

Fuels' cost remain equal in the two scenarios: there are no reason to hypothesize some changes thanks to Mimosa.

For the appraisal of subsidized subscriptions sold in the BaU scenario, it has been supposed

these would be proportionate to the number of cleaner vehicles in registered running park.

Table 3.3: appraisal of subsidized subscriptions in BaU scenario (2008-2011)

	2008	2009	2010	2011
Subsidize Subscriptions MIMOSA	4.854	7.649	8.023	9.840
Cleaner vehiles MIMOSA	23.330	28.380	31.372	31.451
Cleaner vehiles BaU	20.857	22.500	24.088	25.453
Subsidize Subscriptions BAU	4.339	6.064	6.160	7.963

Source: TeMA rielaborations of ATC data.

4 Economic Evaluation

The net present value (NPV) permits to quantify the overall economic impact of a measure. It is defined as the total present value of all future benefits less the discounted sum of all future costs over the appraisal period. It measures the excess or shortfall of monetised resource, in present value terms.

This is based on a standard social cost benefit analysis of the following form[8]:

---

where,

= years of project appraisal

= stakeholder involved and/or affected

= Net present value summed over all stakeholder

= Revenue in year i to stakeholder a,

= User transport benefits in year i accruing to stakeholder a,

= Non user transport benefits in year i accruing to stakeholder a,

= External benefits in year i accruing to stakeholder a,

= Operating (and maintenance) costs in year i to stakeholder a

= Capital costs accruing to stakeholder a in year i (with the assumption that capital costs begin to be incurred in year 0).

= Discount rate

If the net present value is positive, the benefits are higher than the costs and the project impact on social welfare is positive.

In order to quantify Net Present Value of the present CBA, single voices of cost, benefit have been defined.

[8] CIVITAS POINTER (2009).

4.1 Public and private investments

As mentioned above funds of Mimosa are not destined directly to citizens who want purchase a new vehicle or convert their one. Money were used exclusively in higher strategic level, essential for the improvement of knowledge and awareness of citizens. Considering this aspect probably whit out Measure 1.2 less people would buy/convert their car. The economic evaluation consider the use of national funds proportional to the number of "new" cleaner vehicles registered every year.

Table 4.1.1: Mimosa and BaU's funds destinated to cleaner vehicles

Year	Mimosa Funds	New cleaner vehicles (Mimosa)	New cleaner vehicles (BaU)	BaU Funds
2008	€ 1.030.000	6.739	4.467	€ 683.000
2009	€ 740.000	5.992	2.832	€ 350.000
2010	€ 660.000	4.016	2.513	€ 413.000
2011	N.A	1.349	2.301	N.A

Private investments are calculated as a difference between the total cost of investment and the public incentive. As first step a single average investment has been estimated, both for converted and purchased park.

Table 4.1.2: Private investment for conversion or purchasing

CONVERSION	Average Cost for conversion		Contribution for convertion		Single Private investment	
	LPG	METHANE	LPG	METHANE	LPG	METHANE
2008	€ 1.680	€ 2.280	€ 350	€ 500	€ 1.330	€ 1.780
2009 -2011	€ 1.680	€ 2.280	€ 550	€ 650	€ 1.130	€ 1.630
PURCHASE	Average Cost for purchase		Contribution for PURCHASE		Single Private investment	
	LPG	METHANE	LPG	METHANE	LPG	METHANE
2008 - 2009	€ 3.000	€ 3.000	€ 1.500	€ 1.500	€ 1.500	€ 1.500
2010 - 2011	€ 3.000	€ 3.000	€ 0	€ 0	€ 3.000	€ 3.000

New cleaner vehicles "created" every year (difference between two registered running park compositions) are divided in new cars and converted ones. Following the hypothesis presented above, the partition between LPG and methane typologies has been estimated in proportion to registered running park composition of each year, as in the next table.

Table 4.1.3: Partition of annual "created" new cleaner vehicles in Mimosa and BaU.

NEW "created" CLEANER VEHICLES (compared to year before)								
CONVERTED vehicles			MIMOSA		BaU		Citizen private investment	
year	MIMOSA	BAU	LPG	METHANE	LPG	METHANE	LPG	METHANE
2008	2.661	1.764	2.008	653	1.201	563	€ 1.330	€ 1.780
2009	1.267	599	841	426	278	321	€ 1.130	€ 1.630
2010	1.146	865	845	301	419	446	€ 1.130	€ 1.630
2011	825	1.407	608	217	823	584	€ 1.130	€ 1.630
PURCHASED vehicles			MIMOSA		BaU		Citizen private investment	
year	MIMOSA	BAU	LPG	METHANE	LPG	METHANE	LPG	METHANE
2008	4.078	2.703	3.078	1.000	1.840	863	€ 1.500	€ 1.500
2009	4.725	2.233	3.135	1.590	1.034	1.199	€ 1.500	€ 1.500
2010	2.870	2.167	2.117	753	1.051	1.116	€ 3.000	€ 3.000
2011	524	894	229	295	618	276	€ 3.000	€ 3.000

Total costs sustained by private citizens are in the following table:

Table 4.1.4: Differences in total citizens costs between Mimosa and BaU

CITIZENS TOTAL COSTS	MIMOSA	BaU	Δ Cost
2008	€ 9.949.980	€ 6.653.970	€ 3.296.010
2009	€ 8.732.210	€ 4.186.870	€ 4.545.340
2010	€ 10.055.480	€ 6.347.210	€ 3.708.270
2011	€ 2.612.750	€ 4.563.910	€ -1.951.160

4.2 Consumption of different kind of fuel

Use of different typology of fuel implies two considerations: first of all a benefit for private user who changes his/her own vehicle with a cleaner one due to consumption of cheaper carburant; secondary a missed gain for Public Administration who will not obtain the same income because of less tax (excise) and VAT applied to cleaner fuels.

This paragraph analyzes the methodology followed to calculate Public Administration costs, while the private users benefits are in the next paragraph.

First of all annual cost of fuel has been considered as an average value of 12 months (this assumption implies the hypothesis of a constant consumption during the year with no differences between moths sales), divided into citizens cost, VAT and excise; one example of data considered is reported below.

Table 4.2.1: Example of annual cost for Unleaded fuel

2008	VAT (€)	Excise (€)	Consumption (€)
January	227,41	564	1.364,44
February	226,93	564	1.361,60
March	231,03	563,46	1.386,16
April	229,13	547,17	1.374,79
May	242,54	561,83	1.455,25
June	252,02	564	1.512,13
July	253,77	564	1.522,64
August	243,04	564	1.458,25
September	239,31	564	1.435,85
October	224,39	564	1.346,35
November	201,99	564	1.211,92
December	186,81	564	1.120,88
Unleaded	229,86	562,37	1.379,19

Source: Ministry of Economic Development

Annual Bologna's consumptions are estimated starting from Provincial tones sold as proportion between Municipality and Provincial registered running park because no more detailed data are available. Tons considered are only provincial values sold in the ordinary network. The next table illustrates the process adopted.

Table 4.2.2: Provincial fuel consumption (2008-2010)

PROVINCIAL SALES				
Unleaded	TOTAL [ton]	Ordinary network [ton]	Highway network [ton]	Extra network [ton]
2009	184.791	**157.422**	20.557	6.812
2008	193.068	**166.720**	20.534	5.814
Diesel	TOTAL [ton]	Ordinary network [ton]	Highway network [ton]	Extra network [ton]
2009	389.779	**241.050**	90.430	58.299
2008	397.700	**249.612**	87.031	61.057
LPG	TOTAL [ton]	Transport [ton]	Transport network [ton]	
2009	68.153	34.752	**8.962**	
2008	60.817	29.876	**6.625**	

Source: Ministry of Economic Development

Percentage of Municipality consumptions from provincial ones are calculated in the table 4.2.3: as indicated, using the percentage of registered running park composition and the total tons sold in the Province, it has been possible to appraise the Municipality consumptions in the two scenarios (Mimosa and BaU).

Table 4.2.3: Appraisal of annual Municipality consumptions

MUNICIPALITY SALES (estimate)					
Unleaded	% MIMOSA	%BaU	Oridnary network [ton]	Unleaded [ton] (Mimosa)	Unleaded [ton] (BaU)
2009	41,72%	42,79%	157.422	65.671	67.353
2008	41,12%	41,71%	166.720	68.561	69.531
Diesel	% MIMOSA	%BaU	Oridnary network [ton]	Diesel [ton] (Mimosa)	Diesel [ton] (BaU)
2009	29,83%	30,66%	241.050	71895,60	73904,81
2008	30,14%	30,23%	249.612	75234,34	75446,02
LPG	% MIMOSA	%BaU	Transport [ton]	LPG [ton] (Mimosa)	LPG [ton] (BaU)
2009	19,27%	14,10%	34.752	6696,77	4898,56
2008	18,55%	15,84%	29.876	5541,55	4731,69

Source: TeMA rielaboration

Methane consumption has been estimated as a proportion between number of methane vehicles in Emilia Romagna Region and in Municipality starting from Regional annual sales[9].

Considering the average value of fuels cost, P.A. gains and the differences between Mimosa and BaU's scenario, the missed gain has been estimated.

Table 4.2.4: Average P.A. fuel's gain

FUEL TIPE	Average consumption price (€)		Average P.A. gain (VAT + excise) (€)	
	2008	2009	2008	2009
Unleaded	1,379	1,232	0,792	0,769
Diesel	1,342	1,081	0,645	0,603
LPG	0,681	0,563	0,238	0,219
Methane	0,600	0,560	0,120	0,112
FUEL TIPE	Average consumption price (€)		Average P.A. gain (VAT + excise) (€)	
	2008	2009	2008	2009
Unleaded	1,379	1,232	0,792	0,769
Diesel	1,342	1,081	0,645	0,603
LPG	0,681	0,563	0,238	0,219
Methane	0,600	0,560	0,120	0,112

Source: TeMA elaboration

[9] Source FEDERMETANO

Table 4.2.5: Average differences in P.A. gain

Unleaded	Δ Consumption [ton]	Δ Consumption [lt.]	Missed gain (€)
2009	-1.682	-2.336.735	-1.797.551
2008	-970	-1.347.062	-1.067.191
Diesel	Δ Consumption [ton]	Δ Consumption [lt.]	Missed gain (€)
2009	-2009,21	-2.363.780	-1.425.555
2008	-211,68	-249.035	-160.644
LPG	Δ Consumption [ton])	Δ Consumption [lt.]	Missed gain (€)
2009	1798,20	+ 3.392.834	+ 743.557
2008	809,87	+ 1.528.052	+ 363.423
Methane	Δ Consumption [mln m^3])	Δ Consumption [m^3]	Missed gain (€)
2009	1.248	1.248.206	139.799
2008	476	475.915	57.110

Source: TeMA elaboration

4.3 Lower cost of "clean" fuels for private citizens

Private use of cleaner vehicles implies a general gain for citizens who have a methane or LPG car: the reason of this benefit is the lower cost of these fuels which generate a money salvation every kilometer done.

The appraisal of money gained by citizens started from the evaluation of annual kilometers; as mentioned in Chapter 3.5, the annual mileage has been deduced from a study of ISPRA[10]. IAs mentioned above, the total length of the annual trips is estimated for every typology of vehicle depending to vehicle's ages, and the kind of alimentation. For the CBA analysis an average mileage has been calculated differentiating by vehicle age.

Table 4.3.1: Average mileage function of vehicles' ages

Unleaded vehicles					
Vehicle's age	**Average annual mileage**	**Urban**	**Extra urban**	**% Urban**	**% Extra urban**
>18	4.320	3.504	816	81%	19%
15, 16, 17, 18	9.667	3.504	6.163	36%	64%
11, 12, 13, 14	11.500	3.504	7.996	30%	70%
6, 7, 8, 9, 10	13.167	3.504	9.663	27%	73%
2, 3, 4, 5	14.500	3.504	10.996	24%	76%
1	15.280	3.504	11.776	23%	77%

Source: ISPRA

[10] Istituto Superiore per la Protezione e Ricerca Ambientale.

Average kilometer's consumption is: 14 km/lt for unleaded vehicles, 12,6 km/lt for LPG and 23,4 km/kg for methane ones. Considering that some vehicles are hybrid and did not cover all mileage with cleaner fuel, in the analysis it has been considered an average value of methane/LPG's use equal to 80%. Difference between Mimosa and BaU annual mileage has been calculated as difference in number of cleaner vehicles multiplied for annual kilometres.

Moreover, since not all new cleaner vehicles are bought the 1st of January, it is reasonable to assume for the first year of "life" an average mileage of half than the annual kilometres indicate by ISPRA's study.

The first three lines of the following table show the average mileage run by new cleaner vehicles during Mimosa project, divided for the year of "birth" (this division is necessary for the correct evaluation of the ages of vehicles and in consequence their annual mileage). The 4th line represents the sum of the three lines above, multiply by number of more cleaner vehicles in Mimosa. This value is the yearly kilometres done by the shifting vehicles between cleaner vehicles in two scenarios (Table 5.16): in the analysis this mileage is assumed run with unleaded fuel in BaU scenario and with LPG/methane in Mimosa's one.

Table 4.4.2: Annual private gain for use of cleaner fuel

LPG	**2008**	**2009**	**2010**	**…**	**2020**
Km run (new vehicle 2008)	7.640	15.280	14.500	…	11.500
Km run (new vehicle 2009)	0	7.640	15.280	…	11.500
Km run (new vehicle 2010)	0	0	7.640	…	13.167
Total Km	15.623.800	51.600.560	70.358.420	…	54.153.500
UNLEADED cost (€)	1,379	1,232	1,363	…	1,541
LPG cost (€)	0,681	0,563	0,660	…	0,760
Consumption if UNLEADED (€)	1.539.154	4.539.224	6.849.401	…	5.960.645
Consumption if LPG (80%) (€)	1.055.152	2.883.629	4.610.256	…	4.082.878
GAIN (€)	**484.003**	**1.655.595**	**2.239.144**	**…**	**1.877.766**
METHANE	**2008**	**2009**	**2010**	**…**	**2020**
Km run (new vehicle 2008)	7.640	15.280	14.500	…	11.500
Km run (new vehicle 2009)	0	7.640	15.280	…	11.500
Km run (new vehicle 2010)	0	0	7.640	…	13.167
Total Km	1.734.280	7.258.000	10.870.380	…	8.314.500
UNLEADED cost (€)	1,379	1,232	1,363	…	1,541
METHANE cost (€)	0,900	0,840	0,849	…	0,919
Consumption if UNLEADED(€)	170.850	638.475	1.058.233	…	915.172
Consumption if METHANE (80%) (€)	83.450	325.958	493.421	…	408.524
GAIN (€)	**87.400**	**312.517**	**564.811**	**…**	**506.649**

Source: TeMA rielaboration

4.4 Facilitations in parking subscriptions

The missed gain from facilitated subscriptions, as mentioned in chapter 3, is evaluated starting from the number of cheaper subscriptions sold every year (for cleaner vehicles) and from the discount applied to every typology of them. The table below resumes the exposed reasoning:

Table 4.4.1: Subsidized subscriptions sold between 2007-2011 and their related easy price in Mimosa's scenario

MIMOSA	2007	2008	2009	2010	2011
1 month Centro Storico	1.148 45,9%	1.683 34,7%	2.199 28,7%	2.577 32,1%	3.144 32,0%
Single gain lost	35 (€)	35 (€)	35 (€)	35 (€)	35 (€)
1 month Corona Semicentrale	1.200 47,9%	2.972 61,2%	3.805 49,7%	4.018 50,1%	4.502 45,8%
Single gain lost	20(€)	20(€)	20(€)	20(€)	20(€)
1 month Bolognina – Arcoveggio	155 6,2%	14 0,3%	422 5,5%	168 2,1%	272 2,8%
Single gain lost	12,5 (€)	12,5 (€)	12,5 (€)	12,5 (€)	12,5 (€)
6 months Centro Storico	-	52 1,1%	278 3,6%	118 1,5%	295 3,0%
Single gain lost	150 (€)	150 (€)	150 (€)	150 (€)	150 (€)
6 months Corona Semicentrale	-	129 2,7%	758 9,9%	1.111 13,8%	1.534 15,6%
Single gain lost	75 (€)	75 (€)	75 (€)	75 (€)	75 (€)
6 months Bolognina – Arcoveggio	-	4 0,1%	187 2,4%	31 0,4%	93 0,9%
Single gain lost	45 (€)	45 (€)	45 (€)	45 (€)	45 (€)
Total facilitated subscriptions sold	2.503 100%	4.854 100,0%	7.649 100,0%	8.023 100,0%	9.840 100,0%
TOTAL Gain lost MIMOSA	**66.117 (€)**	**136.175 (€)**	**265.305 (€)**	**275.075 (€)**	**366.965 (€)**

Source: TeMA rielaboration from ATC data

The appraisal of units sold in BaU has been started from the percentage of subscriptions' typologies sold during Mimosa and the same values are applied to the number of parking season tickets.

Table 4.4.2: Subsidized subscriptions sold between 2007-2011 and their related easy price in BaU's scenario

BAU	2007	2008	2009	2010	2011
1 month Centro Storico	45,9% 1.148	35% 1.505	28,7% 1.743	32,1% 2.405	32,0% 2.934
Single gain lost	35 (€)	35 (€)	35 (€)	35 (€)	35 (€)
1 month Corona Semicentrale	47,9% 1.200	61,2% 2.657	49,7% 3.017	50,1% 3.749	45,8% 4.201
Single gain lost	20(€)	20(€)	20(€)	20(€)	20(€)
1 month Bolognina - Arcoveggio	6,2% 155	0,3% 13	5,5% 335	2,1% 157	2,8% 254
Single gain lost	12,5 (€)	12,5 (€)	12,5 (€)	12,5 (€)	12,5 (€)
6 months Centro Storico		1,1% 46	3,6% 220	1,5% 110	3,0% 275
Single gain lost	150 (€)	150 (€)	150 (€)	150 (€)	150 (€)
6 months Corona Semicentrale		2,7% 115	9,9% 601	13,8% 1.037	15,6% 1.431
Single gain lost	75 (€)	75 (€)	75 (€)	75 (€)	75 (€)
6 months Bolognina - Arcoveggio		0,1% 4	2,4% 148	0,4% 29	0,9% 87
Single gain lost	45 (€)	45 (€)	45 (€)	45 (€)	45 (€)
Total facilitated subscriptions sold	**100% 2.503**	**100% 4.339**	**100% 6.064**	**100% 7.487**	**100% 9.182**
TOTAL Gain lost BAU	**66.118 (€)**	**121.740 (€)**	**210.337 (€)**	**172.517 (€)**	**239.745 (€)**

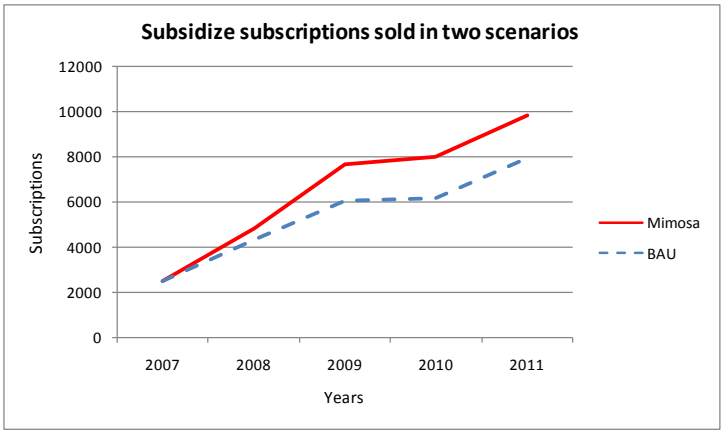
Source: TeMA elaboration

Differences between Mimosa scenario and BaU give the total cost (missed gain) kept by parking owner (P.A.) between 2008 and 2011. The number of facilitated subscriptions sold between 2007-2011 has a growing trend as the following table underlines.

Table 4.4.3: Subsidized subscriptions trend

	2007	2008	2009	2010	2011
Subsidize Subscriptions	2.503	4.854	7.649	8.023	9.840

Figure 4.4.1: Subsidized subscriptions sold between Mimosa



No more data are available after 2011, considering difficulties to forecast subscriptions that will be sold between 2012- 2020 and because the future policy of the parking owner can't be predict: these reasons the gain lost has been considered equal to the last year (2012), maintaining the same order of magnitude.

The assumption is a simplification of realty but it's reasonable supposed the parking owner will not apply the same discount if the demand of cleaner vehicles (for subsidized subscriptions) will have constant grown between 2012 and 2020; presumably if the demand of cleaner park will be greater than the actual, parking policies would change in order to save money. Taking into account all these considerations, the difference in entrance between Mimosa scenario and BaU in 2011 (the maximum between 2008-2011) has been assumed as the value of missed gain for the administrator of public parking for all years after 2012.

Table 4.4.4: differences between missed gain in Mimosa and BaU scenarios

Missed GAIN	2008	2009	2010	2011	…	2020
MIMOSA	136.175	265.305	275.075	366.965	…	360.000
BaU	121.740	210.337	172.517	239.745	…	240.000
COST	**14.435**	**54.968**	**102.558**	**127.220**	**…**	**120.000**

Source: TeMA elaboration

4.5 Better air quality in urban areas and less exposure to greenhouse gasses

The improving of air quality thanks to Mimosa measure 1.2 has been evaluated starting from the registered running park annual composition (both Mimosa and BaU) and from the yearly mileage of every typologies of vehicles. As mentioned , the Copert methodology has been used to estimate emissions and the two kind of kilometers annually covered depending on pollution considered: city's air quality or greenhouse gases. For the first category only mileages the city area have been considered; to the contrary taking into account the second group of pollution, emissions are calculated using all yearly mileages done by vehicles.

Following the criteria indicated in CBA guideline paper[11], pollutant evaluated are NO_x (3,712

[11] Guideline for Focused Measure Cost-Benefit Analysis in CIVITAS MIMOSA, 14 July 2010

€/ton), SO_2 (4,06 €/ton), $PM_{2,5}$ (429,2 €/ton) for air quality and CO_2 (40 €/ton), N_2O (1 ton equal to 310 ton of CO_2), CH_4 (1 ton equal to 21 ton of CO_2) considering greenhouse gases.

After 2011 where no more data are available, the CbA assumed that differences generated during Mimosa measure will remain constant till 2020. The assumption implies that if the emissions will change in future, due to changes in park composition, it is reasonable to assume these would have change even without Mimosa (for more specific information see chapter about BaU's scenario and future forecast about cost/benefit).

The next tables schematize process used to evaluate annual cost of pollutions and greenhouse gas: benefit is calculated as cost of pollution saved between Mimosa and BaU scenario. Every differences in annual tons produced (subtraction between BaU and Mimosa values) have been multiplied for the pollution unit cost, obtaining total benefit caused by measure 1.2 during period 2008-2020.

Table 4.5.1: Annual benefit and money evaluation of less pollutions emitted

Pollution exposure						
Pollution saved (ton/year)	**2008**	**2009**	**2010**	**2011**	**…**	**2020**
NO_x	0,22	3,50	3,67	3,98	…	…
cost (€)/ton	3,712	3,712	3,712	3,712	…	3,712
SO_2	0,0012	0,0380	0,040	-0,005	…	…
cost (€)/ton	4,06	4,06	4,06	4,06	…	4,06
PM $_{2,5}$	0,0082	0,19	0,20	0,75	…	…
cost (€)/ton	429,2	429,2	429,2	429,2		429,2
Total cost saved (€)	**4,4**	**96,3**	**101,3**	**318**		**…**

Source: TeMA elaboration from ACI data and Copert Methodology

Table 4.5.2: Annual benefit and money evaluation of less greenhouse gasses emitted

Greenhouse gasses							
Pollution saved (ton/year)	**Equivalent ton CO_2**	**2008**	**2009**	**2010**	**2011**	**…**	**2020**
N2O	**310**	**-0,005**	**-0,001**	**-0,040**	**-0,009**	**…**	**…**
CO_2	**1**	**93,1**	**692,7**	**713,1**	**1.012,0**	**…**	**…**
CH_4	**21**	**-0,01**	**-0,41**	**-0,57**	**-0,04**	**…**	**…**
Total cost saved (€) (CO_2 = 40* €/ton)		**3.151**	**27.338**	**27.547**	**40.623**	**…**	**…**

Source: TeMA elaboration from ACI data and Copert Methodology

4.6 NET PRESENT VALUE

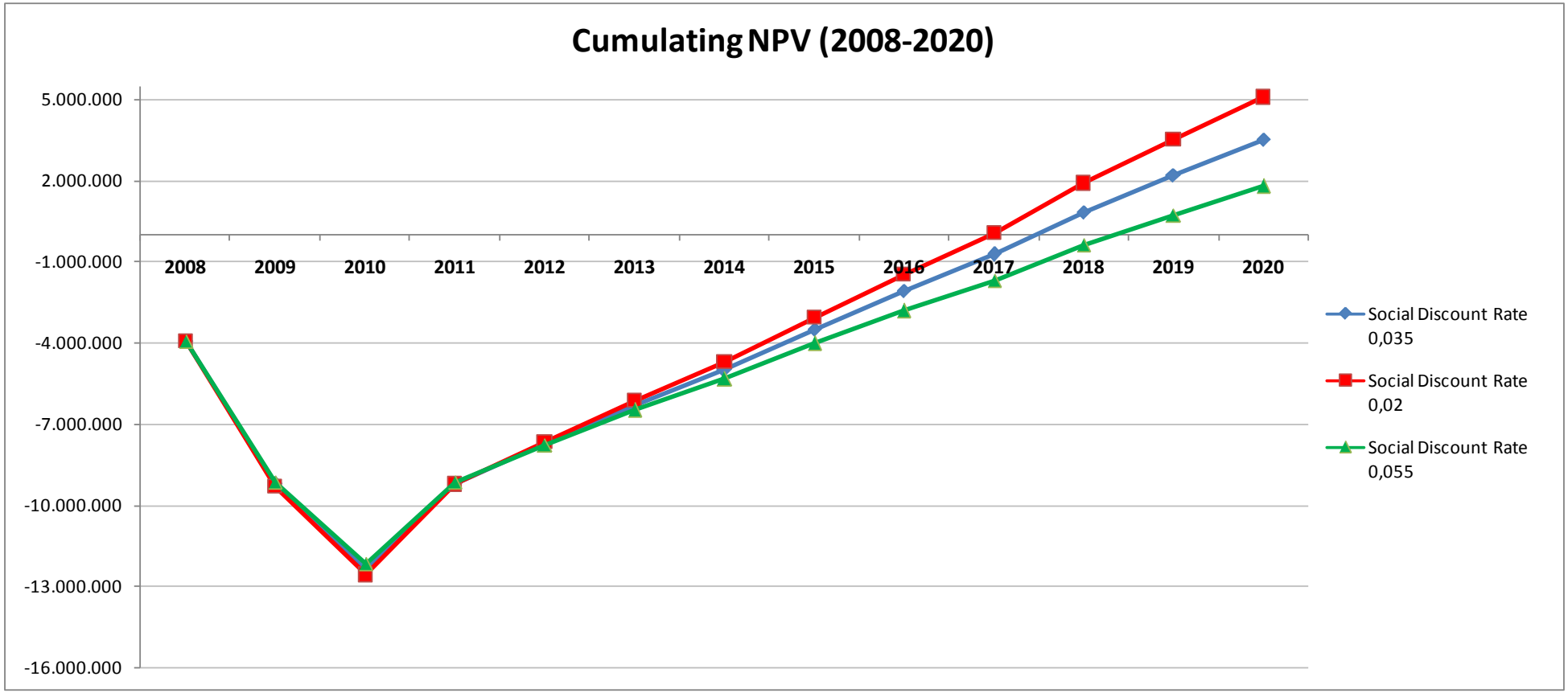
The Net present value has been evaluated first of all by summing all voices of cost and benefit for each year. The values obtained have been brought back to present using the *social discount rate.* As suggested by CbA guidelines, for a sensitivity analysis the value of this economical indicator has been varied between 0,02, 0,035 and 0,055. The table below shows the three results obtained with different values of social discount rate: all cases evaluated have a positive value of NPV, underling the economic convenience of the measure in twelve years of evaluation.

Table 4.6.1: NPV calculation (2008-2020) 1st Hypotesis

NPV		YEAR												
		2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
COST	PUBLIC FOUNDS	347.000	390.000	247.000	353.000	0	0	0	0	0	0	0	0	0
	PRIVATE INITIAL INVESTMENT	3.296.010	4.545.340	3.708.270	-1.951.160	0	0	0	0	0	0	0	0	0
	PARKING SUBSCRIPTIONS	14.435	54.968	133.121	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000	120.000
	DIFFERENT FUELS CONSUMPTIONS	864.411	2.479.549	2.500.000	2.500.000	2.000.000	2.000.000	2.000.000	1.500.000	1.500.000	1.500.000	1.000.000	1.000.000	1.000.000
BENEFIT	PRIVATE FUEL'S CONSUMPTION	571.403	1.968.113	3.171.090	3.807.188	3.766.312	3.766.312	3.653.350	3.489.927	3.420.071	3.420.071	3.278.805	3.074.435	3.074.435
	AIR QUALITY	4	96	101	101	101	101	101	101	101	101	101	101	101
	GREENHOUSE GASES	3.151	27.338	27.547	40.623	40.623	40.623	40.623	40.623	40.623	40.623	40.623	40.623	40.623
SUM		-3.947.298	-5.474.310	-3.389.652	3.540.678	1.697.253	1.697.037	1.584.075	1.920.652	1.850.796	1.850.796	2.209.530	2.005.159	2.005.159

Social Discount Rate		
	0,035	3.529.190
	0,02	5.082.491
	0,055	1.781.283

Figure 4.6.1: Cumulating NPV during the period of evaluation (2008-2020)



5 Conclusions

The results show a measure global benefit in vehicles renewal expenditure during the 12 years of evaluation. Overall, the CBA demonstrates a general benefit for citizens with a positive net present value; the results therefore justify the investment, especially considering that measure 1.2 concerned citizens' health. This means that improving air quality in Bologna was not onerous within the considered time span. As often occurs for any investment, it will take many years to reach the breakeven point, which would be in 2017, nine years after the Measure started.

The evaluation showed the difficulties of comparing costs/benefits of different magnitudes, such as those sustained by public administrations for renewals, lower tax revenues due to lower fuel consumption and the monetization of environmental benefits. Another important aspect is the strong randomness which characterized most of the cost/benefit variables.

It is important underline as the growth of a cleaner vehicles in Bologna' registered running park is widely connected to almost all the costs and benefits considered in the analysis. The availability of incentives and the lower prices of cleaner fuel are fundamental elements which can move the choice to "cleaner" alternatives. Unfortunately these elements can be hardly predicted because their behavior is planned at national higher level and they are extremely variable (as actual events demonstrate, probably five years ago was not predictable the actual fuels cost, unleaded fuel costs increased by 13% in Italy last year).

In addition, in many cases the considered costs were 'lost earnings' for the Public Administrations with a lesser impact than the direct costs would have.