

*Measure title:* **RENEWABLE ENERGY PRODUCTION TO FEED BUSES WITH LOW ENVIRONMENTAL IMPACT**

*City:* **Brescia**

*Project:* **MODERN**

*Measure number:* **01.11**

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## **M01.11 – Executive summary**

The measure belongs to the thematic area “alternative fuels” and it regards the production of energy through the enlargement of the existing Brescia Trasporti (Public Transport Company in Brescia) photovoltaic system, in order reach independence at an energetic level and recharging the batteries of hybrid busses (Hybrid busses are a part of Brescia Trasporti fleet).

The objective of the measure consisted in the energy production and in the emissions reduction. It’s important to highlight that this action strictly belongs to Brescia Trasporti policy.

During the first year of measure implementation of the new photovoltaic system, the energy production was doubled. To obtain such result it was necessary to design the system, obtain its approval by the Municipality, purchase and install it alongside to the existing one.

In order to evaluate the objective achievement, a set of indicators was measured to monitor the objective achievements and to check the emission levels, and operating costs.

The new plant characterised by a peak power of 76,8 KWp was built in the period between January and March 2011, and started its operation in April 2011. During the first year (May 2011-Apr.2012) the new system produced 97.736 kWh. This production is almost twice in respect to the previous power plant. Furthermore, in the first year, the new system entailed the reduction of 52 Ton of CO2 and the saving of 22 TOE.

From the impact point of view the measure is considered of success, while by considering the process evaluation aspects it needs to be pointed out the following:

- it is easier to implement such kind of measure if funding is available;
  - if the funding is limited within a time period it may be possible to have a shortage of technical devices, due to a general rush.
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## **A. Introduction**

### **A1 Objectives**

The measure objectives are:

(D) High level / longer term:

- To improve the environment quality by the use of alternative fuels and of clean and energy efficient vehicles

(E) Strategic level:

- To produce renewable energy with photovoltaic system to feed busses, in accordance with the policy of Brescia Trasporti and more generally with the objectives of the city based on sustainable development. The production of renewable energy can obtain a reduction of CO2 emission in atmosphere and energy saving in terms of TOE (The lifetime of the photovoltaic is about 25 year; during these years it will produce 1.400 MWh with an energy saving of 120 Toe and a reduction of emission into the atmosphere of 905 tons of CO2).

(F) Measure level:

- Extension of the existing photovoltaic plant to reach the capacity of 100 KWp in order to:
  - (1). To recharge batteries of all hybrid busses (existing + new ones) within the available fleet by using energy from a new photovoltaic system that will be integrated to the already existing one.
  - (2). To decrease by 7% the electricity demand in the range of peak with a reduction of 10% of currently incurred costs .
  - (3). To produce (\*): 188 MWh (about 144 MWh/year)
  - (4). To reduce CO2 (\*): 100 tCO2 (about 50 tCO2/year)
  - (5). To save energy (\*): 38 TOE (about 19 TOE/year)

### **A2 Description**

Brescia Trasporti has always cared about environmental and mobility needs. The company has continuously promoted the use of alternative fuels and of clean and energy efficient vehicles (NCG and hybrid busses), in order to reduce pollution, exhaust gases and noise. Additionally, it has sought independence at an energetic level installing a photovoltaic plant.

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The increased consumption of natural gas, by the Brescia Trasporti fleet, increased the level of electricity consumption due to the need of compressing it into the gas tanks. The amount of electricity consumption for compressing the natural gas is about 40% of total consumed energy.

Besides the consumption of electricity used to compress methane, energy is used also to charge the electric buses batteries. Brescia Trasporti has in its fleet four hybrid-electric busses with gas turbine (Horus). These buses reduce levels of noise to very low and also polluting emissions

In 2003 Brescia Trasporti was awarded the “friend of environment” prize thanks to the use of these busses,

The energy produced (46.633Kwh/year, in 2009) by the existing photovoltaic system (built on the bus depot roof, in 2008 ) was sufficient to feed hybrid busses, which were part of the BST fleet.

Brescia Trasporti decided to extend the existing photovoltaic system to reach a capacity of 100 KWp thanks to:

- the availability of space on the roof,
- the new technologies on the performance of the photovoltaic modules,
- the preparation of the existing system for further expansion,

Such energy was needed to feed new hybrid busses within the fleet of Brescia Trasporti - methane and electric propulsion - (in Measure 01.06 “Clean and energy efficient public transport fleet in Brescia” 4 hybrid methane and electric propulsion buses were bought.).

Because the tender for the new photovoltaic plant showed that since 2008 the price of modules had decreased significantly and the available budget was more than enough, Brescia Trasporti decided to increase the peak power up to 76,8 KWp instead of 50 KWp.

The system now has got an annual average production of 150.000 kWh/year, which corresponds to 28 toe (saved petroleum equivalent ton) and to a reduction of the emission in the atmosphere of 80 ton CO<sub>2</sub> every year. In particular, the contribution brought by the new section of the plant (installed thanks to the Civitas initiative) consists of approximately 75000 kWh produced, 14 toe saved and 40 ton CO<sub>2</sub> reduced every year.

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## **B. Measure implementation**

### **B1 Innovative aspects**

The innovative aspects of the measure are:

**New physical infrastructure solutions** – As Brescia Trasporti fleet was equipped with four new innovative hybrid busses (natural gas + electrical propulsion). After benchmarking activities. The upgrade of the existing photovoltaic system was performed installing a 76,8kw photovoltaic system.

It has the following configuration:

- n. 4 inverter “Refusol” 17K (Fig. 1)
- 384 photovoltaic modules “Heckert Solar PXL 200” (Fig. 2)



Fig. 1 Inverter "Refusol" 17K

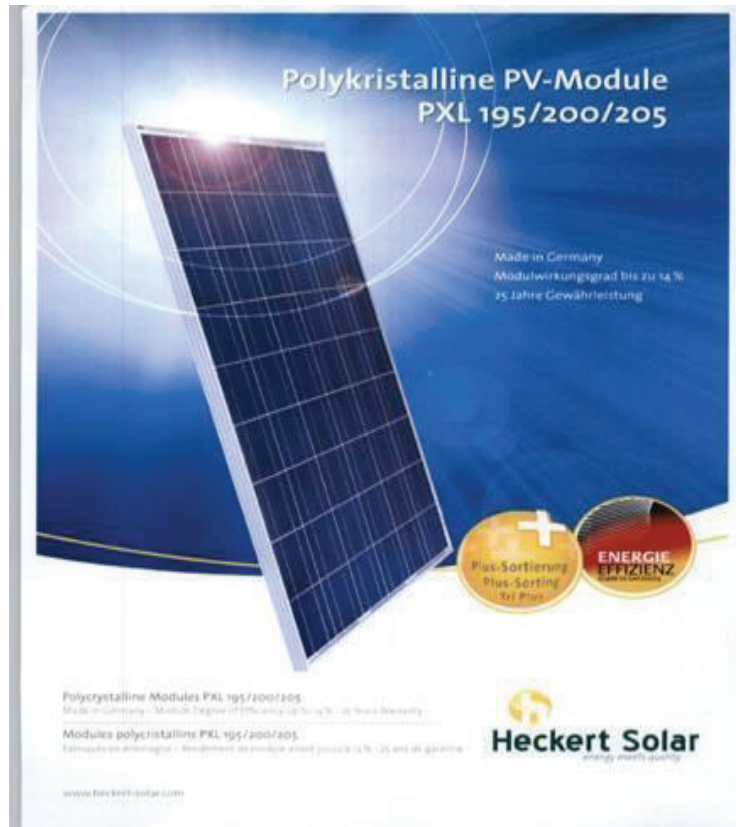


Fig. 2 Photovoltaic Modules Heckert Solar PXL 200

## B2 Research and Technology Development

The research activity of Brescia Trasporti consisted in the evaluation of the photovoltaic system installed in 2008, in order to improve the design of the new system.

Production data, radiation, position and performance were analyzed. In July 2010 Brescia Trasporti completed the draft of the new plant: the layout of the new photovoltaic system was designed in relation to:

- the available space on the roof;
- the exposure to the sun on the roof;
- the shadow caused by the chimneys and the skylights existing on the roof;
- the space required for operator access and movement for maintenance .

Brescia Trasporti in agreement with Brescia Municipality defined the technical features for the supply modules and inverter for an installation of 50 kW and sent them to supply companies.

In 2009 the inverter devices were sold out and were no longer available (as the new decree “Conto Energia” on funding for energy production from photovoltaic system penalized the systems installed after January 1<sup>st</sup> 2011, everybody tried to install them in 2010). The inverter devices were available again at the beginning of 2011.

Most of the offers received in 2009 were not complete. The technical-economic analysis and evaluation of offers received showed that the best configuration, in terms of performance, inverter-panels was presented by the company “Fotosintesi”.

After the economical offers analysis in which it was evident that the price of panels had decreased Brescia Trasporti decided to install a 76,8 kW photovoltaic system.

### **B3 Situation before CIVITAS**

Brescia Trasporti decided to be more independent in energy production through the installation of a photovoltaic plant. In 2008 Brescia Trasporti set up a first photovoltaic system of 50 KWp. The system was built covering 423 m<sup>2</sup> of the bus depot roof.

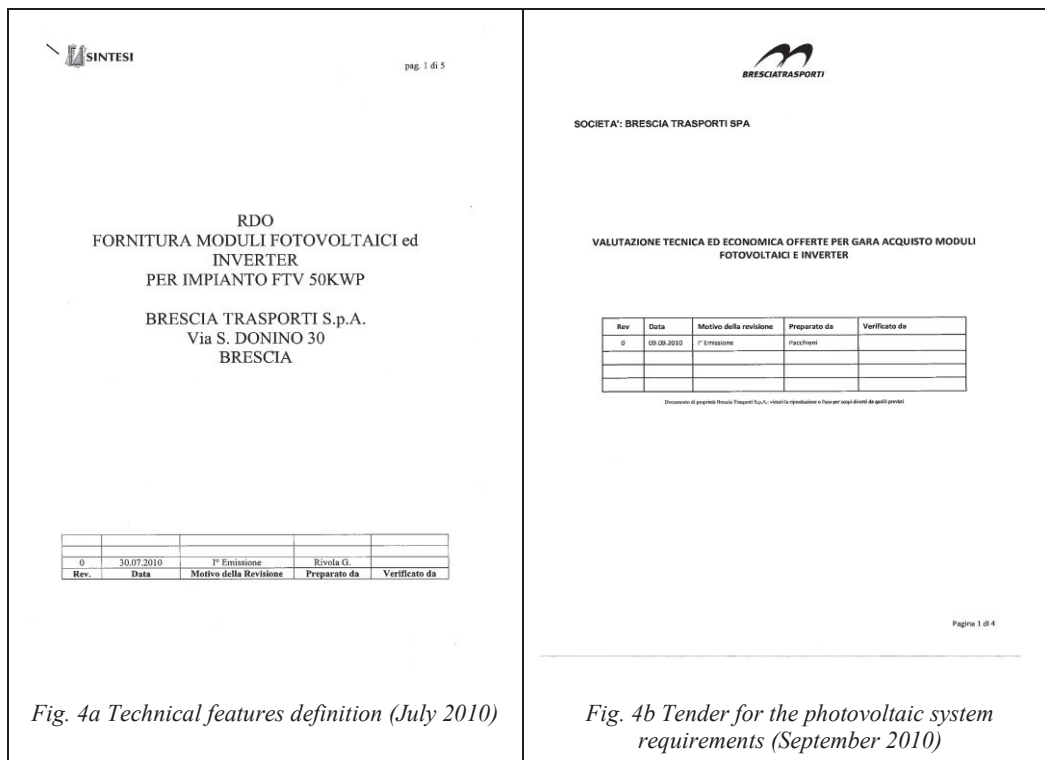
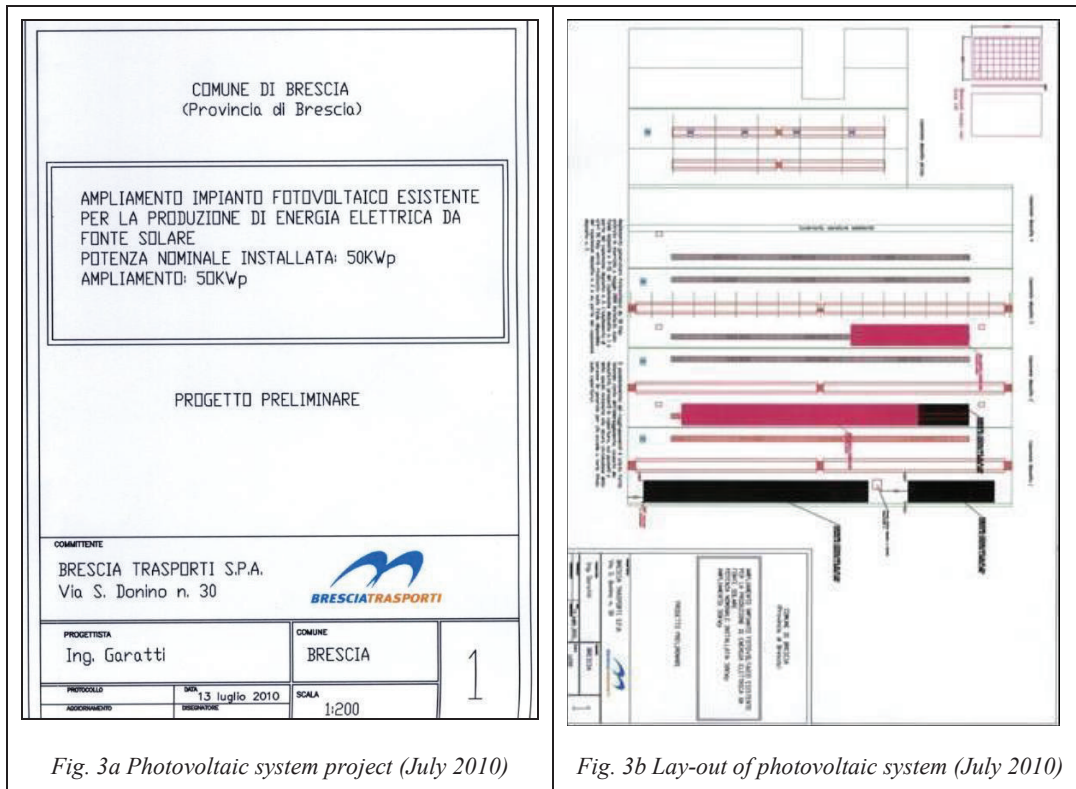
The photovoltaic system has the following characteristic: 252 polycrystalline silicon modules (195 W each), installed in parallel to the surface of the roof. The system, operating from 1<sup>st</sup> May 2008, in about two years produced 39.000 kWh.

The existing system didn't allow to increase the number of hybrid buses remaining independent from an energetic point of view.

### **B4 Actual implementation of the measure**

The measure was developed as explained below, according to the following stages:

**Stage 1: Executive design of the photovoltaic system** (March 2010 – December 2010) – *The first step consisted in research activities to define the executive design of the photovoltaic system according to the safety and innovativeness of the system. In particular Brescia Trasporti aimed at reaching a total capacity over 100KWp (from the total system composed by the existing and the new photovoltaic panels), in order to produce enough energy to feed the busses and to compress the natural gas for the hybrid bus tanks. Particular attention was given to the aspects related to maintenance and operation procedures. This stage included also the project (Fig. 3a, 3b), the authorization, the tender (Fig. 4a, 4b), the devices purchase procedures.*





**Stage 2: Installation of the new photovoltaic system, training of the operators and experimental phase** (December 2010 – March 2011) – *After the technical components purchase, the next stoe consisted in the installation of the panels and of the inverter (Fig. 5, 6), in order to start the test phase, according to the laws.. Only after the system testing and its calibration Brescia Trasporti received the license for the connection of the plant to the public network.*



Fig. 5 Brescia Trasporti – The existing photovoltaic system installed in 2008



Fig. 6 Installation of the new photovoltaic system 76,8 KWp

**Stage 3: kick off of the service** (April 2011 – October 2012) – *On 28<sup>th</sup> April 2011 the new system (Fig. 7) was put into service. In June 2011 the plant already produced 28.720 kWh and the specific energy*

*production of the new plant was higher than the old one (141,93 kWh/kWp instead of 128,55 kWh/kwp). In December 2011 the plant produced 128.000 kWh.*



*Fig. 7 Inverter and panel of the new photovoltaic system 76,8 kWp*

## **B5 Inter-relationships with other measures**

This measure is not related to others in terms of measure output, but it can be considered related to the other Brescia Trasporti SpA measures in terms of high level objectives “to improve the environment quality by the use of alternative fuels and of clean and energy efficient vehicles”

In particular, the measure is related to Measure 1 no. M01.06 – Clean and energy efficient public transport fleet in Brescia.

## C. Evaluation – methodology and results

The implementation of the measure mainly consists in producing renewable energy with photovoltaic system to feed busses. The indicators selection aimed at measuring the measure outputs - to recharge batteries of all hybrid busses and to decrease by 7% the electricity demand in the range of peak with a reduction of 10% of currently incurred costs.

Only few indicators have been selected to have information about the strategic level (i.e. considering the fleet composition on the whole).

### C1 Measurement methodology

The indicators have been divided into two macro-categories: main indicators and complementary indicators.

Main indicators are able to evaluate the measure efficiency in terms of objectives achievement. In addition complementary indicators were introduced in order to assess specific issues. These indicators are used to give additional information in order to better understand the measure performance.

#### C1.1 Impacts and Indicators

**Table C1.1: Indicators**

No.	Impact	Indicator	Data used	Comments
1	Economy	Average Operating Revenues	Data coming from the energy plant (energy produced) per month.	Main Indicator
2	Energy	Fuel mix	Data coming from BST (Fleet composition, mileage and fuel consumption).	Main Indicator
3	Energy	Energy consumption for hybrid bus/tot fuel produced by solar plan	Data coming from BST (energy consumption by electric busses and energy produced by solar plant).	Main Indicator
4	Environment	CO emissions	COPERT methodology	Complementary indicator Referred to the fleet
5	Environment	NOx emissions	COPERT methodology	Complementary indicator Referred to the fleet
6	Environment	Small particulate emissions	COPERT methodology	Complementary indicator Referred to the fleet
7	Environment	CO2 emission avoided	Data coming from the energy plant (energy produced)	Main Indicator

No.	Impact	Indicator	Data used	Comments
8	Environment	% Km Hybrid bus	Data coming from BST (Fleet composition, mileage)	Main Indicator

Detailed description of the indicator methodologies:

**Indicator 1 (Average Operating Revenues)** – Revenues come from the national funding for every kWh produced by the plant (0,40 €/kWh = “conto energia” fare for the existing plant as stated in the Decree 19 July 2007) and from the savings on the bills (0,11 €/kWh), net of tax deductions and of excises. Data referred to energy production (kWh) are monthly collected by an electricity meter placed downstream of the photovoltaic plant. In particular, the methodology for the calculation of the indicator, provided for each month is the following:

**AVERAGE OPERATING COSTS** = (NET REVENUES FROM “CONTO ENERGIA” + REVENUES FROM BILL SAVINGS) – EXCISE UTF

where:

NET REVENUES FROM “CONTO ENERGIA” = (Produced Energy \* “conto energia” fare) – Tax deduction 4%

REVENUES FROM BILL SAVINGS = Produced Energy \* Energy cost VAT excluded 0,1%

EXCISE UTF is a variable value

Details on the indicator calculation methodology is reported in Annex A2 section.

**Indicator 2 (Fuel mix)** – This indicator is expressed by the ratio between the energy consumed by a kind of vehicle (Gasoil, Methane gas and Hybrid powered vehicles) and the total energy consumed by the fleet. The Energy consumption depends on the total mileage and on the consumption factors.

Details on the indicator calculation methodology is reported in Annex A2 section.

**Indicator 3 (Energy consumption for hybrid bus/tot fuel produced by solar plan)** –

The Energy consumption for hybrid busses (Electric-Methane gas) depends on the “electric km” travelled by hybrid busses. The total mileage is therefore divided into km travelled using methane gas (70%) and the ones travelled using Electric Energy (30%). This last value is multiplied by an average consumption factor (1,25 kWh/km). In order to calculate the indicator, that value has been divided by the total energy produced by the photovoltaic plant.

Details on the indicator calculation methodology is reported in Annex A2 section.

**Indicator 4 (CO emissions)** – Emissions are calculated following the COPERT methodology, multiplying the mileage [km] of the fleet described in M01.06 and a specific emission factor [g/km]. Emission factors vary on the fleet, that has been classified by kind of fuel and EURO label .

Details on the indicator calculation methodology and on the fleet composition are reported in Annex A2 section.

**Indicator 5 (NOx emissions)** – Emissions are calculated following the COPERT methodology, multiplying the mileage [km] of the fleet described in M01.06 and a specific emission factor [g/km]. Emission factors vary on the fleet, that has been classified by kind of fuel and EURO label.

Details on the indicator calculation methodology and on the fleet composition are reported in Annex A2 section.

**Indicator 6 (Small particulate emissions)** – Emissions are calculated following the COPERT methodology, multiplying the mileage [km] of the fleet described in M01.06 and a specific emission factor [g/km]. Emission factors vary on the fleet, that has been classified by kind of fuel and EURO label.

Details on the indicator calculation methodology and on the fleet composition are reported in Annex A2 section.

**Indicator 7 (CO2 emission avoided)** - This indicator is calculated considering the CO2 emission avoided using Energy coming from the photovoltaic plant, instead of using energy coming from conventional sources. To produce 1 electric kWh, the equivalent amount of 2,56 kWh under the shape of fossil fuel is burned and about 0,531 kg of CO2 is produced (emission factor of the Italian electric mix referred to the distribution).

**Indicator 8 (% Km Hybrid bus)** - This indicator is given by the ratio between the mileage travelled by the hybrid fleet and the total fleet mileage described in the M01.06.

## C1.2 Establishing a Baseline

It's important to stress that the main objective of the plant extension is to reduce the costs for the energy purchase and to increase the use of renewable energy (and, as a consequence, to reduce the CO<sub>2</sub> emissions in atmosphere). Another practical goal is to recharge the batteries of all the hybrid buses (which at the moment represent a small part of the fleet) using the photovoltaic system.

Indicator 1 (Average Operating Revenues) and 7 (CO<sub>2</sub> emission avoided) are related to the photovoltaic plant and depend on the energy produced by the plant; indicator 3 (Energy consumption for hybrid bus/tot fuel produced by solar plan) and 8 (% Km Hybrid bus) are specifically related to the hybrid buses and indicators 2 (Fuel mix), 4 (CO emissions), 5 (NOx emissions), 6 (Small particulate emissions) are related to the whole fleet and depend on the km travelled by the fleet.

The baseline is assumed in year 2009, before the OP of the measure (which is April 2011, when the extension of the photovoltaic plant was put into operation).

In particular, Indicator n.1 is calculated referring to the operational year of the plant , therefore its baseline is referred to the period that goes from May 2008 to Apr 2009. All the other indicators are referred instead to the solar year, going from January to December.

Photovoltaic Plant	BASELINE 2009
1) Average Operating Revenues	21.710 € (May 2008 – Apr 2009)
7) CO <sub>2</sub> emission avoided	24.762 kg/year

**Table 3 – Baseline for the indicators related to the Photovoltaic Plant**

Hybrid buses	BASELINE 2009
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3) Energy consumption for hybrid bus/tot fuel produced by solar plan	80,34%
8) % Km Hybrid bus	1,21%

**Table 2 – Baseline for the indicators related to the Hybrid buses**

Whole fleet	BASELINE 2009
2) Fuel mix	1,01% of the fuel is consumed by Hybrid busses (Methane gas + Electricity)
4) CO emissions	9.022 kg CO/year
5) NOx emissions	46.407 kg NOx/year
6) Small particulate emissions	480 kg SP/year

**Table 3 – Baseline for the indicators related to the Whole fleet**

### C1.3 Building the Business-as-Usual scenario

The existing plant was put into operation on May 2008 and has been running at top speed since 2009. Without CIVITAS contribution the extension of the plant wouldn't have taken place therefore indicators related to the clean energy production can be considered constant.

In relation to the fleet it must be underlined that only hybrid buses are conditioned by the energy produced by the plant and Brescia Trasporti had already decided to purchase two new hybrid busses therefore we can make the same assumption already made for measure 01.06 "Clean and energy efficient public transport fleet in Brescia", namely:

- the bus urban network was substantially modified in 2004, when it was extended to the suburban area of Brescia. Therefore, since 2004 the total number of km travelled by the whole fleet can be considered constant, because the fleet itineraries, frequency or capacity didn't vary considerably;
- the km covered by each kind of vehicle has been set constant;
- the fleet composition has been estimated in 2012, keeping the same kind of vehicles of the baseline situation but varying the number of vehicles. This hypothesis is especially valid in the case of the hybrid busses, which in the BaU scenario cover the same amount of km of the baseline situation. It's possible to assume that the on demand transport service (served by that kind of vehicles) without the Civitas contribution in 2012 wouldn't have experienced any significant change in terms of mileage.

As a consequence of the methodological assumptions mentioned above, in the BaU scenario, the BaU values of the indicators n.1 (Average Operating Revenues) and n.7 (CO<sub>2</sub> emission avoided), which both depend on the energy produced by the plant, equal the baseline ones. In particular, Indicator. 1 has been calculated projecting the historical data series (because the monthly operating revenues are available since may 2008).

Photovoltaic Plant	BaU 2012
1) Average Operating Revenues	23'885,46 €
7) CO <sub>2</sub> emission avoided	24'762 kg/year

**Table 4 – BaU for the indicators related to the Photovoltaic Plant**

The BaU scenario for the indicators n.3 (Energy consumption of the hybrid busses/tot energy produced by solar plant) and n.8 (% km Hybrid busses) has been built taking into account the purchase of 2 new hybrid busses. As the energy consumed by the hybrid fleet depends on the km covered by the fleet itself (which has been set constant in time), the BaU values of these two indicators equal the baseline ones.

<b>Hybrid busses</b>	<b>BaU 2012</b>
3) Energy consumption for hybrid bus/tot fuel produced by solar plan	80,34 %
8) % Km Hybrid bus	1,21 %

**Table 5 – BaU for the indicators related to the Hybrid busses**

The BaU scenario of the indicators related to the whole fleet depends on the mileage covered by each kind of vehicle composing the fleet (which has been considered constant, according to the assumptions described above), therefore, the fuel mix (Indicator. 2) and the emissions estimation (indicators n.4 “CO emissions”, n.5 “NOx emissions” and n.6 “Small particulate emissions”) equal the baseline values.

<b>Whole fleet</b>	<b>BaU 2012</b>
2) Fuel mix	1,01% of the fuel is consumed by Hybrid busses (Methane gas + Electricity)
4) CO emissions (kg/year)	9.022 kg CO/year
5) NOx emissions (kg/year)	46.407 kg NOx/year
6) Small Particulate emissions (kg/year)	480 kg SP/year

**Table 6 – BaU for the indicators related to the Whole fleet**

## C2 Measure results

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

This measure is not related to others in terms of measure output.

### C2.1 Economy

**Table C2.1.1: Results obtained for the Indicators corresponding to area “economy”**

Indicator	Before (May. 2008-Apr. 2009)	After (May 2011 - April 2012)	B-a-U (May 2011 - April 2012)	Difference: After –Before	Difference: After – B-a-U
1. Average Operating Revenues	21.710,00 €;	76.883,00 €	21.887,70 €	+ 55.173,00€	+54.995,30 €

Indicator n. 1 (Average Operating Revenues), makes evident that installing a photovoltaic plant using the national funding leads to revenues growth (in this case of +210%).

### C2.2 Energy

**Table C2.2.1: Measure results for the indicators of the category “Energy”**

Indicator	Before (year 2009)	After (year 2011)	B-a-U (2011=2012) (*)	Difference: After –Before	Difference: After – B-a-U
2. Fuel mix	1,01% of the fuel is consumed by Hybrid busses (Methane gas + Electric)	(year 2011) 1,03% of the fuel is consumed by Hybrid busses (Methane gas + Electric)	1,01% of the fuel is consumed by Hybrid busses (Methane gas + Electricity)	+ 0,02 %	+ 0,02 %
3. Energy consumption for hybrid bus/tot fuel produced by solar plant	80,34 %	29,75%	80,34 %	-50,59%	-50,59%



**(\*) The BaU scenario in 2012 is the same as the one in 2011 as the methodological assumptions taken for the building of the two scenarios didn't change. For more details see the section "C.1.3 Building the Business-as-Usual scenario".**

Indicator n.2 (fuel mix) expresses the fuel consumption of the hybrid vehicles respect to the total fuel consumed by the fleet.

As the km covered by the hybrid busses didn't substantially vary in time (99.911 km in 2009; 101.300 km in 2011), the fuel consumption keeps a stable trend.

As regards indicator n. 3 (Energy consumption for hybrid bus/tot fuel produced by solar plant), the extension of the photovoltaic plant allowed the use of a lower part of the energy produced by the plant for the hybrid busses battery power supply considering, at the same time, the increasing of the hybrid fleet from 4 to six buses.

### C2.3 Environment

**Table C2.3.1: Measure results for the indicators of the category "Environment"**

Indicator	Before (2009)	After (2011)	B-a-U (2011=2012) (*)	Difference: After –Before	Difference: After – B-a-U
4. CO emissions	9.022 kg/year	8.262 kg/year	9.022 kg/year	- 760 kg/year	- 760 kg/year
5. NOx emissions	46.407 kg/year	42.476 kg/year	46.407 kg/year	- 3.931 kg/year	- 3.931 kg/year
6. Small particulate emissions	480 kg/year	211 kg/year	480 kg/year	-269 kg/year	-269 kg/year
7. CO2 emissions avoided	24.762 kg/year	67.807 kg/year	24.762 kg/year	+ 43.045 kg/year	+ 43.045 kg/year
8. % Km Hybrid bus	1,21%	1,25%	1,21%	+ 0,04 %	+ 0,04 %

**(\*) The BaU scenario in 2012 is the same as the one in 2011 as the methodological assumptions taken for the building of the two scenarios didn't change. For more details see the section "C.1.3 Building the Business-as-Usual scenario".**

As regards the indicators concerning the pollutant gas emissions of the fleet (indicators n. 4, 5, 6 and 7, expressed in kg/year) a general decrease is observed in the after situation.

In particular, the small particulate emissions register the most significant decrease, while the CO<sub>2</sub> avoided emissions is more than doubled.

The km covered by the hybrid busses (expressed by the indicator n. 8) register a stable trend, because, even if two new hybrid busses were purchased, the mileage covered increased less than 1%. as the

hybrid buses are mainly used for “On demand” service for disabled people and for “Bussola” service (the latter remains within the historical centre).

The final consideration about the results obtained through the calculation of the selected indicators is that the objectives set by this measure have been widely achieved.

### Summary of the main CBA results (for more details see Annex 3)

The CBA was carried out comparing the two scenarios: Scenario 0 (any PV extension purchase of two new CNG 8m long buses and their substitution after 15 years, i.e. at the end of the technical life) and Scenario 1 (implemented thanks to the Civitas initiative, i.e extension of the PV plant and purchase of 2 hybrid methane-electric 8m long buses).

From the observation of the CBA results, it’s possible to say that the purchase of n.2 hybrid buses and of the additional photovoltaic system (Scenario 1) is paid back in approx. 12 years (NPV>0 at 2022), likely thanks to:

- the use of a part photovoltaic energy to feed the new hybrid busses;
- the sale of the remaining third of photovoltaic energy (surplus);
- the lower maintenance and emission costs in scenario 1 (Civitas measure) respect to Scenario 0 (Business-as-Usual)

### C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	<p>Recharge batteries of all hybrid busses within the available fleet by using energy from the new photovoltaic system that will be integrated to the already existing one</p> <p><b>Indicator. 3</b> <i>Energy consumption for hybrid buses/total fuel produced by solar plant</i></p> <p><i>Before (year 2009) = 80,34%</i></p> <p><i>After (year 2011) = 29,75 %</i></p> <p><i>The energy required for the hybrid buses batteries recharge, in relation to the present fleet, was already entirely covered by the existing photovoltaic plant before Civitas.</i></p> <p><i>The objective can be anyway considered more than achieved because the extension of the photovoltaic plant, besides covering the energetic cost of the current fleet, will be able to support a fleet composed by a higher number of hybrids vehicles (of those were purchased in 2011). This eventuality is given by the transport company will to extend the 8m hybrid buses fleet for a new On demand transport service addressed to the low density residential areas.</i></p>	***
2	<p>Decrease of 7% of electricity demand in the range of peak with a reduction of 10% of cost currently incurred</p> <p><i>This objective can be expressed in terms of “Average Operating Revenues” (Indicator. 1) instead of “currently incurred costs”.</i></p> <p><i>Before (year May 2008 – Apr 2009) = 21.710,00 €</i></p> <p><i>After (year May 2011 – Apr 2012) = 76.883,00€</i></p>	***

No.	Target	Rating
	<p><i>The objective is Exceeded.</i></p> <p><i>The extension of the photovoltaic plant will allow to increase the revenues and, as a consequence, to decrease the energy costs of the company.</i></p>	
3	<p>Produce 144 Mwh/year (during Civitas: 138 Mwh)</p> <p><i>The achievement can be evaluate considering the energy monthly produced.</i></p> <p><i>From <b>indicator n. 1</b> it's possible to extract the amount of energy monthly produced by the plant.</i></p> <p><i>Before (year May 2008 – Apr 2009) = 46.243 MWh</i></p> <p><i>After (year May 2011 – Apr 2012) = 165.178 MWh</i></p> <p><i>As the plant as good as doubled after its extension, it's possible to assess that also the energy production is more than doubled, therefore this objective can be considered exceeded.</i></p>	***
4	<p>Reduce CO2: 50 tCO2/year (during Civitas: 100 tCO2)</p> <p><i><b>Indicator n. 7</b> "CO2 avoided" is able to express the achievement of this objective. As the plant as good as doubled after its extension, it's possible to assess that also tha amount of CO2 avoided doubled, therefore this objective can be considered exceeded..</i></p> <p><i>Before (year 2009) = 24.762 kg/year</i></p> <p><i>After (year 2011) = 67.807 kg/year</i></p>	**
5	<p>Save energy: 19 TOE/year (during Civitas: 38 TOE)</p> <p><i>The network energy savings thanks to the production of energy from a photovoltaic plant is estimated in 0,23 TOE every MWh produced.</i></p> <p><i>From <b>indicator n. 1</b> it's possible to extract the amount of energy produced by the plant, therefore the calculation of the energy saving is made multiplying that value by 0,23:</i></p> <p><i>Before (year May 2008 – Apr 2009) = 0,23 TOE/MWh * 46,.243 MWh = 10,635 TOE</i></p> <p><i>After (year May 2011 – Apr 2012) = 0,23 TOE/MWh * 165,178 MWh = 37,99 TOE</i></p> <p><i>As the plant as good as doubled after its extension, it's possible to assess that also the energy production increases, therefore this objective can be considered achieved in full.</i></p>	***
<p><b>NA = Not Assessed    O = Not Achieved    * = Substantially achieved (at least 50%)</b>  <b>** = Achieved in full            *** = Exceeded</b></p>		

## C4 Up-scaling of results

No up-scaling is possible at the moment as the available part of the roof has already been covered by photovoltaic elements. Whenever there will be a part of roof available the up-scaling will be possible with economic and energetic benefits proportional to the up-scaling itself.

## C5 Appraisal of evaluation approach

The evaluation approach firstly considered project's objectives as expressed explicitly in the original evaluation plan. The data collection methodology and the data quality are sufficient for the needs of technical evaluation of the measure.

The indicators were selected at the beginning of Civitas project and the chosen ones belong to the following categories: Economy, Energy and Environment. The ex ante and ex post data collections were carried out as defined in the original plan.

Indicators n.2. "Fuel mix" n.3. "Energy consumption for hybrid bus/tot fuel produced by solar plant" and n. 8 "% Km Hybrid bus" evaluated the impact of the measure in relation to the Hybrid fleet, even if the number of the hybrid vehicles compared to all the BST fleet is small (6 vehicles per 203 vehicles in 2011, equal to 3%),

Indicators n. 4 "CO emissions", n. 5 "NOx emissions", n. 6 "Small particulate emissions", n.7 "CO2 emissions avoided" evaluated the results in relation to emission reduction that could be useful whenever a choice related to the possibility of creating a roof available for the photovoltaic panels is taken into consideration (i.e up-scaling action, more details in section C.1.1). Also Indicator n. 1 "Average operating revenues" is useful for the same reason.

## C6 Summary of evaluation results

The key results are as follows:

- **Key result 1 – energy production:** The new plant (76,8 KWp) was built in the period Jan-Mar 2011 and start up in April 2011. In the first year (May 2011-Apr.2012) the new system produced 97.736 kWh. This production was almost the double of the previous production (the old plant in the same time produced 53.739 kWh). The whole plant in the first year (May 2011-Apr.2012) produced 151.475 kWh (97.736kwh +53.739 kWh).
- **Key result 2 – emission reduction:** In the first year (May 2011-Apr.2012) the new system caused the reduction of 52Ton of CO2, the old caused the reduction of 29Ton. The whole plant in the first year (May 2011-Apr.2012) produced the reduction of 81 Ton (52Ton + 29 Ton).
- **Key result 3 – emission reduction:** In the first year (May 2011-Apr.2012) the new system caused the saving of 22.5TOE, the saving of 12,4 TOE. The whole plant in the same period caused the saving of 34.8 TOE.

## C7 Future activities relating to the measure

No activities are foreseen for this measure except regular maintenance of the plant.

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## D. Process Evaluation Findings

### D.0 Focused measure

It is a focus measure which substitutes M. 07.02 “Freight distribution in Brescia”.

Considering that this measure is about an energy power plant, the available quantitative data were considered suitable for Cost Benefit analysis (see Annex 3).

### D1 Deviations from the original plan

The deviations from the original project/plan comprised:

- **Deviation 1 (project) New Measure proposal** – This measure substituted M 01.10 “New CNG fuelling station in Brescia” presented in the first DOW, in accordance with the topics and the budget foreseen in WP 1 of MODERN project. As it was introduced in the first amendment of the DOW this measure is shorter than the others.
- **Deviation 2 (plan) Time plan** – The delay registered in the formal approval of the DOW amendment led to a further delay in the start up of the measure: instead of starting at project month 17 it started five months later (month 22);
- **Deviation 3 (plan) Time plan** – there were also small delays with the entities involved (network manager and department of customs) due to the regulations for start up of the photovoltaic system.

### D2 Barriers and drivers

#### D2.1 Barriers

##### Preparation phase:

No barriers encountered.

##### Implementation phase:

- **Barrier 1: Financial barrier** – Regional funding to the Local Public Transport companies was reduced.
- **Barrier 2: Technological barrier** – Difficulties in finding the necessary devices for the photovoltaic plant because national funding was limited within a time period penalizing the systems installed after January 1st 2011. Everybody tried to install photovoltaic plans in 2010 and as a consequence inverter devices were sold out.
- **Barrier 3: Institutional barrier** – Late formal approval of the first contract amendment by the EC led to a delay in the start of the measure.

##### Operation phase:

No barriers encountered.

## **D2.2 Drivers**

### **Preparation phase:**

No drivers encountered.

### **Implementation phase:**

- **Driver 1: Political Driver** – The measure is in accordance with the policy of Brescia Trasporti and more generally with the policies of the city based on sustainable development. As a matter of fact the production of renewable energy obtains a reduction of CO2 emission in atmosphere and energy saving in terms of TOE.
- **Driver 2: Planning Driver** – There was an accurate planning of the technical requirements analysis and economical aspects necessary for the implementation of the new photovoltaic system based on improvement of the existing one.
- **Driver 3: Organizational Driver** – Agreements were taken with experienced installers.

### **Operation phase:**

No drivers encountered.

## **D2.2 Activities**

### **Implementation phase:**

A constructive partnership was created between Brescia Trasporti (and the holding Brescia Mobilità) and Brescia Municipality in order to develop common actions aiming at the reduction of CO2.

Therefore the implementation phase of the measure foresaw a shared design of the plant avoiding any possible contrast between Brescia Trasporti and Brescia Municipality.

## **D3 Participation**

### **D.3.1 Measure partners**

The partners of this measure are Brescia Mobilità and Brescia Trasporti.

**Brescia Trasporti** is the transportation public company of the Municipality of Brescia, and has a well-know leadership at national level in terms of a high-quality, competitive, modern transport service.

**Brescia Mobilità** is Brescia mobility agency and it is the holding of Brescia Trasporti.

### **D3.2 Participation of stakeholders**

The involvement of stakeholders isn't foreseen, considering that Brescia Trasporti is part of Brescia Mobilità and it has to stand by the advanced policy of Brescia Mobilità itself.

## **D4 Recommendations**

### **D.4.1 Recommendations: measure replication**

**Recommendation 1** - Research activities are important to define the executive design of a photovoltaic system according to the safety and innovativeness of the system itself

### **D.4.2 Recommendations: process**

**Recommendation 1** – Verify the availability of funding that can make the implementation of the measure easier

**Recommendation 2** – if funding is limited within a time period it may be possible to have a shortage of technical devices, due to a general rush.

## Annex 1: Historical data series for the BaU calculation

### Indicator 1 (Average Operating Revenues)

	YEAR 1												TOTALS YEAR 1	
	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09		
Nominal power installed	50	50	50	50	50	50	50	50	50	50	50	50	50	46'243 KWH
<b>PRODUCED ENERGY</b>	7'351	6'345	7'577	6'835	3'295	2'495	1'203	850	863	1'929	3'230	4'270		
"conto energia" fare	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Gross revenues from "conto energia"	2'940	2'538	3'031	2'734	1'318	998	481	340	345	772	1'292	1'708		
tax deduction 4%	118	102	121	109	53	40	19	14	14	31	52	68		
<b>A) Net revenues from "conto energia"</b>	<b>2'823</b>	<b>2'436</b>	<b>2'910</b>	<b>2'625</b>	<b>1'265</b>	<b>958</b>	<b>462</b>	<b>326</b>	<b>331</b>	<b>741</b>	<b>1'240</b>	<b>1'640</b>		<b>17'757 euro</b>
Energy cost (VAT excluded in bill)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
<b>B) Revenues from bill savings</b>	735	635	758	684	330	250	120	85	86	193	323	427		<b>4'624 euro</b>
<b>Total gross revenues (A+B)</b>	<b>3'558</b>	<b>3'071</b>	<b>3'667</b>	<b>3'308</b>	<b>1'595</b>	<b>1'208</b>	<b>582</b>	<b>411</b>	<b>418</b>	<b>934</b>	<b>1'563</b>	<b>2'067</b>		<b>22'382 euro</b>
excise UTF	56	56	56	56	56	56	56	56	56	56	56	56	56	
<b>TOTAL NET REVENUES</b>	<b>3'502</b>	<b>3'015</b>	<b>3'611</b>	<b>3'252</b>	<b>1'539</b>	<b>1'152</b>	<b>526</b>	<b>355</b>	<b>362</b>	<b>878</b>	<b>1'507</b>	<b>2'011</b>		<b>21'710 euro</b>

Tab. A1.1: data useful to calculate the revenue related to the year 1 (May 2008/April 2009)

	YEAR 2												TOTALS YEAR 2	
	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10		
Nominal power installed	50	50	50	50	50	50	50	50	50	50	50	50	50	48'354 kWh
<b>PRODUCED ENERGY</b>	4'523	6'827	7'727	6'707	4'787	3'557	1'216	997	1'259	1'815	3'395	5'544		
"conto energia" fare	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
Gross revenues from "conto energia"	1'809	2'731	3'091	2'683	1'915	1'423	486	399	504	726	1'358	2'218		
tax deduction 4%	72	109	124	107	77	57	19	16	20	29	54	89		
<b>A) Net revenues from "conto energia"</b>	<b>1'737</b>	<b>2'622</b>	<b>2'967</b>	<b>2'575</b>	<b>1'838</b>	<b>1'366</b>	<b>467</b>	<b>383</b>	<b>483</b>	<b>697</b>	<b>1'304</b>	<b>2'129</b>		<b>18'568 euro</b>
Energy cost (VAT excluded in bill)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
<b>B) Revenues from bill savings</b>	452	683	773	671	479	356	122	100	126	182	340	554		<b>4'835 euro</b>
<b>Total gross revenues (A+B)</b>	<b>2'189</b>	<b>3'304</b>	<b>3'740</b>	<b>3'246</b>	<b>2'317</b>	<b>1'722</b>	<b>589</b>	<b>483</b>	<b>609</b>	<b>878</b>	<b>1'643</b>	<b>2'683</b>		<b>23'403 euro</b>





Mileage and fuel consumption	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID		TOTAL
						methane	electric	
km travelled in 2009	520'811	470'463	508'843	1'199'516	5'458'189	69'938	29'973	8'257'733
%	6,33%	5,72%	6,18%	14,58%	66,34%	1,21%		
Factor consumption (km / lt - mc or kWh/km)	2,0287	2,0287	2,0287	2,0287	1,4613	1,4613	1,25	
Fuel consumption by type (lt - mc-KWH)	256'722	231'904	250'822	591'273	3'735'160	4'7860	37'467	
Fuel consumption by type (kg - mc)		1'111'152						
Fuel consumption by type MJ		45'557'222			128'676'255	1'648'774	134'880	175'882'251
Fuel mix %		25,90%			73,16%	1,01%		

Tab.A1.5: data useful to calculate the indicator "fuel mix"

**Indicator 3** (Energy consumption for hybrid bus/tot fuel produced by solar plan)

YEAR	2009
Tot km travelled by hybrid busses	99 911
30% by electric fuel	29 973
70% by methan fuel	69 938
Average consumption by electric busses (kwh/km)	1,25

YEAR	2009
B = energy consumption by electric bus(kwh/year)	37 467
C = energy produced by solar plant (kwh/year)	46 633
<b>A = Energy consumption (B/C) = Indicator 3</b>	<b>80,34%</b>

Tab.A1.6: data useful to calculate the indicator “energy consumption”

**Indicator 4 (CO emissions)**

Calculation CO emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID
km traveled in 2009	520.811	470.463	508.843	1.199.516	5.458.189	99.911
CO emission factor (g/km)	2,2	1,9	1,9	1,69	0,721	0,530
CO emission per year (kg/year)	1.146	894	967	2.027	3.935	53,0
						<b>TOT</b>
						<b>9.022</b>

Tab.A1.7: data useful to calculate the indicator “CO emission”

**Indicator 5 (NOx emissions)**

Calculation NOx emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID
km travelled in 2009	520.811	470.463	508.843	1.199.516	5.458.189	99.911
NOx emission factor (g/km)	12,8	9,04	9,04	9,36	3,584	0,980
NOx emission per year (kg/year)	6.666	4.253	4.600	11.227	19.562	98
						<b>TOT</b>
						<b>46.407</b>

Tab.A1.8: data useful to calculate the indicator “NOx emissions”

**Indicator 6 (Small particulate emissions)**

Calculation PT emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID
km travelled in 2009	520.811	470.463	508.843	1.199.516	5.458.189	99.911
SP emission factor (g/km)	0,0268	0,358	0,0268	0,194	0,009	0,017
SP emission per year (kg/year)	14	168	14	233	49	2
						<b>TOT</b>
						<b>480</b>

Tab.A1.9: data useful to calculate the indicator “Small particulate emissions”

**Indicator 7 (CO2 emission avoided)**

CO2 AVOIDED	2008(*)	2009
B = energy produced by solar plant (kwh/year)	35'922	46'633
C = Emission factor (kgCO2/kwh)	0,531	0,531
D = CO2 avoided (kg/year)	19'075	24'762

(\*) The plant was put into service on 1<sup>st</sup> May 2008. Production refers to the period that goes from May to December 2008

Tab.A1.10: data useful to calculate the indicator “CO2 emissions avoided”

**Indicator 8 (% Km Hybrid bus)**

KM HYBRID BUS	2008	2009
B = tot km travelled by hybrid bus	95.909	99.911
C = tot km travelled by fleet	8.491.903	8.257.733
A= % km hybrid bus (B/C)	1,13%	1,21%

*Tab.A1.11: data useful to calculate the indicator “% Km Hybrid bus”*

## Annex 2: Ex ante and Ex Post data collection

### Indicator 1 (Average Operating Revenues)

		YEAR 1												TOTALS YEAR 1			
		May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09				
Nominal power installed	kWp	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
<b>PRODUCED ENERGY</b>	kWh	7'351	6'345	7'577	6'835	3'295	2'495	1'203	850	863	1'929	3'230	4'270	4'270	4'270	4'270	46'243 KWH
"conto energia" fare	€/kWh	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	
Gross revenues from "conto energia" tax deduction 4%	€	2'940	2'538	3'031	2'734	1'318	998	481	340	345	772	1'292	1'708	1'708	1'708	1'708	
<b>A) Net revenues from "conto energia"</b>	€	2'823	2'436	2'910	2'625	1'265	958	462	326	331	741	1'240	1'640	1'640	1'640	1'640	17'757 euro
Energy cost (VAT excluded in bill)	€/kWh	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,10	
<b>B) Revenues from bill savings</b>	€	735	635	758	684	330	250	120	85	86	193	323	427	427	427	427	4'624 euro
<b>Total gross revenues (A+B) excise UTF</b>	€	3'558	3'071	3'667	3'308	1'595	1'208	582	411	418	934	1'563	2'067	2'067	2'067	2'067	22'382 euro
<b>TOTAL NET REVENUES</b>	€	3'502	3'015	3'611	3'252	1'539	1'152	526	355	362	878	1'507	2'011	2'011	2'011	2'011	21'710 euro

Tab.A2.1.-data useful to calculate the revenue related to the year 1 (May 2008/April 2009)

### Ex post data collection (year 2011)

This are revenues derive from:

- government funding per each kWh produced by the equipment (0,40 €/kWh for the existing equipment – 0,384 €/kWh for the new equipment),
- revenues due to economic saving in electric bill (0,10 €/kWh)
- revenues due to energy put in electricity network (0,103 €/kWh)

net of deductions and excises. The production data (kWh produced) are obtained monthly through electricity meter of photovoltaic power system.

	mag-11	giu-11	lug-11	ago-11	set-11	ott-11	nov-11	dic-11
Nominal power installed	126,8	126,8	126,8	126,8	126,8	126,8	126,8	126,8
Produced energy (old plant)	7'568	6'317	7'197	7'571	5'002	3'892	1'888	1'248
Produced energy (new plant)	17'820	10'900	12'386	12'744	8'460	6'750	3'450	2'323
<b>PRODUCED ENERGY</b>	<b>39'091</b>	<b>56'308</b>	<b>75'891</b>	<b>96'206</b>	<b>109'668</b>	<b>120'310</b>	<b>125'648</b>	<b>129'219</b>
"conto energia" fare (old plant)	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
"conto energia" fare (new plant)	0,384	0,384	0,384	0,384	0,384	0,384	0,384	0,384
Gross revenues from "conto energia" (old plant)	3'027	2'527	2'879	3'028	2'001	1'557	755	499
Gross revenues from "conto energia" (new plant)	6'843	4'186	4'756	4'894	3'249	2'592	1'325	892
tax deduction 4%	395	268	305	317	210	166	83	56
<b>A) Net revenues from "conto energia"</b>	<b>9'475</b>	<b>6'444</b>	<b>7'330</b>	<b>7'605</b>	<b>5'039</b>	<b>3'983</b>	<b>1'997</b>	<b>1'336</b>
Energy cost (VAT excluded in bill)	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
<b>B) Revenues from bill savings</b>	<b>2'539</b>	<b>1'722</b>	<b>1'958</b>	<b>2'032</b>	<b>1'346</b>	<b>1'064</b>	<b>534</b>	<b>357</b>
Energy put in the network	0	2'400	1'200	1'200	0	0	0	0
<b>Price of the energy put in the network (VAT excluded)</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>	<b>0,103</b>
<b>C) Revenues from the energy put in the network</b>	<b>0</b>	<b>247</b>	<b>124</b>	<b>124</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>TOTAL GROSS REVENUES (A+B+C)</b>	<b>12'014</b>	<b>8'413</b>	<b>9'412</b>	<b>9'760</b>	<b>6'386</b>	<b>5'047</b>	<b>2'531</b>	<b>1'693</b>
excise UTF	30	30	30	30	30	30	30	30
maintenance cost					900			
<b>TOTAL NET REVENUES</b>	<b>11'984</b>	<b>8'383</b>	<b>9'382</b>	<b>9'730</b>	<b>5'456</b>	<b>5'017</b>	<b>2'501</b>	<b>1'663</b>
<b>TOTAL CUMULATED NET REVENUES</b>	<b>18'096</b>	<b>26'479</b>	<b>35'861</b>	<b>45'591</b>	<b>51'047</b>	<b>56'064</b>	<b>58'564</b>	<b>60'227</b>

	gen-12	feb-12	mar-12	apr-12
Nominal power installed	50	50	50	126,8
Produced energy (old plant)	kWp	2054	1685	4564
Produced energy (new plant)	kWh	3780	2820	8323
<b>PRODUCED ENERGY</b>	kWh	5834	10339	22883
"conto energia" fare (old plant)	€/kWh	0,4	0,4	0,4
"conto energia" fare (new plant)	€/kWh	0,384	0,384	0,384
Gross revenues from "conto energia" (old plant)	€	822	674	1826
Gross revenues from "conto energia" (new plant)	€	1452	1083	3196
tax deduction 4%	€	91	70	204
<b>A) Net revenues from "conto energia"</b>	€	2182	1687	4893
Energy cost (VAT excluded in bill)	€	0,1	0,1	0,1
<b>B) Revenues from bill savings</b>	€	583	451	1254
Energy put in the network	kWh	0	0	1200
<b>Price of the energy put in the network (VAT excluded)</b>	€/kWh	0,103	0,103	0,103
<b>C) Revenues from the energy put in the network</b>	€	0	0	124
<b>TOTAL GROSS REVENUES (A+B+C)</b>	€	2766	2137	6072
excise UTF	€	30	30	30
maintenance cost	€			400
<b>TOTAL NET REVENUES</b>	€	2736	2107	5642
<b>TOTAL CUMULATED NET REVENUES</b>	€	2736	4843	10485
				16656

Tab.A2.2.-data useful to calculate the revenue related to the year May 2011/April 2012



**Indicator 2 (Fuel mix) Ex ante: year 2009**

Mileage and fuel consumption	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID		TOTAL
						methane	electric	
km travelled in 2009	520'811	470'463	508'843	1'199'516	5'458'189	69'938	29'973	8'227'760
%	6,33%	5,72%	6,18%	14,58%	66,34%	1,21%		
Factor consumption (km / lt - mc - kWh)	2,0287	2,0287	2,0287	2,0287	1,4613	1,4613	1,25	
Fuel consumption by type (lt - mc-KWH)	256'722	231'904	250'822	591'273	3'735'160	47'860	37'467	
Fuel consumption by type (kg - mc)		1'111'152						
Fuel consumption by type MJ		45'557'222			128'676'255	1'648'774	134'880	175'882'251
Fuel mix %		25,90%			73,16%	1,01%		

Tab.A2.3: data useful to calculate the indicator "fuel mix" (year 2009)

Fleet composition 2011							hybrid (electric-methane)	TOT
n. autobus	diesel euro 0+crt	diesel euro 1	diesel euro 1+crt	diesel euro 2	diesel euro 2+crt	methan gas	6	203
% sul totale	10%	5%	7%	4%	14%	56%	3%	

Tab.A2.4: Brescia Trasporti Fleet composition in 2011

Ex post:

Mileage and fuel consumption	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHAN GAS		HYBRID		TOTAL
					diesel EURO 2+CRT	methan	electric		
km traveled in 2011	416.351	222.225	419.223	149.254	951.163	5.845.017	70.910	30.390	8.104.533
%	5,14%	2,74%	5,17%	1,84%	11,74%	72,12%	1,25%		
Factor consumption (km / lt - mc - kwh)	2,0176	2,0176	2,0176	2,0176	2,0176	1,467	1,467	1,25	175.683.237
Fuel consumption by type (lt - mc-KWH)	206.360	110.143	207.783	73.976	471.433	3.984.333	48.337	37.988	
Fuel consumption by type (kg - mc)	893.195								
Fuel consumption by type MJ	36.620.998								
Fuel mix %	20,84%								
						137.260.283	1.665.201	136.755	175.683.237
						78,13%	1,03%		

Tab.A2.5: data useful to calculate the indicator "fuel mix" (year 2011)

**Indicator 3** (Energy consumption for hybrid bus/tot fuel produced by solar plan) The Ex ante situation refers to year 2009, 2010:

year	2009	2010	2011
tot km travelled by hybrid bus	99.911	93283	101.300
30% by electric fuel	29.973	27.985	30.390
70% by methane fuel	69.938	65.298	51.772

average consumption by electric bus (kWh/km)	1,25
--	------

year	2009	2010	2011
B = energy consumption by electric bus(kWh/year)	37.467	34.981	37.988
C = energy produced by existing solar plant (kWh/year)	46.633	49.419	52.864
D = energy produced by new solar plant (kWh/year)			74.833
E = TOT energy produced by solar plant (kWh/year) (C+D)	46.633	49.419	127.697
A = Energy consumption (B/E)	80,34%	70,78%	29,75%

**B = energy consumption (only new solar plant (B/D))**

**50,76%**

Tab.A2.6: data useful to calculate the indicator "energy consumption"

**Indicator 4 (CO emissions)** Ex ante situation is referred to year 2009.

Calculation CO emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID
km travelled in 2009	520.811	470.463	508.843	1.199.516	5.458.189	99.911
CO emission factor (g/km)	2,2	1,9	1,9	1,69	0,721	0,530
CO emission per year (kg/year)	1.146	894	967	2.027	3.935	53,0
						<b>TOT</b>
						<b>9.022</b>

Tab.A2.7: data useful to calculate the indicator "CO emission" year 2009

Ex post:

Calculation CO emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	diesel EURO 2+CRT	METHANE GAS	HYBRID	TOT
km travelled in 2011	416.351	222.225	419.223	149.254	951.163	5.845.017	101.300	<b>8.104.533</b>
CO emission factor (g/km)	2,2	1,9	1,9	1,69	1,69	0,721	0,530	
CO emission per year (kg/year)	916	422	797	252	1.607	4.214	53,7	<b>8.262</b>

Tab.A2.8: data useful to calculate the indicator "CO emission" year 2011

**Indicator 5 (NOx emissions)** Ex ante situation is referred to year 2009.

Calculation NOx emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID
km travelled in 2009	520.811	470.463	508.843	1.199.516	5.458.189	99.911
NOx emission factor (g/km)	12,8	9,04	9,04	9,36	3,584	0,980
NOx emission per year (kg/year)	6.666	4.253	4.600	11.227	19.562	98
						<b>TOT</b>
						<b>46.407</b>

Tab.A2.9: data useful to calculate the indicator "NOx emission" year 2009

Ex post:

Calculation NOx emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	METHANE GAS	HYBRID	TOT
km travelled in 2011	416.351	222.225	419.223	149.254	5.845.017	101.300	<b>8.104.533</b>
Nox emission factor (g/km)	12,8	9,04	9,04	9,36	3,584	0,980	
Nox emission per year (kg/year)	5.329	2.009	3.790	1.397	20.949	99	<b>42.476</b>

Tab.A2.10: data useful to calculate the indicator "NOx emission" year 2011

**Indicator 6 (Small particulate emissions)** Ex ante situation is referred to year 2009.

Calculation PT emission per year (kg)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 2	METHANE GAS	HYBRID
km travelled in 2009	520.811	470.463	508.843	1.199.516	99.911

SP emission factor (g/km)	0,0268	0,358	0,0268	0,194	0,009	0,017	TOT
SP emission per year (kg/year)	14	168	14	233	49	2	480

Tab.A2.11: data useful to calculate the indicator "Small particulate emissions" year 2009

Ex post:

Calculation year (kg)	PT emission per year (kg/year)	diesel EURO 0+crt	diesel EURO 1	diesel EURO 1+CRT	diesel EURO 2	diesel EURO 2+CRT	METHANE GAS	HYBRID	TOT
km travelled in 2011		416.351	222.225	419.223	149.254	951.163	5.845.017	101.300	8.104.533
PT emission factor (g/km)		0,0268	0,358	0,0268	0,194	0,0268	0,009	0,017	
PT emission per year (kg/year)		11	80	11	29	25	53	2	211

Tab.A2.12: data useful to calculate the indicator "Small particulate emissions" year 2011

**Indicator 7 (CO2 emission avoided)** Ex ante situation is referred to year 2008, 2009 and 2010.

CO2 AVOIDED	2008(*)	2009	2010	2011
A = energy produced by existing solar plant (kWh/year)	35.922	46.633	49414	52864
B = energy produced by new solar plant (kWh/year)				74833
C = Emission factor (kgCO2/kWh)	0,531	0,531	0,531	0,531
<b>D = CO2 avoided (kg/year)</b>	<b>19.075</b>	<b>24.762</b>	<b>26.239</b>	<b>67.807</b>

Tab.A2.13: data useful to calculate the indicator "CO2 emission avoided" year 2008-2011

**Indicator 8 (% Km Hybrid bus)** Ex ante situation is referred to year 2009

KM HYBRID BUS	2009	2010	2011
B = tot km travelled by hybrid bus	99.911	93.283	101.300

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C = tot km travelled by fleet	8.257.733	8.264.227	8.104.533
A= % km hybrid bus (B/C)	1,21%	1,13%	1,25%

*Tab.A2.14: data useful to calculate the indicator “% Km Hybrid bus” year 2009-2011*

## Annex 3: Cost Benefit Analysis

### Evaluation period for CBA

The reference year is 2011 and the CBA time horizon coincides with the technical/economic life time of the photovoltaic system (20 years; final CBA year: 2030), longer than the technical/economic life time of the new purchased buses (15 years).

### Method and values for modification

This specific cost/benefit analysis (CBA) is referred exclusively to the actions implemented with CIVITAS support regarding the renewable energy production to feed buses with low environmental impact (Measure M01.11).

Therefore, the new additional photovoltaic system, operating from April 2011, and n.2 new hybrid buses, registered in February 2011, have been taken into consideration.

The previous 50 kWp photovoltaic system, implemented in 2008 by Brescia Trasporti, and the first 4 hybrid busses, purchased in 2003, haven't been considered in this CBA, because they haven't been financed by the CIVITAS initiative. As a consequence, the maintenance costs and the operative revenues deriving from the oldest part of the plant have been neglected. Only the contribution coming from the new part of the plant (co-financed by the Civitas initiative) has been taken into consideration.

The nominal power of the new part of the photovoltaic system is 76,8 kWp and the yearly potential energy production is approx. 100.000 kWh (74.833 kWh have been produced from April 2011 to December 2011).

The total investment cost is 215.540 €2011 (supply of inverters and photovoltaic modules: 177.760 €; other components and installation: 37.780 €).

The plant maintenance costs have been estimated approx. 1.000 €/year

The cost of two new hybrid busses is 415.000 €2011/each and the yearly mileage is 23.000 km/each, of which 7.000 km supported only by electrical batteries.

The CBA takes into consideration the investment costs of the new photovoltaic system/hybrid busses and the consequent variations of the emission costs (reduction of 0,531 kg CO<sub>2</sub>/kWh with photovoltaic production and zero CO<sub>2</sub>, CO, NO<sub>x</sub> and PM emissions with electrical battery use of the new hybrid busses) and of the maintenance costs (the drivers cost has been evaluated unchanged).

The emission quantities of the main environmental polluting agents are shown in Table A3.1 referred to a 12 m methane bus: grams of carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), particulate matter (PM) referred to the energy consumption of 1 kilowatt-hour. As first approximation, the same polluting emission quantities have been assumed for the different methane bus types (8 m vs 12 m long).

TABLE A3.1 – Polluting emission factors referred to a methane bus

EMISSION FACTOR	METHANE BUS
CO emission factor (g/kWh)	2,53
NOx emission factor (g/kWh)	0,38
PM emission factor (g/kWh)	0,003
CO2 emission factor (g/kWh)	206,45

Source: Brescia Mobilità – EURO Normative

The money return of the environmental benefits has been carried out basing on EU data, as agreed during the CIVITAS meeting in Funchal: in particular, the figures (total external costs in urban zone) referred to the main polluting agents (CO, NOx, PM and CO<sub>2</sub>) taken into consideration in the CBA, are shown in Table A3.2 and are referred to Euro 2011.

TABLE A3.2 – Money return of the main polluting agents (€2011/Kg)

EMISSION TYPE	ESTERNAL COST (€2011/kg)
CO emission (*)	0,004
NOx emission (**)	3,830
PM emission (**)	442,848
CO2 emission (**)	0,113

Source: (\*) Astra – Scenario Low External Cost - 2005

(\*\*) HEATCO, D5 Proposal for harmonized Guidelines – Brussels, 2006

Any action able to modify the transport service has been implemented (i.e. variations of the runs number and/or of the means capacity), therefore the traffic revenues are unchanged.

The following economic items (referred to year 2011) have been calculated:

- Net Present Value (NPV)
- B/C ratio
- Investment return rate (IRR).

In particular, CBA has been carried out comparing the scenario Business-as-Usual (Scenario 0: hypothetical situation without CIVITAS actions) with the effective scenario (Scenario 1), which includes the actions implemented thanks to the CIVITAS funding.

**Scenario 0 (Reference case or BaU)**

The energy production and the transport service have been kept constant respect to the CIVITAS operational phase (year 2011). As a consequence, the energy consumption and the pollutant emissions, which vary depending on the mileage, are constant and equal the CBA base year values.

It is assumed that the 8 m buses are substitute at the end of their technical/economic life (15 years) with new 8 m methane busses (no hybrid type). The hypothetical purchase cost has been estimated 274.000 €2011/bus (approx. 33% lower than hybrid busses).

The total residual value of the busses at 2030 has been evaluated 365.200 €2011.

The maintenance costs have been estimated on the base of the yearly kilometrical values, supposed as first approximation to equal the costs of 12 m methane busses and shown in detail in Table A3.3 (average yearly value: 6.879 €/year).

TABLE A3.3 – SCENARIO 0: kilometrical maintenance costs for each methane bus age

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bus City Class Methane 12 m (€/Km)	0.0277	0.0978	0.1560	0.2507	0.1696	0.2703	0.3772	0.4672	0.1664	0.1660	0.4883	0.2192	0.2347	0.2505	1.1448



Source: Brescia Mobilità

As already mentioned in the introduction to this CBA, the contribution deriving from the oldest part of the plant have been neglected, because it has been realized before Civitas. Therefore, only the contribution coming from the new part of the plant (co-financed by the Civitas initiative) has been taken into consideration for the calculation of the maintenance costs and the operative revenues.

### Scenario 1 (Civitas measure)

In this scenario, the situation generated by the Civitas action has been taken into consideration: the new part of the photovoltaic plant (producing 76,8 kWp since 2011) and the purchase, in 2011, of n.2 new hybrid busses have been considered for the calculation of the CBA parameters.

The total investment cost regarding the purchase of the new photovoltaic system and of n.2 hybrid busses (2011) is 1.045.540 €2011 and the residual value at 2030 is estimated 553.333 €2011.

The average yearly maintenance costs of the photovoltaic system and of each hybrid bus are estimated respectively 1.000 €/year and 4.035 €/year.

In particular, the maintenance cost during the hybrid bus life has been distributed in the period of 15 years (see Table A3.4), adopting as first approximation in proportional way the same yearly distribution of the methane bus cost.

TABLE A3.4 – SCENARIO 1: kilometrical maintenance costs for each hybrid bus age

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bus Methane/Hybrid (€/Km)	0,0162	0,0574	0,0915	0,1470	0,0995	0,1586	0,2213	0,2740	0,0976	0,0974	0,2864	0,1286	0,1376	0,1469	0,6715

Source: Brescia Mobilità

The following tables (from A3.5 to A3.11) show the detailed CBA for each year of the time horizon considered (2011-2030).

### Life time cost and benefit

Table A3.5 Busses Capital cost in the evaluation period (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	€830,000
	Reference case (or BAU)	€547,800
Year 2012	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2013	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2014	CIVITAS measure	-
	Reference case (or BAU)	-

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	Cases for comparison	Cost
Year 2015	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2016	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2017	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2018	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2019	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2020	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2021	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2022	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2023	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2024	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2025	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2026	CIVITAS measure	€830,000
	Reference case (or BAU)	€547,800
Year 2027	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2028	CIVITAS measure	-
	Reference case (or BAU)	-
Year 2029	CIVITAS measure	-
	Reference case (or BAU)	-

	Cases for comparison	Cost
Year 2030	CIVITAS measure	-
	Reference case (or BAU)	-

Table A3.6 Photovoltaic system Capital cost in the evaluation period (not discounted)

	Cases for comparison	Cost (e.g. €200,000)
Year 2011	CIVITAS measure	€215,540
	Reference case (or BAU)	-

Table A3.7 Busses Maintenance cost in the evaluation period (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	€747
	Reference case (or BAU)	€1,274
Year 2012	CIVITAS measure	€2,640
	Reference case (or BAU)	€4,500
Year 2013	CIVITAS measure	€4,209
	Reference case (or BAU)	€7,175
Year 2014	CIVITAS measure	€6,764
	Reference case (or BAU)	€11,532
Year 2015	CIVITAS measure	€4,575
	Reference case (or BAU)	€7,800
Year 2016	CIVITAS measure	€7,294
	Reference case (or BAU)	€12,436
Year 2017	CIVITAS measure	€10,179
	Reference case (or BAU)	€17,353
Year 2018	CIVITAS measure	€12,606
	Reference case (or BAU)	€21,492
Year 2019	CIVITAS measure	€4,489
	Reference case (or BAU)	€7,663
Year	CIVITAS measure	€4,479

	Cases for comparison	Cost
2020	Reference case (or BAU)	€7,636
Year 2021	CIVITAS measure	€13,175
	Reference case (or BAU)	€22,462
Year 2022	CIVITAS measure	€5,916
	Reference case (or BAU)	€10,085
Year 2023	CIVITAS measure	€6,331
	Reference case (or BAU)	€10,794
Year 2024	CIVITAS measure	€6,578
	Reference case (or BAU)	€11,522
Year 2025	CIVITAS measure	€30,889
	Reference case (or BAU)	€52,663
Year 2026	CIVITAS measure	€747
	Reference case (or BAU)	€1,274
Year 2027	CIVITAS measure	€2,640
	Reference case (or BAU)	€4,500
Year 2028	CIVITAS measure	€4,209
	Reference case (or BAU)	€7,175
Year 2029	CIVITAS measure	€6,764
	Reference case (or BAU)	€11,532
Year 2030	CIVITAS measure	€4,575
	Reference case (or BAU)	€7,800

Table A3.8 Photovoltaic system Maintenance cost in the evaluation period (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	€750
	Reference case (or BAU)	-
Year 2012	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2013	CIVITAS measure	€1,000
	Reference case (or BAU)	-

	Cases for comparison	Cost
Year 2014	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2015	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2016	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2017	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2018	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2019	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2020	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2021	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2022	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2023	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2024	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2025	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2026	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2027	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2028	CIVITAS measure	€1,000
	Reference case (or BAU)	-

	Cases for comparison	Cost
Year 2029	CIVITAS measure	€1,000
	Reference case (or BAU)	-
Year 2030	CIVITAS measure	€1,000
	Reference case (or BAU)	-

Table A3.9 Photovoltaic system Operating revenues in the evaluation period (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	€28.596
	Reference case (or BAU)	-
Year 2012	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2013	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2014	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2015	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2016	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2017	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2018	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2019	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2020	CIVITAS measure	€41.148
	Reference case (or BAU)	-

	Cases for comparison	Cost
Year 2021	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2022	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2023	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2024	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2025	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2026	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2027	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2028	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2029	CIVITAS measure	€41.148
	Reference case (or BAU)	-
Year 2030	CIVITAS measure	€41.148
	Reference case (or BAU)	-

Table A3.10 Busses Environmental emissions (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2012	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2013	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year	CIVITAS measure	-

	Cases for comparison	Cost
2014	Reference case (or BAU)	€2,384
Year 2015	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2016	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2017	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2018	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2019	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2020	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2021	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2022	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2023	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2024	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2025	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2026	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2027	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year 2028	CIVITAS measure	-
	Reference case (or BAU)	€2,384
Year	CIVITAS measure	-



	Cases for comparison	Cost
2029	Reference case (or BAU)	€2,384
Year 2030	CIVITAS measure	-
	Reference case (or BAU)	€2,384

Table A3.11 Photovoltaic system Environmental emissions (not discounted)

	Cases for comparison	Cost
Year 2011	CIVITAS measure	€4,475
	Reference case (or BAU)	-
Year 2012	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2013	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2014	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2015	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2016	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2017	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2018	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2019	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2020	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2021	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2022	CIVITAS measure	€4,593
	Reference case (or BAU)	-

	Cases for comparison	Cost
Year 2023	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2024	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2025	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2026	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2027	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2028	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2029	CIVITAS measure	€4,593
	Reference case (or BAU)	-
Year 2030	CIVITAS measure	€4,593
	Reference case (or BAU)	-

### Summary of CBA results

The CBA has been carried out comparing the two scenarios previously described.

The average yearly interest rate estimated in the CBA is 3,5%.

Table A3.12 shows the main results of the CBA (net present value, benefits/costs ratio, investment rate return), referred to the final year 2030.

TABLE A3.12 – CBA results between Scenario 1 and Scenario 0 (year 2030)

SCENARIO 1 vs SCENARIO 0	
INTEREST RATE	3,5%
NET PRESENT VALUE (€ 2011)	176.529
BENEFITS/COSTS RATIO	1,56
I.R.R.	7,8%

It's possible to say that the purchase of n.2 hybrid buses and of the additional photovoltaic system (Scenario 1) is re-paid in approx. 12 years (NPV>0 at 2022), thanks to:

- the use of a part photovoltaic energy to feed the new hybrid busses;
- the sale of the remaining third of photovoltaic energy (surplus);
- the lower maintenance and emission costs in scenario 1 (Civitas measure) respect to Scenario 0 (Business-as-Usual), which hypothetically foresees to keep unchanged the situation before the CIVITAS operational phase.

The CBA calculation is shown in the following table and all the figures are referred to Euro 2011

TABLE A3.13 – CBA - Scenario 1 vs. Scenario 0

MEASURE M04.11- RENEWABLE ENERGY PRODUCTION TO FEED BUSES WITH LOW ENVIRONMENTAL IMPACT  
 COSTS/BENEFITS ANALYSIS - Scenario 1 vs Scenario 0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030		
<b>SCENARIO 0 - Buses as Usual: with traditional methane buses</b>																						
Buses investment costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Buses residual value	547,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Buses operating revenues	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Buses maintenance costs	1,274	4,500	7,175	11,532	7,800	12,436	17,353	21,492	7,653	7,656	22,462	10,085	10,794	11,522	52,663	1,274	4,500	7,175	11,532	7,800	-	
Buses emissions	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	2,384	-
<b>SCENARIO 1 - CIVITAS support: with new photovoltaic energy production and n.2 new hybrid buses</b>																						
Photovoltaic system investment costs	215,540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Photovoltaic system operating revenues	28,596	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	-
Photovoltaic system maintenance costs	750	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	-
Photovoltaic emissions	4,475	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	4,593	-
Buses investment costs	830,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buses residual value	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buses operating revenues	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buses maintenance costs	747	2,640	4,209	6,764	4,575	7,294	10,179	12,606	4,489	4,479	13,175	5,916	6,331	6,758	30,889	747	2,640	4,209	6,764	4,575	-	
Buses emissions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>SCENARIO 1 vs SCENARIO 0</b>																						
Investment costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Residual value	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Operating revenues	28,596	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	41,148	-
Maintenance costs	8,662	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	6,971	-
Emissions	462,509	48,986	50,092	51,893	50,350	52,267	54,300	56,011	50,289	50,282	56,412	51,205	51,563	51,859	68,869	234,543	48,986	50,092	51,893	50,350	52,267	-
TOTAL	482,509	413,623	363,431	311,533	261,188	208,921	154,821	98,610	48,321	1,951	56,374	103,669	161,256	213,145	282,844	47,498	95,481	146,573	198,483	238,949	282,844	-
OVERALL TOTAL	35,455	48,986	50,092	51,893	50,350	52,267	54,300	56,011	50,289	50,282	56,412	51,205	51,563	51,859	68,869	48,125	48,986	50,092	51,893	50,350	52,267	-
TOTAL COST	497,963	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INTEREST RATE	3.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NET PRESENT VALUE	-	401,139	355,960	310,738	268,345	225,825	183,146	140,611	103,712	68,066	29,426	4,520	37,505	69,561	110,886	24,579	2,716	29,683	56,676	176,529	310,738	-
BENE.FITS/COSTS RATIO	-	0.17	0.27	0.37	0.48	0.56	0.69	0.80	0.90	1.00	1.12	1.22	1.32	1.43	1.57	1.69	1.78	1.87	1.95	2.02	2.09	-
I.R.R.	-	-	-	-	-	-	-	-	-	0.1%	2.2%	3.7%	4.9%	5.9%	6.9%	7.2%	7.6%	7.9%	8.1%	8.3%	8.4%	-