Measure title: **Alternative fuels in Craiova**

City: **Craiova** *Project:* **MODERN** *Measure number:* **01.02**

Executive summary

Replacing fossil fuels with biodiesel offers a solution against global warming without loss of engine performance and without major engine changes. For this reason, Craiova intended to offer its citizens a better life by using alternative fuels.

In recent years, the necessity of having a clean air in cities has been at the center of attention of many public authorities, research institutions and business companies. The city of Craiova is well aware of this need and is currently working to achieve this goal by different interventions. This measure is such an intervention and its objective consisted in promoting the use of biofuels to replace conventional diesel in the public transport system.

The measure introduced for demonstration 10 buses (Roman UDM type) belonging to the Public Transport Company (RAT), which were slightly modified with additional filters to run with biodiesel up to 20% concentration.

First tests were made on 2 buses fuelled with mixtures of 5 (this is the standard fuel which is supplied at filling stations), 10, 15 and 20% biodiesel in conventional diesel. The physical properties of different biodiesel mixtures and the emissions of buses using biodiesel mixtures were measured and analysed within the University of Craiova in dedicated laboratories. Based on these tests it was decided that for operation to be used a blend of 20% biodiesel and the 10 buses for demonstration were included in the operation program and run in the city.

For the evaluation of the measure’s impact, were defined indicators from three categories: economy (costs), energy (efficiency) and environment (specific emissions). Different alternatives, scenarios and situations were characterized based on these indicators. These cases were compared with the CIVITAS intervention and highlighted in a realistic way the effect of the measure, its efficiency and the impact produced.

The evaluation’s results demonstrated a real benefit for RAT in terms of operational costs (reduction of operational costs of 1.32%) and for the quality of life in the city, due to the emissions’ reduction equal to 8.91% of CO2 emissions for the buses running with biodiesel B20 compared with 2% reduction that is the measure’s target assumed for the emissions. It should be mentioned that the demonstration period was short and the results should be considered only a first assessment of the new fuel and an encouraging reason to repeat the trials for a longer period of time.

During the implementation it has been found that there is a large deficiency in terms of legislative framework to encourage biodiesel production and to support its widespread use as fuel. In addition, the global economic situation steadily worsened since 2008 led to the withdrawal from the market of many producers of biodiesel. To overcome these barriers we have been forced to reduce the demonstration group of buses from 88 to 10 and to change the original timetable when needed, without causing problems in the timely completion of the measure.

The introduction of biodiesel in the public transport is no longer a pioneering action. There are cities/transport companies already using for a long time this fuel without any problems. The result of the evaluation in our case is a positive one but the economic context, biodiesel market trends, and national legislative context represent strong criteria in the decision to introduce biodiesel as usual practice in the public transport future operation.

Based on the results of evaluation, on the experience of other cities and considering the technical state of the RAT's buses, the introduction of B20 as current fuel in parallel with a careful monitoring of buses could lead to real benefits.

We believe also that the wide application of this fuel depends actually only on political and economic reasons that are being found from global, down to local level. There are regulations/general recommendations and there are particular initiatives at cities level but to accelerate the adoption of biodiesel is needed to stimulate both producers and users, to develop a legislative framework focused on this area and to make much lobbying so that to overcome the operators' inertia.

A.Introduction

A1 Objectives

The measure objectives are:

(A) High level / longer term:

- To reduce emissions in the city

(B) Strategic level:

- To implement alternative fuel in PT

(C) Measure level:

- To use a fuel mixture with up to 20% biodiesel
- To test this mix on a batch of 10 buses belonging to RAT
- To decrease emissions level up to 2% for buses operating with mix of biodiesel in conventional diesel fuel.

A2 Description

Transportation activities release in the atmosphere around 33% of CO2 as result of fossil fuel combustion. Replacing fossil fuels with biodiesel offers a solution against global warming without loss of engine performance and without engine changes.

Numerous studies and scientific researches demonstrate that climatic changes from the last decades are the effect of the carbon dioxide increasing level, with transportation system being one of the main reasons. Replacing fossil fuels with alternative ones is now getting more and more a widespread solution to tackle climate change, with mature technologies offering an attractive and efficient alternative.

Following the experience of other CIVITAS cities, Craiova city aims to start a set of actions targeting a partial replacement in the public transport system of fossil fuels with biodiesel.

Initially, the Public Transport Company of Craiova – RAT – planned to introduce the biodiesel in two stages: firstly on a limited number of buses (10 buses) and then extending the intervention to 88 buses.

Unfortunately, the economic context induced by the global economic crisis and the poor national legislation in the field of regulations on biodiesel usage led to some changes in terms of the sample size of buses to be used for the pilot tests from 88 to 10 vehicles.

Hence, in the implementation stage 10 buses have been endowed with additional filters to be able to run with biodiesel. During the technical work on buses the drivers and the maintenance technicians have been trained to learn working with the new fuel, under a program supported by the company responsible for the buses adaptations.

Two out of the 10 buses have been set in a testing program for a period of 4 weeks. The two buses have been fuelled by different blends, namely 5% (which is the standard fuel according to the national regulation), 10%, 15% and 20% biodiesel. For each mixture were measured the density, power content and viscosity. Emissions corresponding to each mixture were determined for different engine speeds. The data collected have then been analysed and it was decided to select the B20 (i.e. 20% biodiesel) as the blend for the demonstration stage to be performed with 10 buses.

The 10 buses running with 20% biodiesel demonstrated a reduction of 8.93% of the emissions which is a good and encouraging result for the city environment and also a small reduction of operational costs which could be a good and promising reason for extending the measure to a larger number of buses.

B.Measure implementation

B1 Innovative aspects

- **Use of new technology/ITS**

Use of non-conventional fuel – in our case biodiesel – in the public transport of Craiova represents a technical novelty for our city and also a solution for the limitation of GHG in the city. The alternative fuels are getting used for the first time in the public transport of Craiova.

This is a new technology which will be applied at DEMO scale on a batch of 10 buses supporting the general efforts to meet the principles of sustainable public transport.

The mix of conventional diesel fuel and biodiesel leads to a lower level of emissions and does not change the engine performance..

Research and Technology Development

State of the art in the use of bio-fuels

During the research and technology activities the state of the art in the use of bio-fuels and the bio-fuels market have been examined by using literature and online sources. Besides this usual desk work, a research about good practices and supporting policies adopted by other countries regarding the use of biodiesel has been performed. The analysis has been made by studying policies and regulations of neighbour countries (i.e. Bulgaria, Serbia, Ukraine and Hungary), other European countries and worldwide (United States, Canada, Japan, China, South America and South-East Asia).

From the research work it was noted that many countries have introduced various regulations on the introduction of biodiesel. These policies are generally aligned to a common global policy focused on two directions: to reduce GHG and decrease fossil fuels dependence.

The Graz city (AT) was presented as good practice concerning the research and observations made during the 3-years field tests which were carried out in co-operation with the Institute of Internal Combustion Engines and Thermodynamics (Graz University of Technology), the Institute of Organic Chemistry (University of Graz) and the Austrian Biodiesel Institute. The city buses were regularly checked by these institutes, monitoring the exhaust gas emissions, the driver abilities, the effects on engine power and fuel consumption, any changes in the quality of the motor oil, and the wear and deposit in the engine. After a total mileage of 270’000 km with biodiesel, no additional, abnormal wear in comparison to the use of mineral oil diesel was found. The positive results of field tests encouraged Graz to extend the use of biodiesel to a large number of buses leading to remarkable results of city air quality. The Graz case could encourage also other cities in the use of biodiesel in the urban transport.

The technical and market aspects of using biodiesel in on buses have been analysed in details by also correlating them with local conditions. Additionally, the technical and economic conditions affecting the use of biodiesel have been investigated.

According to the European Biodiesel Board, the Romanian production of biodiesel reached in 2010 approximately 70’000 tons that is the 0.73% of the total production with respect to the 9,570,000 tons at EU27 level[1].

In the recent years more than in the past, due to the macroeconomic context affected by the global recession, the investments in biodiesel industry were reduced and the production declined dramatically.

Beside the production issues, the quality of biodiesel is variable and it can often be contaminated mainly by glycerine, it can face problems because of its gel point, and there can be some water. Glycerine, in fact, creates problems causing deposits with negative effects on combustion chamber. The gel point, instead, comes out to be a problem in two cases: when using the biodiesel over 25% and in zones with temperate climate like Romania, where 4-6 months per year the temperature drops below zero making biodiesel unusable. Water presence could induce problems in the injection process and during engine operation.

All these inconveniences were solved by installing in the 10 tested buses specific filters before the fuel injection in the combustion chamber.

For harmonizing Romanian legislation with the EU one and for completing the legislative framework in the energy field, it was adopted the Government Decision nr.1844/2005 on the promotion of biofuels and other renewable fuels in transport by transposing the European Directive 2003/30/CE. According to this decision a minimum percentage of biofuels or other renewable fuels placed on the market has been gradually introduced in the fossil fuel, as follows:

- 2% from 2007
- Minimum of 5.75% by 31 December 2010

Currently the Romanian legislation is in line with EU requirements and introduced gradually biodiesel in the fossil diesel. As a consequence, the standard diesel at the fuelling station now contains 5% biodiesel. The blends can be legally made only by licenced companies and supplied to users (transport companies, fuelling stations).

According to the *Government Ordinance 456* of 2007 the mandatory blending percentages for fuel used in transport were set out as follows:

- From 1 July 2007 a minimum content of 2% of biodiesel
- From 1 January 2008 a minimum content of 3% of biodiesel
- From 1 July 2008 a minimum content of 4% of biodiesel
- From 1 January 2010 a minimum content of 5% of biodiesel

[1] http://www.ebb-eu.org/stats.php

Unfortunately Romania does not benefit of a very well developed program in terms of "green" fuel production. In addition, the promotion and supporting initiatives of biodiesel production were quite poor in the last years. Romanian producers complain that biodiesel is proving an unprofitable business in Romania. They say that big oil producers prefer to import biodiesel rather than buy it from local producers. This situation has led many producers to leave the production of biodiesel.

Studies result about diesel engine modifications for using more than 20% bio-diesel

Another part of RTD studies analysed the engine modifications required by considering two possible alternatives: fuel mix up to 20% of biodiesel and over 20% – considered this limit being critical for engines working without major modifications.

The use of biodiesel over 20% needs major changes of the engine and so they require a homologation (approval) according to the national regulations. In addition, the climate zone where Craiova is located does not allow the use of biodiesel in the cold season, approximately 4-6 months per year when its viscosity is high.

Following the study findings, the biodiesel content was limited to 20% and the measure was redesigned taking into account the technical implications knowing that RAT buses fleet is quite old and could not have supported a change of fuel used because of potential consequences on the engine operation.

Considering the physical and chemical properties of biodiesel and all the consideration outlined in the RTD studies, the following conclusions to use biodiesel with B20 blend have been drawn up:

1. The engines require minimal technical modifications;
2. The costs for these modifications are minimal;
3. No approval is necessary for the modified engines;
4. No approval is necessary for the vehicles running with the modified engines;
5. No approval is necessary for the feed pumps of fuel stations;
6. No approval is necessary for the fuel supply tanks.

The technical modifications to the buses working with biodiesel B20 have been made in order to provide quality assurance for elastic and plastic components on the alimentation route in case of using biodiesel. The main element installed to protect the engine supply route against the acid corrosion of biodiesel fuel, consisted in a special filter as shown in the figure below:

Figure 1 – Biodiesel filter

The normal bus filters have then be replaced with the new ones. The inlet and outlet couplings on the engine supply circuit have been fixed and sealed on the new filter.

B2 Situation before CIVITAS

Craiova surface is around 100 km^2, being divided by 17 buses routes. The Public Transport Company has a fleet of 176 buses most of them being older than 10 years. In November 2008 RAT purchased 17 new buses MAN Lion's City because buses older than 10 years were depreciated and did not comply with the requirements of the Environmental Protection Agency. Currently the RAT fleet is predominantly old and should be enforced by new buses or by adoption of new solutions to limit the pollution level.

According to the targets defined by the EC about the use of biofuels, Member States should introduce progressively biofuels in their transport fuel mix, reducing the dependence from fossil fuel. The existing legislation recommended a limit of 4% biofuel in 2008 and a target of 5.75% for 2010. The limits for 2020 were initially foreseen equal to 10% but it seems that this standard is too high for a relatively short period and therefore, according to the latest analysis performed by the DG-TREN, it is expected a substitution of only 6.9% in 2020.

The European standards have been applied in Romania according to the stipulated terms and diesel fuel at the pump contains now 5% biodiesel. The use of biodiesel as alternative fuel came to the attention of the Municipality as a result of the experience of other cities in Romania (Constanta, Cluj, Alba Iulia) which have introduced this fuel in different research programs and obtained successful results. The existing and numerous research papers, the published results on the use of biodiesel, the European policies to promote the use of alternative fuels, the targets that the EU has stipulated in this direction, all these have motivated the decision to implement the measure in Craiova.

B3 Actual implementation of the measure

- **Stage 1**: **Planning and design of the measure**

In order to determine how the measure can be applied and integrated into the development strategy of the Public Transport Company (RAT), several meetings with the technical team from Craiova and politicians from the Municipality were organized prior to the starting of the RTD work in fact but also during the development of this initial task.

Through the RTD analyses and studies described in paragraph B.2, it was found out that there was a reduced possibility of obtaining alternative fuel in the quantity required to test 88 buses due to several economic barriers which became more pronounced in 2009 when the economic crisis became evident. As a consequence the number of buses used for tests was reduced to 10 instead of the 88 initially foreseen.

The work undertaken in this stage contributed to the decision of introducing the above changes in the original shape of the measure and to design accordingly the measure.

- **Stage 2: Training for involved technicians**

The following activities have been carried out:

- definition of the participants, the trainers and the training program
- development of the training by the company which made the up-grade of the buses

The training program was held in 3 sections:

1. <u>Technical staff training – 4 engineers</u>

   The company that installed the biodiesel filters organized a training session for 4 engineers from RAT. The training program was divided into theoretical and practical notions and lasted one day. Moreover, the four engineers assisted at the filters installation and had the opportunity to know in details how they operate. The training program was further organized and held by the 4 technicians.

2. <u>Training of maintenance mechanics – 12 mechanics</u>

   12 mechanics were trained about the installation and use of devices for use of biodiesel fuel. The course lasted 3 hours for each group of 4 mechanics and was divided into theoretical and practical notions. Finally, the mechanics received written instructions on the operation and maintenance of the filters.

3. <u>Training of buses drivers – 10 drivers</u>

   The training program was held for 10 drivers. The course content was the same as for mechanics. Biodiesel filters do not involve special issues for drivers but considering that it is a new fuel it has been considered necessary drivers to be aware of changes made.

- **Stage 3: Modification of buses to run with biodiesel up to 20%**

The buses for trials with biodiesel mixtures were selected and prepared to run with biodiesel by endowing them with filtering devices to avoid the fuel entering in the lubrication system. Biodiesel filters were installed on 10 buses belonging to RAT fleet as follows: 7 ROMAN 112 UDM, 1 Mercedes, 1 MAN SL, 1 Bredabus.

Figure 2 – Modifications on buses

Stage 4: Test with bio-diesel up to 20% (January – April 2012)

In recent years most of the regional biodiesel producers closed their activity due to a lot of reasons among which the lack of raw material, increasing of fees, general recession process. As a consequence, the use of biodiesel has been limited to 10 buses. The tests were made on 2 buses fuelled gradually with mixtures of 5% (standard fuel of fuelling station), 10%, 15% and 20% biodiesel in conventional diesel.

A testing plan was developed including the detailed working methodology. Basically the tests consisted in preparing controlled mixtures of biodiesel, fuelling the 2 assigned buses and examine them within dedicated laboratories of the Craiova University according to an agreed protocol. The initial testing plan provided in the deliverable developed in this stage was changed and adapted to the available conditions. The methodology for the tests followed a certain number of steps, namely:

1. Preparation of mixtures of diesel – biodiesel by the fleet operator (RAT) under controlled conditions of the concentration; 4 blends were analysed in laboratory: 5% (standard diesel fuel), 10%, 15% and 20% biodiesel mixtures. The measured parameters have been: calorific power, viscosity, and density.
2. Analysis of the emissions in engine gas exhaust pipe (NO_x, SO2, CO, CO_2, and O_2) produced by using the above mentioned biodiesel blends performed on 2 ROMAN 112 UDM buses.
3. Each bus was tested 2 consecutive days by using each of the 4 biodiesel blends. The testing program was:
    - 8 and 9 March 2012, for standard diesel (i.e. 5% biodiesel in volume, B5)
    - 15 and 16 March 2012, with fuel containing 10% biodiesel in volume (B10)
    - 22 and 23 March 2012, with fuel containing 15% biodiesel in volume (B15)
    - 29 and 30 March 2012, with fuel containing 20% biodiesel in volume (B20)

    The pollutant emissions level analysis in engine gas exhaust pipe (NOx, SO2, CO, CO2, and O2) was determined for each bus working in 3 representative consecutive rotational speeds ranges (recommended by the buses owner/operator): 550 ÷ 600 RPM, 850 ÷ 900 RPM and 1150 ÷ 1200 RPM.

The data referring to the physical parameters have been presented by the University of Craiova in the study performed and the database with emissions were attached to the study in two excel files, one for each bus. (The raw data of emissions are presented in Annex 1).

The different biodiesel mixture and the buses emissions were analysed and the tests results led to the decision on the optimal content of biodiesel for the operation of 10 buses.

Figure 3 – Equipment for the emissions' measurements

Figure 4 – Measurement of emissions at tailpipe

- **Stage 5: System running**

The 10 buses started to run with biodiesel blend B20 for two weeks in the first half of October 2012 and were carefully monitored to promptly intervene in case of technical malfunctions.

In last five years most of the regional biodiesel producers closed their activity due to a lot of reasons: lack of raw material, increasing of fees, general recession process. Moreover, the national regulations do not allow to blend fuels than in licenced warehouses. According to the current legislation, the mixture of 20% (B20) is not standardized and therefore cannot be used except for limited test actions. Purchase of biodiesel for 10 buses and finding a legal solution for mixing it with diesel fuel inside

RAT has been a major issue that led to delays of the demonstration phase and limited the operating period to only 2 weeks (first half of October 2012).

Due to the fact that the 10 buses have run in the city only a short period of time, this period has been considered as a pilot test extended to a larger number of buses (from 2 to 10) and not a fully operational stage.

RAT usually keeps a record of every bus daily activity and centralizes these data monthly and annually. To monitor the 10 buses that worked with biodiesel the same type of evidence sheets have been used. Hence, the main data monitored and information recorded have been:

- Name of bus driver;
- Mileage at the beginning of the month and cumulative mileage at the end of each day;
- The effective time of the trip;
- The fuel consumption.

In evaluating the indicators aggregated data have been used for the mileage and the actual consumption recorded by the 10 buses during the 2 testing weeks.

At the end of each day, the drivers had the duty to mention the technical failures occurred to the monitored buses or the important issues related to the engine operation. During the demonstration there were no failures or engine malfunctions that could be caused by fuel switching, but drivers noted that buses had not enough power when they were fully loaded and passengers have noticed a distinct smell when traveling.

The monitoring sheets for buses running with biodiesel and the cumulative data sheet are reported in Annex 2**.**

Figure 5 – Fuelling station of RAT buses

B4 Inter-relationships with other measures

M01.02 Alternative Fuels in Craiova and M01.07 Transition towards Clean Fleets in Craiova aim both to reduce the emissions coming from public transport. The measure M01.07, in fact, foresaw to find an appropriate grant to replace the fleet of old buses running daily in Craiova with low polluting vehicles and an option was also the acquisition of buses that can run with B20.

C Impact Evaluation Findings

C1 Measurement methodology

C1.1 Impacts and Indicators

Table C1.1: Indicators

No.	Impact	Indicator	Data used	Comments
1	**Economy**	Average Operating costs	– Km travelled /month – Fuel consumption /month	For the 10 buses targeted: – 7 ROMAN 112 UDM, – 1 Mercedes, – 1 MAN SL, – 1 Bredabus
2	**Energy**	Vehicle Fuel Efficiency	– Fuel consumption /month for 10 buses operating with biodiesel – Km travelled/month for 10 buses operating with biodiesel	
3	**Environment**	CO_2, CO, NO_x emissions	– Emissions measured on the testing bench (ppm or %) – Fuel consumption /month for 10 buses operating with biodiesel – Km travelled/month for 10 buses operating with biodiesel – Average vehicle speed in urban area	

Detailed description of the indicator methodologies

The following elements should be considered in the context of indicators calculation:

- The 10 buses operated with biodiesel two weeks in the first half of October 2012.
- The indicators calculation and their analysis were done for a month (October 2011) for the ex-ante, and October 2012 for ex-post analysis. Therefore data from the same period of the year have been collected for both the ex-ante and ex-post periods in order to have similar operating conditions in terms of traffic, occupancy, air temperature, and so to reduce the number of variables that could influence the buses operative conditions and avoid as much as possible any misinterpretations.
- The hypothesis to extrapolate data for the whole year does not make sense because it would be applied a linear variation which would lead to the same results.

- **Indicator 2 (*Average Operating costs*)** - Ratio of total operating costs incurred by the 10 monitored buses divided by the total vehicle-km travelled in the period considered. All data are related to the 10 monitored buses.

  A = B / C, where:

A = Average operational costs for the service (€/vKm)

B = Total operational costs for the service (€), limited to the fuel cost, this being the only cost element that changes. It has been assumed that all the other cost categories (personnel, maintenance, spare parts, etc.) are similar for the buses running with conventional diesel as for those running with biodiesel mixture of 20%.

C = Total vehicle- Km

Argumentation for operational costs: Sources of literature specify that B20 does not affect the engine life differently than conventional diesel. Moreover, due to its higher lubrication this fuel can improve the engine life. For instance in a study called "Biodiesel"[2] it is specified that the use of B20 for covering 2.25 x 10^6 km did not produce any problems. Also, in a study of the European Biodiesel Board it is specified that the tests performed for long periods of time (i.e. 12 years) by using a B50 blend (50% biodiesel) – which means more that the blend used for testing the 10 buses – have shown that the functional components of a vehicle do not wear down in a different way than in the case with only conventional diesel[3]. Similar considerations have been found by the city of Graz (AT).

The data used in the indicator calculation were provided by RAT and are characteristic to the first 2 weeks of October 2012.

RAT usually keeps a record of every bus daily activity and centralizes these data monthly and yearly per total fleet and type of buses. Depending on the case we asked the appropriate data.

- **Indicator 3** ***(Vehicle Fuel Efficiency)*** Energy consumption of 10 buses adapted to run with biodiesel per unit of transport activity.

A = B / C, where:

A = Average vehicle energy efficiency (MJ/vkm)

B = Total energy consumed for the 10 vehicles considered (MJ)

The energy content of fuel (MJ/kg) was determined in laboratory during the testing period for various blends of biodiesel together with other physical properties of mixtures, like density, and viscosity. The values of these parameters have been calculated by the University of Craiova[4].

[2] Biodiesel, Andreea Cretu, http://www.scribd.com/doc/94699012/Biodieselul
[3] European Biodiesel Board: : http://www.ebb-eu.org/studies.php
[4] Research concerning level analysis of pollutant emissions produced by buses operating with biodiesel fuel in Craiova city / contract no. 5C/27.02.2012.

Figure 6 – Equipment for the energy content measurement

Figure 7 – Equipment for viscosity determination

B = Total energy consumed for the 10 vehicles considered (MJ) was calculated with the formula:

$\mathbf{B = P_{cal} \times \rho \times M}$, where

P_{cal} = Energy content of fuel ((MJ/kg)

ρ = Fuel density determined in laboratory (kg/m3) and converted in kg/litre

M = Quantity of fuel consumed by 10 buses, resulted from data provided by RAT (litres)

C = Total amount of vehicle-kilometres completed by the 10 monitored vehicles, unit: (vkm)

*** It should be noted that RAT provided for the ex-ante indicators calculation the monthly record of mileage and fuel consumption by type of buses so the mileage/fuel consumed by 10 buses have been proportionally calculated from the data corresponding to all buses of the same type that have operated in the considered period.

- **Environment indicators*(CO_2, CO, NO_x)***

Emissions measurement was a subcontracted work with the University of Craiova.

The testing program, measurement methodology and equipment used have been detailed in the developed study. Measurements were made both on the buses running with conventional diesel and on B20 (20% biodiesel).

Figure 8 – Measurements of emissions at tailpipe

The environmental indicators considered in the measure's evaluation have been:

- **Indicator n. 8 (CO2)**
- **Indicator n. 9 (CO)**
- **Indicator n. 10 (NO_x)**

O2 emissions were additionally measured even if they are not listed as indicator but allowed us to convert the ppm in g/unit of activity for the measured emissions.

Emissions were measured in ppm or % and then converted in g/vkm using a simplified methodology adopted.

Measurements were made for different engine speeds from 500 to 1200 rpm. The normal operating speed of an engine in urban conditions is of 1200 rpm/minute so we extracted from emissions only the data corresponding to the rotational speed of 1200 rpm/minute.

The COPERT methodology does not have options for a fuel mixture as in the case of this measure. Therefore to calculate the environmental indicators a simplified method based on Core Inventory of Air Emissions - EMEP/CORINAIRE of the European Environment Agency has been used. The method was developed and used by IPA in FP6/CREATING project and it has been adapted for the evaluation of this measure.

The calculation methodology we adopted is further presented.

Step1: Calculation of the exhaust gas flow

The exhaust gas based on the fuel flow and air to fuel ratio is as follows:

$\mathbf{G_{EXHW} = G_{FUEL} \times (1 + \lambda \times A/F_{st})}$ where:

G_{EXHW}= exhaust gas mass flow rate (kg/h)

G_{FUEL}= fuel mass consumption (kg/h)

λ = air to fuel ratio

Lambda was calculated by using EC regulations for internal combustion engines (EC Directive 26/2004):

$$\lambda = \frac{\left(100 - \frac{conc_{CO} \times 10^{-4}}{2} - conc_{HC} \times 10^{-4}\right) + \left(0.45 \times \frac{1 - \frac{2 \times conc_{CO} \times 10^{-4}}{3.5 \times conc_{CO_2}}}{1 + \frac{conc_{CO} \times 10^{-4}}{3.5 \times conc_{CO_2}}}\right) \times \left(conc_{CO_2} + conc_{CO} \times 10^{-4}\right)}{6.9078 \times \left(conc_{CO_2} + conc_{CO} \times 10^{-4} + conc_{HC} \times 10^{-4}\right)}$$

where:

$conc_{CO}$ = concentration of CO (ppm)

$conc_{CO_2}$= concentration of CO2 (%)

$conc_{HC}$= concentration of hydrocarbons (ppm)

The HC (hydrocarbons emissions) were not measured but generally in a well done burning process they have values under 100 ppm and their influence on the lambda value is insignificant. So we might consider them zero.

A/F_{st} = stoichiometric air to fuel ratio

Different sources provide different reports for A/Fst both for conventional diesel fuel and biodiesel depending on the raw materials in the biodiesel case. Using constantly the same A/Fst values the calculation error which could occur is the same and will not produce errors in the interpretation of data.

In the calculation methodology the following values for A/Fst have been used (Stoichiometric air/fuel ratio) [kg air/kg fuel]:

- Fossil diesel: 14.53
- Biodiesel 100% (B100): 12.3

[Source: An overview of biofuel technologies, market and policies in Europe**,** E. van Thuijl, C.J. Roos, L.W.M. Beurskens/Energy research Centre of the Netherlands (ECN)[5].

For the fuels used in the measure we calculated the following values for the A/Fst:

- B5 (biodiesel 5% which is assimilated with diesel because the current diesel fuel at fuel stations have already a content of 5% biodiesel according to the national regulations): A/Fst= 14.42
- B20: A/Fst =14.09

The A/Fst calculated are presented in the table below:

Stoichiometric ratio air/fuel (A/Fst) **for different fuels**	
Diesel oil	14,530
Biodiesel fuels	12,300

		Biodiesel	**Diesel oil**	**Biodiesel 5% (B5)**
Quantity used for fuels mixture	[litres]	5	95	100
density	[kg/l]	0,819	0,84	
Quantity used for fuels mixture	[kg]	4,095	79,8	83,895
air for combustion	[kg]	50,3685	1159,494	1209,8625
A/Fst for B5				**14,42**

		Biodiesel	**Diesel oil**	**Biodiesel 20% (B20)**
Quantity used for fuels mixture	[litres]	20,00	80,00	100
density	[kg/l]	0,819	0,84	
Quantity used for fuels mixture	[kg]	16,38	67,2	83,58
air for combustion	[kg]	201,474	976,416	1177,89
A/Fst for B20				**14,09**

<u>Step 2 - Calculation of emissions mass flow rates</u>

The emissions mass flow rates is calculated as follows:

$$\mathbf{Gas(i)_{mass} = conc(i) \times \rho(i) \times G_{EXHW} \times 10^{-6} \quad (kg/h)}$$ where:

[5]http://www.ssc.it/pdf/2005/biofuel_UE2005.pdf

$Gas(i)_{mass}$ = instantaneous flow of gas i in exhaust gases, calculated above (kg/h)

conc(i) = concentration of gas i in exhaust gases, measured (ppm)

ρ(i) = density of exhaust component, kg/ m^3, (we assume that the density of exhaust gases is around 1 kg/m^3)

The ρ(i) calculated for each exhaust gas is given in the table below:

Gas	Molar weight / molar volume	Density (kg/m3)	Comments
CO2	44 / 22.4	**1,96**	
CO	28 / 22,4	**1,25**	
O2	32 / 22,4	**1,43**	
HC ($H_{1.85}C_1$)	(1,85+1*12)/22,4	**0,62**	average carbon to hydrogen ratio: 1: 1.85 in case of diesel fuel
NO_x(x=1.8)	(14+1,8*16)/22.4	**1,91**	considered as a mixture of equal parts of NO, NO2, NO3 si N2O3 (supposition)

Step 3 - Calculation of the specific emissions

The Specific emission (g/vehicle-km) shall be calculated for each individual component in the following way:

$$Specific\ emissions = \frac{Gas(i)_{mass} \times 10^{-3}}{fuel_{cons} \times vehicle\ speed} \times average\ fuel\ cons$$ where,

Specific emissions = emissions per unit of transport activity (g/vehicle-km)
$Gas(i)_{mass}$ = instantaneous flow of gas i in exhaust gases (kg/h)
$Fuel_{cons}$ = fuel consumption (litres/km)

For buses running with conventional diesel we used monthly data provided by RAT. For the 10 buses running with biodiesel blend we used the data recorded by drivers during the demonstration period.

- vehicle speed = average speed of buses in the city (km/h)
  The vehicle speed value is an average one provided by RAT based on daily activity sheets where the arrival and departure time are recorded. The route length is known and the speed of buses is periodically calculated. An average speed is calculated every year and used in statistics. For the 10 buses running with B20 the vehicles speed was calculated based on mileage and time recorded by drivers demonstration sheets
- average fuel consumption = fuel consumption per unit of transport activity(litres/vehicle-km)

The calculus methodology was applied to indicators number 8,9 and 10.

C1.2 Establishing a Baseline

The economic developments during the period 2008-2011 caused significant market disturbances affecting the fuel unit costs. Also other cost elements have been modified (maintenance, staff salaries) in an unpredictable way. All these fluctuations caused by economic crisis would certainly induce discrepancies between the results when we tried to evaluate the situation during this period. To remove these random perturbations we decided that the reference year be 2011, year when it was felt some economic stability which had allowed us a comparative analysis with the year when the project MODERN acted.

The analysis of the reference year was based on data from RAT, the phisical parameters and environmental data obtained by measurements and included in the study of the University of Craiova.

The results we obtained in the baseline year are:

Baseline (ex-ante) Year 2011			
Indicator number / name		**Unit**	**Results**
Indicator 2	***Average Operating costs***	EURO/vkm	0.4012
Indicator 3	***Vehicle Fuel Efficiency***	MJ/vkm	15.61
Indicator 8	***CO2 emissions***	g/vkm	1’345.27
Indicator 9	***CO emissions***	g/vkm	46.72
Indicator 10	***NOx emissions***	g/vkm	6.20

The calculation sheets for each baseline (ex-ante) indicator, year 2011, are in **annex 3** and the data used in the indicators calculation are presented in the tables bellow:

Indicator 2 - ***Average operating costs ex-ante (EURO/vkm)***

Operational costs for 10 buses (EURO)	11’823
Total vehicle- km (mileage) for 10 buses (km)	29’469
Price (EURO/litre)	0.99
Fuel consumption per unit of activity (l/vkm)	0.4044
Average Operating costs – ex-ante (EURO/vkm)	**0.4012**

Indicator 3 ***Vehicle Fuel Efficiency ex-ante (MJ/vkm)***

Energy content of fuel (MJ/kg)	45.862
Fuel density (kg/l)	0.8415
Fuel consumption for 10 buses (litres)	11’918
Total vehicle- km (mileage) for 10 buses (km)	29’469
Energy content of fuel consumed by 10 buses (MJ)	459’947
Vehicle Fuel Efficiency (MJ/vkm)	15.61

Indicators 8,9,10 Emissions ex-ante (g/vkm)

Emissions measured at the tailpipe depend on the fuel type and the engine working parameters when the measurements are being made. The emissions measured for buses running with diesel fuel and calculations data are further presented:

Average values of emissions measured for buses running with standard diesel oil (B5)	***CO (ppm)***	***CO2 (%)***	***NO_x (ppm)***
	970.64	1.78	84.30

Engine speed (rot/min)	1’200
A/Fst (Stoichiometric ratio air)	14.42
Fuel consumption per unit of activity (l/vkm)	0.404
CO - Specific emissions ex-ante g/vkm	***46.72***
CO2 - Specific emissions ex-ante g/vkm	***1’345.27***
NO_x- Specific emissions ex-ante g/vkm	***6.20***

C1.3 Building the Business-as-Usual scenario

The introduction of biodiesel seemed an appropriate measure for Craiova and in full compliance with European policies on renewable energy orientation at the time of project proposal preparation. During the project implementation, as a result of adaptation to the economic conditions of the moment, this measure has undergone some changes by reducing the sample size demonstration.

If in 2007 the idea of introducing biodiesel to the entire fleet of buses through MODERN project or even on their own initiative seemed a realistic one, the year 2009 brought major changes regarding this type of intervention: reducing the biodiesel market and the number of producers, the lack of a steady offer of biodiesel.

Looking at the overall economic and financial context created by the global crisis we can say that without the MODERN project (Business-as-Usual scenario), RAT and Craiova Municipality would not have been introduced biodiesel as an alternative to the fossil fuels currently used. So BAU scenario is equal to the “nothing to do” scenario.

Business-as-Usual scenario has the start situation in 2011 (reference year) and configures the evolution of indicators for 2012 in case of not introducing biodiesel.

The indicators value for the BAU scenario are the following:

Indicator name	**Unit**	**BAU Results**	
		2011	**2012**
Indicator 2 / *Average Operating costs*	EURO/vkm	0.4012	0.4022
Indicator 3 / *Vehicle Fuel Efficiency*	MJ/vkm	15.61	15.05
Indicator 8 / *CO2 emissions*	g/vkm	1’345.27	1’296.96
Indicator 9 / *CO emissions*	g/vkm	46.72	45.04
Indicator 10 / *NO_x emissions*	g/vkm	6.20	5.98

The calculation sheets for each BAU indicator related to the BAU for the years 2011 and 2012 are reported in Annex 4 while the data used for the indicators calculation are presented in the tables below:

Indicator 2/*Average Operating costs – BAU*

	2011	2012
Operational costs for 10 buses (EURO)	11’823	11’553
Total vehicle - km (mileage) for 10 buses (km)	29’469	28’726
Price (EURO/litre)	0.99	1.03
Fuel consumption per unit of activity (l/vkm)	0.404	0.390
Average Operating costs – BAU (EURO/vkm)	0.4012	0.4022

During the analysis, the price of fuel and the exchange rate RON / EURO have suffered frequent changes following specific markets trends. In any case, we can say that the values obtained allow us to draw conclusions and predictions for the following period. In a period of economic stability when the elements of the operation cost are constant, the element which must be controlled and produces changes in this indicator is the fuel consumption per unit of activity. The indicator does not differ too much in the two years, what is normal considering that the diesel fuel prices were very close in the two years (0,99 and 1,03 Euro/liter) and the fuel consumptions per unit of activity have had almost the same value in both years of 0,04 liter/vkm).

Indicator 3 / *Vehicle Fuel Efficiency – BAU*

	2011	2012
Energy content of fuel (MJ/kg)	45.862	45.862
Fuel density (kg/l)	0.8415	0.8415
Fuel consumption for 10 buses (litres)	11’918	11’200
Total vehicle- km (mileage) for 10 buses (km)	29’469	28’726
Energy content of fuel consumed by 10 buses (MJ)	459’947	432’248
Vehicle Fuel Efficiency (MJ/vkm)	15.61	15.05

This indicator, as it is defined, represents the energy consumption per unit of activity which means that we get efficiency if this indicator is less, i.e. we have lower fuel consumption per unit of activity or use a lower amount of energy to perform the same activity. Efficiency means energy saving or, in our case, fuel saving.

In our BAU scenario the differences between the fuel efficiency per vkm in 2011 and 2012 are insignificant and show a stable situation which is expected in the case of the constant activity that takes place under the same conditions.

Indicators 8,9,10 Emissions -BAU

Average values of emissions measured for buses running with standard diesel oil (B5)	***CO (ppm)***	***CO2 (%)***	***NO_x(ppm)***
	970.64	1.78	84.30

	2011	**2012**
Engine speed (rot/min)	1200	1200
A/Fst (Stoichiometric ratio air)	14.42	14.42
Fuel consumption per unit of activity (l/vkm	0.404	0.390
CO - Specific emissions ex-ante g/vkm	46.72	45.04
CO2 - Specific emissions ex-ante g/vkm	1’345.27	1’296.96
NO_x- Specific emissions ex-ante g/vkm	6.20	5.98

General comments on the emissions indicators:

Emissions have a slight downward trend and this is normally given that the amount of fuel per unit of activity decreased slightly in 2012 compared with 2011. Without any intervention on fuel quality, fuel type, adoption of retrofitting technologies or new buses, the emissions will be more or less dictated by the amount of fuel consumed (they are a result of the quantity of the fuel burned) and will follow only the fuel consumed trend.

C2 Measure results

This measure was demonstrated in 2012 for a short period of time (2 weeks) due to the dificulties in acquiring the biodiesel needed for running of 10 buses for a long period of time.

During this period the 10 buses prepared with specific filters operated with biodiesel blend B20 (20%). They were carefully monitored and all the data refering to their activity were recorded for each bus under observation.

The ex-post evaluation (“after”) provide data referring only to this period.

The values of ex-post indicators are listed in the table below:

Indicator number	***Indicator name***	***Unit of measurement***	***Indicator value***
Indicator 2	*Average Operating costs*	EURO/vkm	0.396
Indicator 3	*Vehicle Fuel Efficiency*	MJ/vkm	14.34
Indicator 8	*CO2 emissions*	g/vkm	1’225.38
Indicator 9	*CO emissions*	g/vkm	40.76
Indicator 10	NO_x *emissions*	g/vkm	7.17

The calculation sheets for ex-post indicators are reported in Annex 5 while the data used for calculating the indicators are presented in the tables bellow:

Indicator 2 - ***Average operating costs ex-post (EURO/vkm)***

Operational costs for 10 buses (EURO)	3’783
Total vehicle- km (mileage) for 10 buses (km)	9’555
Price (EURO/litre)	1.02
Fuel consumption per unit of activity (l/vkm)	0.387
Average Operating costs – ex-post (EURO/vkm)	**0.396**

Indicator 3 ***Vehicle Fuel Efficiency ex-post (MJ/vkm)***

Energy content of fuel (MJ/kg)	45’245
Fuel density (kg/l)	0.819
Fuel consumption for 10 buses (litres)	3’697
Total vehicle- km (mileage) for 10 buses (km)	9’555
Energy content of fuel consumed by 10 buses (MJ)	136’995
Vehicle Fuel Efficiency (MJ/vkm)	**14.34**

Indicators 8,9,10 Emissions ex-post (g/vkm)

Emissions measured at the tailpipe depend on the fuel type and the engine working parameters when the measurements are made.

Average values of emissions measured for buses running with biodiesel fuel B20	***CO (ppm)***	***CO2 (%)***	***NO_x(ppm)***
	852.76	**1.63**	**98.23**

Engine speed (rot/min)	1’200
A/Fst (Stoichiometric ratio air)	14.09
Fuel consumption per unit of activity (l/vkm	0.387
CO - Specific emissions ex-ante g/vkm	40.76
CO2 - Specific emissions ex-ante g/vkm	1’225.38
NO_x- Specific emissions ex-ante g/vkm	7.17

C2.1 Economy

Table C2.1.1 – Economic Indicators values

Indicator	Before (date)	B-a-U (date)	After (date)	Difference: After –Before	Difference: After – B-a-U
Indicator 2 / *Average Operating costs (€/vkm)*	0.401 (2011)	0.401 (2011)			
		0.402 (2012)	0.396 (2012)	-0.005	-0.006
Differences (%)				-1.32%	-1.56%

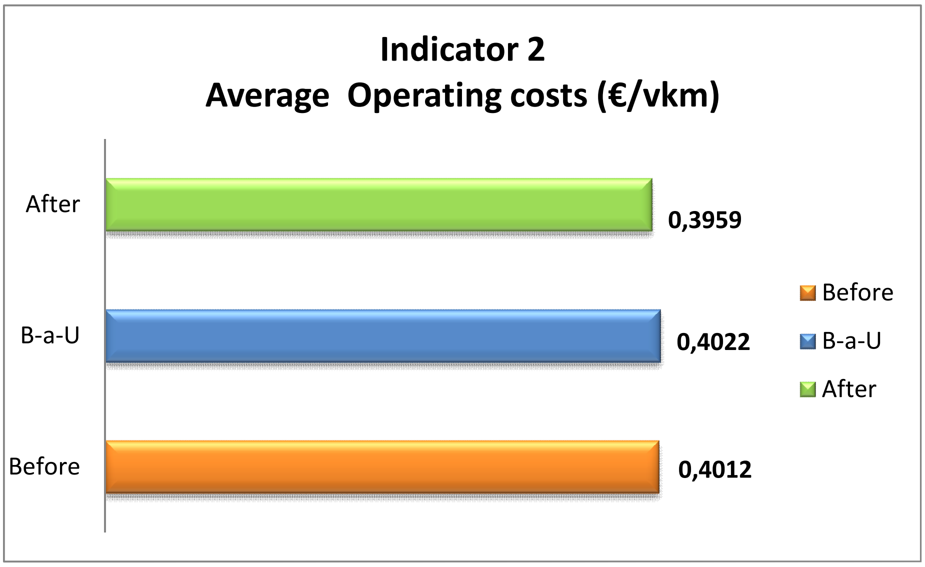

Figure 9 – Average operating costs indicator values

As expected the total costs of the new technology based on biodiesel B20 reported to the unit of activity is lower (0.396 EURO/vkm) than the current technology based on the use of traditional diesel (0.402 EURO/vkm), even if the difference is not so huge. This indicator shows therefore a positive result with respect to the idea of introducing biodiesel in the public transport fleet.

The PT Company RAT expressed its aim to continue the experimentation on a large basis in order to fully evaluate the possibility to use this fuel almost for the oldest part of the fleet. Then, for the new buses they are going to impose in the purchase specifications the use of this fuel.

C2.2 Energy

Table C2.2.1 – Energy Indicators values

Indicator	**Before (date)**	**B-a-U (date)**	**After (date)**	**Difference: After –Before**	**Difference: After – B-a-U**
Indicator 3 */Vehicle Fuel Efficiency (MJ/vkm)*	15.61 (2011)	15.61 (2011)			
		15.05 (2012)	14.43 (2012)	-1.27	-0.71
Differences (%)				-8.14%	-4.72%

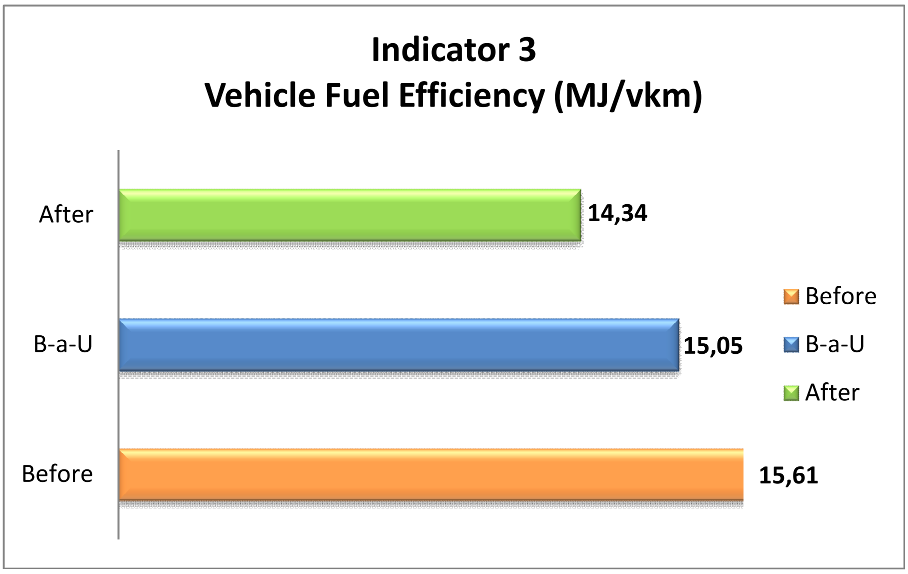

Figure 10 – Vehicle Fuel Efficiency indicator values

Concerning the vehicle fuel efficiency – given the lower energy content of B20 than diesel fuel – it was expected that by using biodiesel B20, this indicator would have had higher values and so been less efficient than the ex-ante situation or BAU situation in 2012. Consequently, it would have expected to face a higher fuel consumption in respect to the same level of service provided.

Contrary to expectations, during the demonstration with B20 on 10 buses the energy efficiency was better than the case of using diesel fuel on the same buses. This "anomaly" could be explained by the fact that the monitoring period was very short and not all the circumstances normally occurring during an annual activity have been encountered.

C2.3 Environment

Table C2.3.1 – Environmental Indicators values

Indicator	**Before**	**B-a-U**	**After**	**Difference:**	**Difference:**

	(date)	**(date)**	**(date)**	**After –Before**	**After – B-a-U**
Indicator 8 / *CO2 emissions /vkm)*	1345.27 (2011)	1345.27 (2011)			
		1296.96 (2012)	1225,38 (2012)	-119.89	-71.58
Differences (%)				-8.91%	-5.52%
Indicator 9 / *CO emissions (g/vkm)*	46.72 (2011)	46.72 (2011)			
		45.04 (2012)	40.76 (2012)	-5.96	-4.28
Differences (%)				-12.76%	-9.51%
Indicator 10 / *NO_x emissions (g/vkm)*	6.20 (2011)	6.20 (2011)			
		5.98 (2012)	7.17 (2012)	0.97	1.20
Differences (%)				15.71%	20.02%

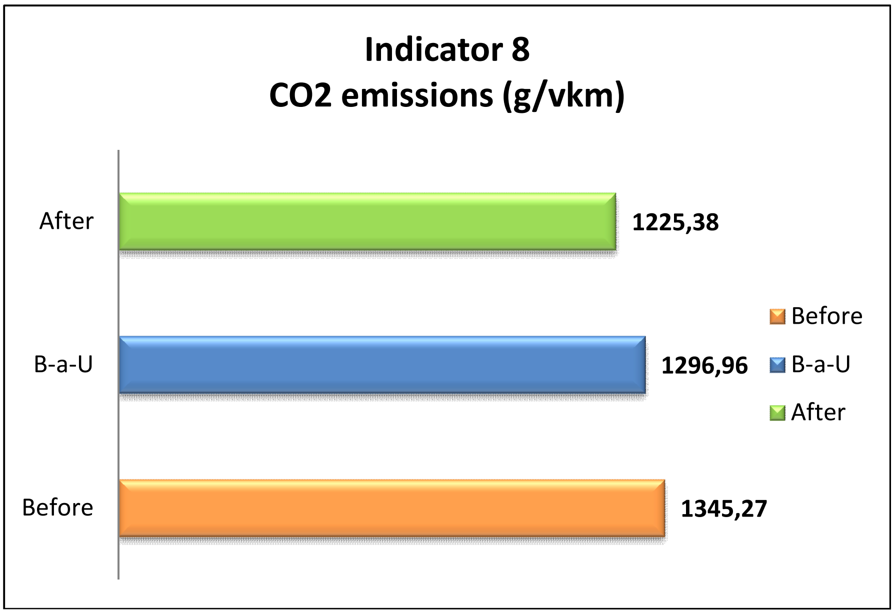

Figure 11 – CO2 Emissions indicator values

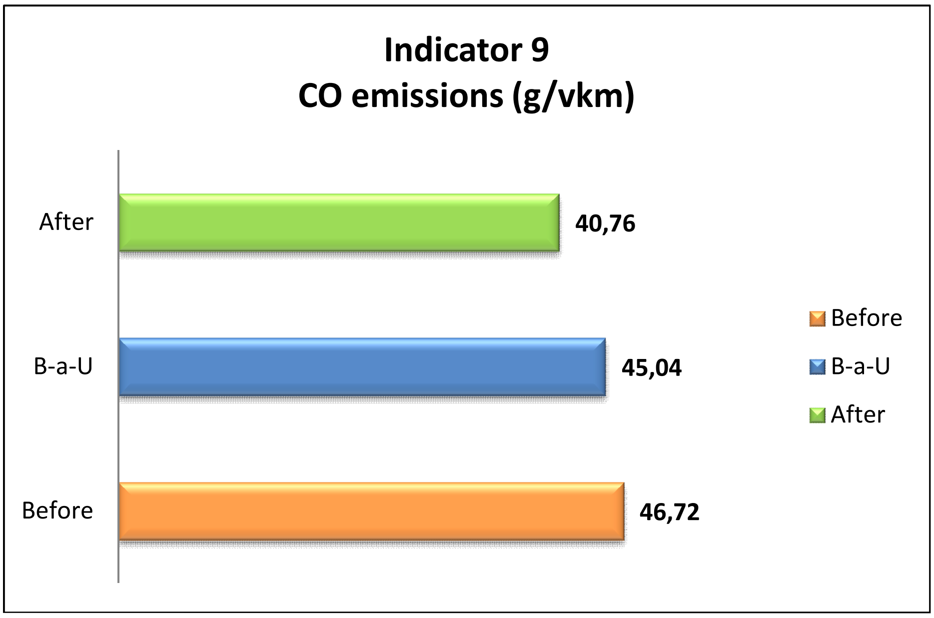

Figure 12 – CO Emissions indicator values

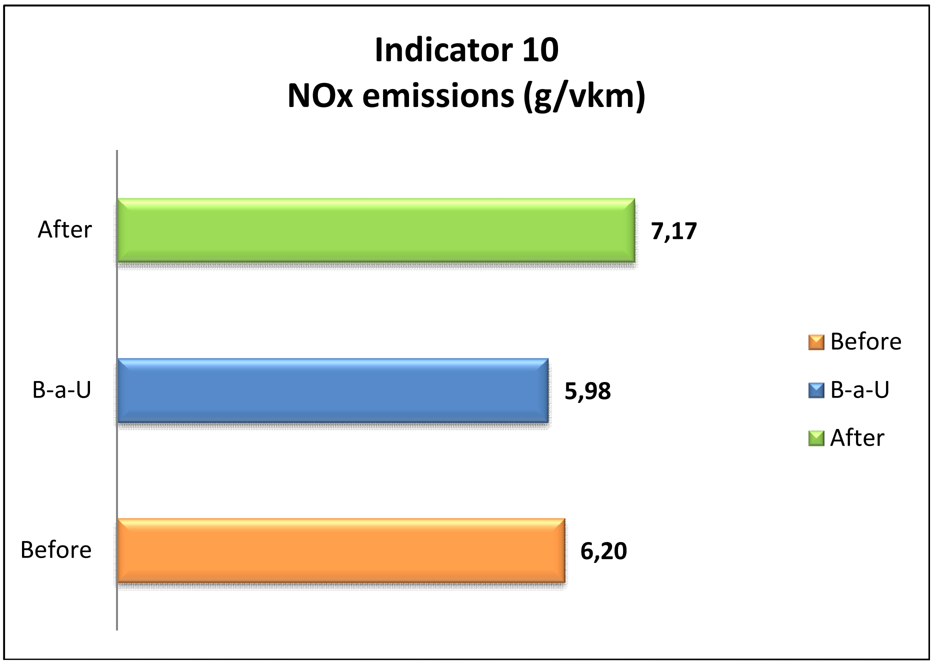

Figure 13 – NOx Emissions Indicators values

As it was expected, the CO_2 emissions decreased; that's because B20 has a lower carbon content. Biodiesel also contains in its composition (formula) oxygen which contributes to a better combustion, so less CO.

In terms of NO_x emissions, different sources have been consulted to understand whether or not it is normally to have a growth when using B20. Several studies on this topic produced different outcomes. For example, EPA and the National Renewable Energy Laboratory (NREL) in a study of 2006 stated that B20 has no net impact on NO_x[6]. Other sources state that NO_x emissions are higher for biodiesel but can be significantly reduced depending on engine operating conditions (e.g. injection time, engine temperature)[7].

There is, however, a general consensus regarding the fact that biodiesel increases NO_x emissions depending on engine type, age, concentration, and combustion conditions (temperature, time of injection).

Through MODERN project it has been demonstrated that the introduction of biodiesel fuel leads to the reduction of emissions with 2%, target that was achieved.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To introduce in the demonstration program 10 buses belonging to the Public Transport Company; buses were **updated with special devices in order to be able to use biodiesel fuel up to 20%**. Based on the tests conducted it has been decided that the 10 buses will run with 20% biodiesel blend.	★★
2	**Decreasing of the emissions level up to 2%** for buses operating with mixture of biodiesel in conventional diesel fuel. The target was exceeded and a reduction of 8.93% has been achieved.	★★★
NA = Not Assessed O = Not Achieved ★ = Substantially achieved (at least 50%) ★★ = Achieved in full ★★★ = Exceeded		

C4 Up-scaling of results

Since the results achieved seem to be very promising, RAT is going to take into consideration the hypothesis to introduce the 20% blend to the all fleet. This would also allow to have a decrease in fuel thefts that now happen in the company depots.

C5 Appraisal of evaluation approach

The evaluation process of the measure followed the POINTER guideline with some specific approaches when no recommended tools for evaluation were available. For the measure impact assessment a set of indicators were included in the evaluation plan at the beginning of the project.

These indicators were modified as we understood better which elements highlight the best the socio-economic impact of the measure.

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[6] http://www.seco.cpa.state.tx.us/re_biodiesel-air.htm

[7] University of Illinois, Combustion and Emissions Characteristics of Biodiesel Fuel, Alan C. Hansen, Department of Agricultural and Biological Engineering, University of Illinois, CABER Seminar May 5, 2008, http://bioenergy.illinois.edu/education/08seminars/080505_hansen.pdf

The evaluation activity was generally a difficult one for at least two reasons:

- Technical obstacles (old/used buses) and the lack of suppliers of biodiesel on the market have led to changing of the measure objectives and caused delays in implementation and evaluation involved in
- Difficulties in terms of obtaining in due time data to calculate indicators (especially emissions data)

Generally, the problems in the measure evaluation ranged from the data provision, methods for measurement or data processing to the large number of variables that influence the impact and that cannot be controlled. The last it seems to be maybe the most misleading in terms of accuracy of impact assessment considering the global economic recession which affected a lot of activities and a lot of market elements (prices, production, exchange rate, etc.).

An example is the fuel prices: be it diesel or biodiesel this is determined by economic policies and is not related to the actual cost of the production. Although the price of biodiesel production is lower than that of fossil fuels, the current market price is very close to that of diesel fuel making it unprofitable for a transport company if we put it in balance the deficits which means more fuel consumption in case of biodiesel (theoretically speaking).

Another example is the CO2 emissions that are undoubtedly lower for biodiesel but recent research works have shown that production of biodiesel implies higher CO2 emissions than for oil refining. By using biodiesel the air quality is considerably improving in cities but at the global level it might be affected in the negative way.

The emissions measurement for on road vehicles is not a simple one and is based on a lot of standards. The continuous measurement of emissions during the operation of the vehicles (on road vehicles) is not an usual one and is practiced only for specific reasons or for researches.

The fact that we were able to measure these emissions and use a calculation method to obtain emissions per unit of activity is a plus for the measure evaluation and certainly it should not be changed. What should be improved is the data collection process: emissions measured in different conditions of temperature and on different types of buses as age and as brand.

What should be changed: the communication between partners, with measure leader and the most important the communication with the top management of the local partners so that to involve them both in the implementation and evaluation activities.

Another weakness in the evaluation process was the activity of data collection within RAT (public transport company). This collection system was improved in the last years but is still slow and not able to provide quickly the requested data or specific reports.

C6 Summary of evaluation results

The key results are as follows:

- **Key result 1** – **Average operating costs** –as it was expected, given that the cost of the biodiesel is lower than the one of the fossil fuel, the operating costs decreased with 1.32% after the implementation of the measure. It must be stated that in the operating costs’ structure, several elements are included, but the element that contributes mostly to the operating costs’ variation is the price of fuels; the fuel consumption per unit of activity in case of diesel oil and B20 are very closed. The replacement of a part of traditional fuel with biodiesel, in our case 20%, produces modifications over this indicator as a consequence of different costs of fuels. Because the cost of fuels is determined by the economic policies, this indicator might be favourable or unfavourable to the CIVITAS intervention. Given a stable market, maturity and fluency in using biodiesel fuels sustained and encouraged by the national policies, this indicator is definitely favourable to CIVITAS intervention.

- **Key result 2 – Vehicle fuel efficiency** – It is well-known the fact that biodiesel has a lower energy content compared to the traditional fuel and this deficiency is compensated by a larger consumption of fuel. Contrary to expectations and theoretical considerations, the ex-post results showed a better energy efficiency when using B20 (14.43 MJ /vkm) than with regular diesel fuel (15.61 MJ/vkm). This result reflects actually a situation limited to a short period of data collection therefore, to substantiate the results these should be based on a longer period of monitoring. In the analysis of this indicator it is also important to have a balance between this indicator and the one regarding the costs.
- **Key result 3 – CO emissions** – the results of the evaluation of this indicator show a reduction of its level of 12.76% through the implementation of the measure, thing that indicates a better fuel combustion.
- **Key result 4 – CO2 emissions** – it is remarkable the fact that by using a mix fuel with 20% biodiesel, the CO2 emissions become reduced with 8.91%.
- **Key result 5 – NO_x emissions** – by using the biodiesel, the NO_x emissions register a substantial increase of 15.71%. It is known and accepted the fact that the NO_x emissions rise in this case, but the modern technologies offer solutions for the reduction of these emissions; the most used are the ones that use different additives to reduce NO_x emissions in biodiesel blends.

C7 Future activities relating to the measure

The wide application of the biodiesel depends actually only on political and economic reasons that are being found from global, down to local level. There are regulations / general recommendations and there are particular initiatives at cities level but to accelerate the adoption of biodiesel is needed to stimulate both producers and users, to develop a legislative framework focused on this area and to make much lobbying so that to overcome the operators' inertia.

The Municipality is a complex mechanism which can produce major changes in the quality of urban life under an effective management and coordination. As a lesson learned, for the future we need to do more for the city because the people are working with us and not against us.

The results of the evaluation are encouraging and should be widely disseminated and promoted as a starting point for future possible decisions in Craiova or in other cities. During the entire project we had some TV shows on local TVs in which we talked about the use of alternative biodiesels and the demonstrative results, together with other measures in CIVITAS MODERN.

Figure 14 – Capture from the video material related to the alternative fuels in Craiova

D Process Evaluation Findings

D.0 Focused measure

x	0	No focused measure
	1	Most important reason
	2	Second most important reason
	3	Third most important reason

D.1 Deviations from the original plan

The deviations from the original plan comprised:

- **Deviation 1** – The shape of the measure by performing technological tests over a lower number of buses (10) instead of 88 and enlarging the use of biodiesel on 88 buses after the testing results. The measure's objectives and the technical content were not changed, only the budget was reduced because RAT requested budget only for the testing of 10 buses. The upgrade of the results to the overall fleet in case of a successful experimental phase would be financed by own sources.
- **Deviation 2** – Testing 10 buses with biodiesel mixture up to 20% instead of up to 100% ; first tests were performed on 2 buses with different biodiesel mixtures up to 20%. The demonstration of the measure was limited to 10 buses without additional enlargement to other buses due to economic reasons (the forecasts for the following years in the biodiesel national market) and because the biodiesel needed for running the tests became available only on October 2012.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Barrier 1– Institutional barrier:** In 2009 the top management of RAT (Public Transport Company of Craiova)was changed; this led to some disruptions in the decision-making process.
- **Barrier 2 – Technological barrier:** The bio-diesel availability depends on the market evolution and on the producers' policy in the circumstances of global economic crisis. Practically the biodiesel production is limited by market demand. Large-scale use of biodiesel mixtures should be supported by national policy and by an adequate infrastructure to feed a large number of vehicles.

Implementation phase

- **Barrier 1 – Institutional barrier:** Romanian government introduced taxes for bio diesel producers making unprofitable the commercialization activity
- **Barrier 2 –Institutional barrier:** Most of the regional biodiesel producers closed their activity due to a lot of reasons: lack of raw material, increasing of taxes, general economic crisis.
- **Barrier 3 –Problem related barrier:** The producers cannot ensure the quantity of fuel needed to constantly feed the public transport fleet so that the use of biofuel is limited to 10 buses.

Operation phase

- **Barrier 1 – Institutional barrier:** the decision of adopting biodiesel mixture for 10 buses was a difficult one and still produces concern since RAT fleet are old and any change in the operational procedures could lead to the removal of buses from the operational fleet with the consequent reduction of the transport capacity.

D.2.2 Drivers

Preparation phase

- **Driver 1 -** Not applicable

Implementation phase

- **Driver 1 –Institutional driver:** Support from the University of Craiova and Environment Agency (with equipment and experience) to perform the emissions measurements of buses working with biodiesel.

Operation phase

- **Driver 1** – Not applicable

D.2.3 Activities

Preparation phase

- **Activities 1– Institutional activity:** Measure leader, site coordinator and the manager of the project discussed with RAT's administration concerning to the importance of the measure's implementation offering examples of other European cities
- **Activities 2 –Involvement, communication activity:** The measure leader organized round tables with key stakeholders sharing different viewpoints. The measure's leader and the team organize face-to face interviews with potential providers of alternative fuel

- **Activities 3 –Organizational activity:** The implementation team learnt about alternative fuels by extra measure meeting or deep documentation and up-dated the knowledge about alternative fuels.
- **Activities 4 – Technological activity :** The measure leader and research team involved experts on alternative fuels to highlight its benefits

Implementation phase

- **Activities 1 – Planning activity:** Reducing the number of buses to the minimum necessary for testing so that the conclusion of the tests be relevant and at the same time the limitation of the biodiesel content at 20%
- **Activities 2 – Planning activity:** The market analyses on the availability of biodiesel fuel

Operation phase

- **Activities 1 – Involvement, communication activity:** To overcome the concerns about the introduction of biodiesel as alternative fuel on 10 demonstration buses, the tests' results and examples of other cities already using this alternative were presented within several meetings with management team of RAT.

D.3 Participation

D.3.1. Measure Partners

- **Measure partner 1 –IPA SA Craiova Subsidiary- leading partner** is a 47 year-old Romanian industrial R&D company and it is the Romanian national institute for research and development, engineering in energy, automation and IT, with a large experience in European projects in technology transfer and in information dissemination.

- **Measure partner 2 – RAT – Craiova Public Transport Company- principle participant** is the main public transport operator in the whole Oltenia region. In Craiova (320,000 inhabitants) it provides transport by trams, buses and micro-buses of their own (250 vehicles), transporting 65 million travellers every year.

- **Measure partner 3 – LCM – The Local Council of Craiova Municipality-occasional participant** (Primaria Municipiului Craiova) was organized and functions according to Law No. 215/2001 regarding the Local Public Administration with the subsequent modification and completion.

D.3.2 Stakeholders

- **Faculty of Electrical Engineering of Craiova–**tests of the buses running with bio-diesel in different percentages blended (5%,10%,15%,20%) and for three different engine RPM for emissions of CO, CO2, SO2, NO_x are performed in the laboratory of this faculty.
- **Craiova Environment Agency** – process of the data provided following the tests.
- **Orfescu SRL Company** – supplier of equipment needed for the buses in order to run with bio-diesel.
- **Romanian Auto Registry** – checking technical condition of the buses in order to run with the bio-diesel in safety conditions.
- **Bio-diesel suppliers from the region.**

D.4Recommendations

D.4.1 Recommendations: measure replication

- **Recommendation 1 –Legal framework**

Currently the public transport operators have difficulties in getting biofuel in a certain concentration from recognized suppliers (those who respect and certify the quality of the fuel according to the current standards) at a competitive price. Based on these reasons it is important that biodiesel fuel use be more in the government attention. Incentive legislation should be developed in order to speed up the introduction of biodiesel based fuels as a clean solution to the pollution in the city. The national legislation should be enforced both on the production direction and on the use direction.

- **Recommendation 2 –Biodiesel supply network**

Having a feeding network of biodiesel fuel in various concentrations with specific additives to control viscosity and the NO_x emissions, is a prerequisite for widespread biodiesel introducing in the public transportation.

D.4.2 Recommendations: process (related to barrier-, driver- and action fields)

Recommendation 1 –Biodiesel a solution for public transport

The measure has demonstrated a real benefit for RAT in terms of operational costs and for the quality of life in the city due to the emissions' reduction. It should add also that there are cities that applied B20 at buses for over 10 years and after this long-running period they found no operational problems associated with biodiesel and, even more the injector life increased and decreased the need for maintenance in this period[8].

[8]http://www.rimlifegreentech.com/biodiesel_current_usage.htm

Based on the results of evaluation, on the experience of other cities and considering the technical state of the RAT's buses we would recommend the introduction of B20 as current fuel in parallel with a careful monitoring of buses.

Recommendation 2 –Shift fuels

Even if the biodiesel market is not constant in terms of supply (not provide enough biodiesel), B20 and diesel fuel can be used alternatively without any technical intervention or investment. B20 becomes ineffective only if its price leads to the increasing of the company's operating costs.

Annexes

Annex 1 – Emissions measurements

Annex 2 – Biodiesel data sheets

Annex 3 – Calculation sheets for ex-ante evaluation

Annex 4 – Calculation sheets for BAU evaluation

Annex 5 – Calculation sheets for ex-post evaluation

Annex 1 – Emissions measurements

Engine speed: 1150-1200 rot/min

Standard diesel fuel (B5)							
	Bus 1- DJ-03ROA				***Bus 2 - DJ-03NTL***		
	CO	*CO2*	*NOx*		*CO*	*CO2*	*NOx*
	ppm	*%*	*ppm*		*ppm*	*%*	*ppm*
1	1006.33	1.95	99.10		899.33	1.50	70.00
2	1010.00	1.95	100.50		893.67	1.51	69.00
3	999.33	1.94	100.50		901.00	1.66	70.67
4	1126.33	1.92	100.33		890.33	1.72	73.33
5	1147.33	1.95	99.00		852.00	1.56	68.00
6	1135.33	1.95	98.33		865.33	1.55	68.00
7	1122.00	1.98	98.00		885.67	1.68	68.33
8	1112.00	1.98	98.33		877.67	1.62	65.33
9	1107.33	1.99	99.33		865.33	1.65	66.67
10	1086.67	2.00	99.33		877.00	1.66	68.33
11	1091.67	2.00	99.33		849.33	1.61	66.67
12	1084.67	2.00	100.00		841.67	1.57	66.67
13	1074.00	1.93	100.33		874.00	1.68	69.00
14	1068.67	1.94	101.00		882.33	1.74	70.67
15	1074.33	1.93	100.33		849.00	1.69	71.67
16	1065.33	1.92	100.67		838.33	1.64	71.33
17	1060.67	1.92	101.00		827.67	1.56	67.67
18	1059.00	1.91	101.33		824.33	1.56	67.33
19	1056.67	1.91	101.00		822.67	1.44	65.67
20	1057.00	1.89	100.00		864.33	1.61	70.00
Average values	**1077.23**	**1.95**	**99.89**		**864.05**	**1.61**	**68.72**

Standard diesel fuel B5			
Engine speed	*CO*	*CO2*	*NOx*
1200 rot/min	*ppm*	*%*	*ppm*
Average values bus 1	1077.23	1.95	99.89
Average values bus 2	864.05	1.61	68.72
Average values	**970.64**	**1.78**	**84.30**
	ppm	*ppm*	*ppm*
Average values (ppm)	**970.64**	**17787.33**	**84.30**

Emissions measurements

Engine speed: 1150-1200 rot/min

Biodiesel fuel (B20)						
	Bus 1- DJ-03ROA			***Bus 2 - DJ-03NTL***		
	CO	*CO2*	*NOx*	*CO*	*CO2*	*NOx*
	ppm	*%*	*ppm*	*ppm*	*%*	*ppm*
1	880.00	1.64	105.00	812.00	1.43	80.67
2	974.00	1.84	105.20	791.00	1.42	82.00
3	868.00	1.74	105.10	787.00	1.41	80.00
4	835.00	1.79	105.40	783.00	1.45	80.67
5	853.00	1.81	105.80	831.33	1.43	81.00
6	947.00	1.88	107.60	826.00	1.39	81.00
7	954.00	1.90	114.30	788.00	1.40	81.33
8	955.00	1.91	114.30	785.00	1.41	81.00
9	905.00	1.82	114.10	783.00	1.41	81.00
10	910.00	1.91	117.10	777.00	1.41	81.33
11	910.00	1.91	117.10	780.00	1.40	83.33
12	917.00	1.88	116.60	774.00	1.40	82.00
13	913.00	1.89	117.60	779.00	1.43	82.00
14	954.00	1.88	117.60	777.00	1.41	82.00
15	960.00	1.86	117.40	772.00	1.44	82.67
16	929.00	1.87	120.00	776.00	1.43	82.33
17	948.00	1.87	123.60	763.00	1.40	83.00
18	940.00	1.86	123.80	769.00	1.41	82.00
19	944.00	1.87	123.20	761.00	1.41	82.67
20	935.00	1.83	123.70	765.00	1.43	82.67
Average values	**921.55**	**1.85**	**114.73**	**783.97**	**1.42**	**81.73**

Biodiesel fuel B20			
Engine speed	*CO*	*CO2*	*NOx*
1200 rot/min	*ppm*	*%*	*ppm*
Average values bus 1	921.55	1.85	114.73
Average values bus 2	783.97	1.42	81.73
Average values	**852.76**	**1.63**	**98.23**
	ppm	*ppm*	*ppm*
Average values (ppm)	**852.76**	**16315.75**	**98.23**

Annex 2 – Biodiesel data sheets

24 Oct. 2012 13:35 P1 FAX NO. :0251508077 :RAT CRAIOVA

Unitatea RAT CRAIOVA
Autocoloana Secția 1
– BIODIESEL –

Biodiesel data sheets

CENTRALIZATORUL
realizărilor de consum extrase din F.A.Z.
Pe luna 04.10.2012 – 15.10.2012

Nr. crt.	Numele și prenumele șoferului	Marca și tipul autovehi	Nr. înmatriculare	Parcursul realizat (km) Efectiv	Echivalent	Consumul de combustibil (litri) Rest rezervor început de lună	Alimentat lichid	Consum efectiv B.C.F.	Restituit lichid	Rest rezervor sfârșit de lună	Consum efectiv	Consum normat	Diferențe: ec. (-) dep. (+)	Consum (litri) Efectiv	Normat
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	DUMITRU AUREL 31,25%	MAN NL 202	428	302,5	378,1	230	126	=	=	215	141	122	+19		
2	BARBUCEANU VALI 34%	BREDABUS	458	754,3	943,1	266	345	=	=	285	326	328	-2		
3	BUZATU ION 35,71%	MERCEDES	507	939,5	1174,5	212	445	=	=	237	420	425	-5		
4	CERCELARU FLORIN 31%	UDM R 112	400	1288,7	1663,6	176	575	=	=	220	531	527	+4		
5	URDES VALENTIN 31%	UDM R 112	403	1402	1682	171	537	=	=	215	493	529	-36		
6	BADULESCU ILIE 31%	UDM R 112	410	1566	1875	180	599	=	=	220	559	591	-32		
7	MITEA GABRIEL 31%	UDM R 112	413	1135	1329	220	405	=	=	220	405	418	-13		
8	TOMA DUMITRU 31%	UDM R 112	415	841	1009	180	383	=	=	220	343	320	+23		
9	CAPRA FLORIAN 31%	UDM R 112	416	571	685	158	258	=	=	200	216	216	∅		
10	GHITA IONUT 31%	UDM R 112	417	665	798	176	307	=	=	220	263	253	+10		
				9555,8							3697				

TEHNICIAN
BOBOVOICI MARIA

24 Oct. 2012 13:37 P4 FAX NO. :0251508077 :RAT CRAIOVA

FISA ACTIVITATII ZILNICE PENTRU MASINA BREDA BUS cu numarul de inventar 458, sectia: 1 in perioada 05.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Porniri motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
5	41758	1.BARBUCEANU VALENTIN	52.40	65.52	02:50	00:20	03:10	02:35		02:35			0		22.70
5	41758	2.BARBUCEANU VALENTIN	34.90	43.64	03:35	00:05	03:40	01:40		01:40		266	54		15.26
6	42411	1.BARBUCEANU VALENTIN	125.00	156.26	07:30	00:15	07:45	13:30		13:30			0		53.98
7	42459	1.BARBUCEANU VALENTIN	161.40	201.80	08:20	02:00	10:20	08:50		08:50			0		69.46
8	41777	2.BARBUCEANU VALENTIN	95.90	119.91	06:35	00:35	07:10	05:00		05:00	00: 5		135		41.95
9	42276	2.BARBUCEANU VALENTIN	98.70	123.41	06:45	00:40	07:25	05:05		05:05			42		42.81
10	42755	1.BARBUCEANU VALENTIN	22.40	28.01	02:40	00:00	02:40	01:05		01:05			59		9.95
10	42755	2.BARBUCEANU VALENTIN	35.80	44.76	03:25	00:15	03:40	01:40		01:40			0		15.64
TOTAL DECADA 1			626.50	783.31	41:40	04:10	45:50	39:25		39:25	00: 5		290		271.75
11	42773	1.BARBUCEANU VALENTIN	43.40	54.27	02:20	00:40	03:00	02:05		02:05			0		18.88
11	42773	2.BARBUCEANU VALENTIN	35.80	44.76	03:25	00:15	03:40	01:40		01:40			0		15.64
12	42103	1.BARBUCEANU VALENTIN	22.00	27.51	02:30	00:00	02:30	01:00		01:00			55		9.78
12	42103	2.BARBUCEANU VALENTIN	35.80	44.76	03:45	00:15	04:00	01:40		01:40			0		15.64
13		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15	42114	1.BARBUCEANU MARIN	43.20	54.02	02:20	00:55	03:15	02:20		02:20			0		18.79
15	42114	2.BARBUCEANU MARIN	36.60	45.76	03:35	00:05	03:40	01:45		01:45			35		15.98
TOTAL DECADA 2			216.80	271.08	17:55	02:10	20:05	10:30		10:30			90		94.71
TOTAL PERIOADA			843.30	1054.39	59:35	06:20	65:55	49:55		49:55	00: 5		380		366.46

CONSUM COMBUSTBIL

RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
286.00	380	366.46	0.000	299.54	0	299.54	666.00
	BCF						
	0						

757,3 943,11

Numar de zile si imobilizari pe cauze

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot	CO	CM	CFS	Altele
15	13	0	0	0	0	0	0	0	2					

	Parcurs realizat (km) de la introducerea in exploatare KM efectivi	KM echivalenti	KM. ECHIVALENTI rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	117571.20	146841.89							
Luna curenta	843.30	1054.39							
Total	118414.50	147896.28							

BABOLEA DANIELA-FLORENTINA

Measure title: **Alternative fuels in Craiova**

City: **Craiova** *Project:* **MODERN** *Measure number:* **01.02**

24 Oct. 2012 13:38 P5 FAX NO. :0251586077 FM :RAT CRAIOVA

FISA ACTIVITATII ZILNICE PENTRU MASINA MERCEDES cu numarul de inventar 507, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Pornire motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
4	42210	1.ZAMFIR TITI - LUCIAN	62.90	78.65	07:05	00:55	08:00	03:25		03:25			65		28.28
4	42210	2.BUZATU ION	62.30	77.90	04:17	00:48	05:05	03:10		03:10	00:27		53		29.82
5	42310	1.ZAMFIR TITI - LUCIAN	43.20	54.02	02:15	00:35	02:50	02:20		02:20			50		19.57
5	42310	2.BUZATU ION	175.90	219.91	05:40	01:40	07:20	06:30		06:30			10		78.29
6		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
7		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
8	42809	1.BUZATU ION	62.90	78.65	03:26	01:14	04:40	03:25		03:25			12		28.28
8	42809	2.ZAMFIR TITI - LUCIAN	62.90	78.65	03:25	00:50	04:15	03:25		03:25	00: 5		64		28.62
9	42929	1.BUZATU ION	82.60	103.28	04:46	01:14	06:00	04:30		04:30			10		37.00
9	42929	2.ZAMFIR TITI - LUCIAN	23.70	29.63	07:15	00:45	08:00	01:05		01:05			56		10.93
10	42706	1.BUZATU ION	82.60	103.28	04:22	01:43	06:05	04:30		04:30			8		37.00
10	42706	2.ZAMFIR TITI - LUCIAN	82.60	103.28	04:34	00:51	05:25	04:30		04:30	00: 6		45		37.40
TOTAL DECADA 1			741.60	927.25	47:05	10:35	57:40	36:50		36:50	00:38		373		335.19
11	42610	1.BUZATU ION	82.60	103.28	04:31	00:59	05:30	04:30		04:30			11		37.00
11	42610	2.ZAMFIR TITI - LUCIAN	42.10	52.64	02:10	01:25	03:35	02:05		02:05			66		19.08
12	42509	1.BUZATU ION	82.60	103.28	04:15	01:20	05:35	04:30		04:30			[illegible]		37.45
13	42139	1.BUZATU ION	26.60	33.26	02:05	00:00	02:05	01:13		01:13			0		12.22
13	42139	2.BUZATU ION	26.80	33.50	01:15	00:25	01:40	01:15		01:15			0		12.30
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15	42010	2.BUZATU ION	102.30	127.91	05:50	00:45	06:35	05:35		05:35	00:15		[illegible]		47.17
TOTAL DECADA 2			363.00	453.87	20:06	04:54	25:00	19:08		19:08	00:15		[illegible]		165.22
TOTAL PERIOADA			1104.60	1381.12	67:11	15:29	82:40	55:58		55:58	00:53		468		500.41

CONSUM COMBUSTBIL							
RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
170.00	468	500.41	25.000	112.59	0	112.59	613.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze														
Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Altele
15	12	0	0	0	0	0	0	0	3					0

BABOLEA DANIELA-FLORENTINA

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	896480.40	1118955.3							
Luna curenta	1104.60	1381.12							
Total	897585.00	1120336.4							

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 400, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Pornire motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
4	42232	1.CERCELARU FLORIAN	86.70	104.04	07:18	00:32	07:50	07:15		07:15			60		32.64
4	42232	2.JEGA MARIN	87.30	104.76	06:48	01:07	07:55	06:45		06:45			44		32.86
5	42333	1.CERCELARU FLORIAN	92.90	111.48	07:24	00:42	08:06	07:15		07:15			0		34.96
5	42333	2.CERCELARU FLORIAN	68.70	82.44	05:10	00:44	05:54	04:45		04:45			61		25.94
6	42435	1.CERCELARU FLORIAN	87.70	105.24	07:05	00:25	07:30	07:15		07:15			0		33.01
6	42435	2.JEGA MARIN	114.90	137.88	08:45	00:00	08:45	09:15		09:15			0		43.13
7	42483	1.JEGA MARIN	102.10	122.52	07:45	00:15	08:00	08:15		08:15			0		38.37
7	42483	2.CERCELARU FLORIAN	76.50	91.80	05:45	00:00	05:45	06:15		06:15			0		28.85
8	42840	2.CERCELARU FLORIAN	62.30	74.76	03:45	00:40	04:25	03:10		03:10	00:35		169		26.28
9	42952	1.JEGA MARIN	74.20	89.04	06:05	00:25	06:30	05:30		05:30			58		27.99
9	42952	2.CERCELARU FLORIAN	99.00	118.80	08:35	00:45	09:20	07:30		07:30			0		37.22
10	42731	1.JEGA MARIN	74.60	89.52	06:13	00:32	06:45	05:30		05:30			64		28.14
10	42731	2.CERCELARU FLORIAN	62.30	74.76	03:37	00:28	04:05	03:10		03:10	00:22		0		25.03
TOTAL DECADA 1			1089.20	1307.04	84:15	06:35	90:50	81:50		81:50	00:57		456		414.41
11	42632	1.JEGA MARIN	37.00	44.40	02:35	00:25	03:00	02:30		02:30			0		14.15
11	42632	2.CERCELARU FLORIAN	86.60	103.92	06:50	00:30	07:20	06:30		06:30			0		32.60
12	42538	1.JEGA MARIN	84.20	101.04	05:53	01:07	07:00	05:30		05:30			110		31.71
12	42538	2.CERCELARU FLORIAN	99.40	119.28	08:27	00:28	08:55	07:30		07:30			0		37.36
13		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15	42046	1.CERCELARU FLORIAN	78.30	93.96	06:43	01:17	08:00	05:45		05:45			69		29.90
TOTAL DECADA 2			385.50	462.60	30:28	03:47	34:15	27:45		27:45			179		145.72
TOTAL PERIOADA			1474.70	1769.64	114:43	10:22	125:05	109:35		109:35	00:57		635		560.13

CONSUM COMBUSTIBIL							
RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
187.00	635	560.13	0.000	261.87	0	261.87	822.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze														
Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Altele
15	13	0	0	0	0	0	0	0	2					0

BABOLEA DANIELA-FLORENTINA

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	659030.00	741386.00							
Luna curenta	1474.70	1769.64							
Total	660504.70	743155.64							

24 Oct. 2012 13:40 P7 FAX NO. :0251586077

Measure title: **Alternative fuels in Craiova**

City: **Craiova** *Project:* **MODERN** *Measure number:* **01.02**

FISA ACTIVITATII ZILNICE PENTRU MASINA MAN NL 202 cu numarul de inventar 428, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Porniri motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
4	42204	1.CIOBANU ILIUTA – VIOREL	43.20	54.02	07:40	02:35	10:15	02:20		02:20	00: 5		32		17.61
4	42204	2.DUMITRU AUREL	43.20	54.02	03:33	01:25	04:58	02:20		02:20		230	20		17.27
5	42304	1.DUMITRU AUREL	43.20	54.02	07:15	00:45	08:00	02:20		02:20			24		17.27
5	42304	2.DUMITRU AUREL	43.20	54.02	02:43	00:37	03:20	02:20		02:20			14		17.27
6		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
7		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
8		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0		0.00
9	42923	1.DUMITRU AUREL	43.20	54.02	07:23	00:37	08:00	02:20		02:20			46		17.66
10	42703	1.DUMITRU AUREL	43.20	54.02	02:24	00:46	03:10	02:20		02:20			2		17.27
10	42703	2.ZANOAGA STANCU	62.90	78.65	03:42	01:03	04:45	03:25		03:25	00: 7		20		25.44
TOTAL DECADA 1			322.10	402.77	34:40	07:48	42:28	17:25		17:25	00:12		158		129.79
11	42604	1.DUMITRU AUREL	23.50	29.39	07:03	00:57	08:00	01:15		01:15			0		9.58
11	42604	2.ZANOAGA STANCU			08:00	00:00	08:00	00:00		00:00			0		0.39
12		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0		0.00
13		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0		0.00
TOTAL DECADA 2			23.50	29.39	15:03	00:57	16:00	01:15		01:15			0		9.97
TOTAL PERIOADA			345.60	432.16	49:43	08:45	58:28	18:40		18:40	00:12		158		139.76

CONSUM COMBUSTBIL 302,4

RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
174.00	158	139.76	0.000	192.24	0	192.24	332.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze (378,14)

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Alte
15	8	0	0	0	0	0	0	0	4					

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	moto
Inceput luna	918460.75	1143755.1							
Luna curenta	345.60	432.16							
Total	918806.35	1144187.2							

BABOLEA DANIELA-FLORENTINA

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 410, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag.

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Porniri motor	Combustibil Alim.	Combustibil Restit
4	42234	1.BADULESCU ILIE	86.70	104.04	07:18	00:32	07:50	07:15		07:15			51	
4	42234	2.STINGA IONUT	61.70	74.04	04:55	00:10	05:05	04:45		04:45			40	
5	42335	1.BADULESCU ILIE	49.40	59.28	03:44	00:26	04:10	03:30		03:30			0	
5	42335	2.STINGA IONUT	61.80	74.16	05:05	00:10	05:15	04:30		04:30			34	
6	42382	1.BADULESCU ILIE	115.70	138.84	08:35	00:30	09:05	07:45		07:45			0	
7	42916	2.BADULESCU ILIE	111.40	133.68	08:40	00:30	09:10	08:30		08:30			0	
8	42841	1.STINGA IONUT	87.00	104.40	07:10	00:15	07:25	06:30		06:30			0	
8	42841	2.BADULESCU ILIE	108.60	130.32	08:04	00:39	08:43	07:00		07:00			140	
9	42953	1.STINGA IONUT	92.70	111.24	07:25	00:05	07:30	06:45		06:45			59	
9	42953	2.BADULESCU ILIE	91.60	109.92	06:42	01:03	07:45	06:00		06:00			0	
10	42733	1.STINGA IONUT	35.70	42.84	02:15	00:45	03:00	02:15		02:15			51	
10	42733	2.BADULESCU ILIE	88.90	106.68	06:30	00:15	06:45	05:45		05:45			0	
TOTAL DECADA 1			991.20	1189.44	76:23	05:20	81:43	70:30		70:30			375	
11	42634	1.STINGA IONUT	81.70	98.04	07:30	00:20	07:50	06:15		06:15			0	
11	42634	2.BADULESCU ILIE	114.10	136.92	08:50	00:35	09:25	07:45		07:45			0	
12	42540	1.STINGA IONUT	86.50	103.80	07:15	00:30	07:45	06:45		06:45			90	
12	42540	2.BADULESCU ILIE	96.60	115.92	07:16	00:29	07:45	07:00		07:00			0	
13	42684	2.STINGA IONUT	111.40	133.68	08:35	00:00	08:35	08:30		08:30			0	
14	42184	1.STINGA IONUT	86.60	103.92	06:20	00:10	06:30	06:30		06:30			0	
15	42040	1.BADULESCU ILIE	84.70	101.64	05:45	02:05	07:50	05:20		05:20			185	
15	42040	2.STINGA IONUT	90.80	108.96	07:30	01:05	08:35	06:00		06:00			0	
TOTAL DECADA 2			752.40	902.88	59:01	05:14	64:15	54:05		54:05			275	
TOTAL PERIOADA			1743.60	2092.32	135:24	10:34	145:58	124:35		124:35			650	

CONSUM COMBUSTBIL

RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
165.00	650	657.94	0.000	157.06	0	157.06	815.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CF
15	15	0	0	0	0	0	0	0	0				

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei
Inceput luna	483430.35	547493.81						
Luna curenta	1743.60	2092.32						
Total	485173.95	549586.13						

BABOLEA DANIELA-FLORENTINA

FROM :RAT CRAIOVA FAX NO. :0251506077 24 Oct. 2012 13:41 P9

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 403, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Pornire motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
4	42233	1.URDES VALENTIN	93.30	111.96	07:19	00:36	07:55	07:15		07:15			66		35.10
4	42233	2.URDES MARIN-MARINEL	93.50	112.20	07:00	01:35	08:35	06:45		06:45			44		35.17
5	42334	1.URDES VALENTIN	43.90	52.68	02:58	00:17	03:15	03:05		03:05			35		16.72
5	42334	2.URDES MARIN-MARINEL	99.80	119.76	07:36	01:24	09:00	07:30		07:30			10		37.51
6		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
7		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
8	42875	2.URDES VALENTIN	99.00	118.80	07:43	00:40	08:23	07:30		07:30			39		37.60
9	42792	1.URDES VALENTIN	50.60	60.72	03:30	00:15	03:45	03:30		03:30			55		19.21
9	42792	2.NITOI DANIEL	61.00	73.20	04:32	00:20	04:52	04:30		04:30			0		23.08
10	42732	1.URDES VALENTIN	87.00	104.40	06:38	00:42	07:20	06:30		06:30			53		32.75
10	42732	2.NITOI DANIEL	99.80	119.76	08:25	00:15	08:40	07:30		07:30			0		37.51
TOTAL DECADA 1			727.90	873.48	55:41	06:04	61:45	54:05		54:05			302		274.65
11	42633	1.URDES VALENTIN	49.50	59.40	03:25	00:30	03:55	03:45		03:45			46		18.80
11	42633	2.NITOI DANIEL	99.70	119.64	08:25	00:00	08:25	08:15		08:15			0		37.48
12	42539	1.URDES VALENTIN	81.90	98.28	06:02	01:58	08:00	05:45		05:45			62		30.85
12	42539	2.NITOI DANIEL	92.90	111.48	08:02	00:03	08:05	07:15		07:15			0		34.95
13	42688	1.NITOI DANIEL	37.00	44.40	02:30	00:00	02:30	02:30		02:30			0		14.15
13	42688	2.URDES VALENTIN	127.40	152.88	09:30	00:10	09:40	09:30		09:30			0		47.78
14	42179	1.URDES VALENTIN	80.50	96.60	06:15	00:25	06:40	06:15		06:15			0		30.33
14	42179	2.NITOI DANIEL	105.30	126.36	08:25	00:00	08:25	08:15		08:15			0		39.56
15	42039	1.URDES VALENTIN	93.10	111.72	06:46	00:59	07:45	06:45		06:45			193		35.02
15	42039	2.NITOI DANIEL	93.70	112.44	07:30	01:30	09:00	07:15		07:15			0		35.24
TOTAL DECADA 2			861.00	1033.20	66:50	05:35	72:25	65:30		65:30			301		324.16
TOTAL PERIOADA			1588.90	1906.68	122:31	11:39	134:10	119:35		119:35			603		598.81

CONSUM COMBUSTBIL

RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
138.00	603	598.81	0.000	142.19	0	142.19	741.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Altele
15	13	0	0	0	0	0	0	0	2					0

BABOLEA DANIELA-FLORENTINA

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	634898.10	735226.12							
Luna curenta	1588.90	1906.68							
Total	636487.00	737132.80							

P10 24 Oct. 2012 13:42 FAX NO. :0251506077 :RAT CRAIOVA

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 415, sectia: 1 in perioada 04.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Pornire motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
4	42238	2.TOMA DUMITRU	87.00	104.40	06:05	01:55	08:00	06:30		06:30			40		33.14
5	42337	2.TOMA DUMITRU	99.60	119.52	06:00	02:25	08:25	07:30		07:30			35		37.83
6	42437	2.TOMA DUMITRU	123.80	148.56	07:30	01:55	09:25	09:30		09:30			0		46.83
7	42484	1.TOMA DUMITRU	99.00	118.80	06:20	01:05	07:25	07:30		07:30			0		37.60
8	42863	1.TOMA DUMITRU	49.40	59.28	03:06	00:24	03:30	03:30		03:30			152		18.76
8	42863	2.TOMA DUMITRU	49.60	59.52	03:00	00:55	03:55	03:30		03:30			0		18.84
9	42956	1.TOMA DUMITRU	86.80	104.16	05:30	02:10	07:40	06:30		06:30			54		33.06
10	42735	1.TOMA DUMITRU	87.00	104.40	05:30	01:45	07:15	06:30		06:30			37		33.14
TOTAL DECADA 1			682.20	818.64	43:01	12:34	55:35	51:00		51:00			318		259.20
11	42637	1.TOMA DUMITRU	87.00	104.40	05:30	01:40	07:10	06:30		06:30			0		33.14
12	42545	1.TOMA DUMITRU	71.60	85.92	04:22	01:38	06:00	05:00		05:00			65		27.41
13		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15	42188	1.GALUTA FLORIN	24.60	29.52	01:23	00:22	01:45	01:30		01:30			0		9.93
TOTAL DECADA 2			183.20	219.84	11:15	03:40	14:55	13:00		13:00			65		70.48
TOTAL PERIOADA			865.40	1038.48	54:16	16:14	70:30	64:00		64:00			383		329.68

CONSUM COMBUSTBIL

RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
129.00	383	329.68	0.000	182.32	0	182.32	512.00
	BCF						
	0						

Numar de zile si imobilizari pe cauze

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Altele
15	13	0	0	0	0	0	0	0	2					0

BABOLEA DANIELA-FLORENTINA

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	560017.70	632299.44							
Luna curenta	865.40	1038.48							
Total	560883.10	633337.92							

Measure title: **Alternative fuels in Craiova**

City: **Craiova** *Project:* **MODERN** *Measure number:* **01.02**

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 413, sectia: 1 in perioada 08.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Porniri motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
8	42843	1.FOTA FLORIN	74.60	89.52	05:40	01:20	07:00	05:30		05:30			115		28.14
8	42843	2.MITEA GABRIEL	86.60	103.92	06:55	00:30	07:25	06:30		06:30			0		32.60
9	42955	1.FOTA FLORIN	87.00	104.40	06:45	00:30	07:15	06:30		06:30			0		32.75
9	42955	2.MITEA GABRIEL	87.00	104.40	08:20	00:00	08:20	06:30		06:30			65		32.75
10	42734	1.FOTA FLORIN	43.10	51.72	03:00	00:40	03:40	02:45		02:45			50		16.42
10	42734	2.MITEA GABRIEL	82.40	98.88	08:15	00:00	08:15	06:20		06:20			0		31.04
TOTAL DECADA 1			460.70	552.84	38:55	03:00	41:55	34:05		34:05			230		173.70
11	42636	1.FOTA FLORIN	80.70	96.84	06:10	01:50	08:00	05:45		05:45			64		30.41
11	42636	2.MITEA GABRIEL	68.50	82.20	06:00	00:00	06:00	05:15		05:15			0		25.87
12	42542	1.FOTA FLORIN	49.80	59.76	03:30	00:40	04:10	03:30		03:30			56		18.91
12	42542	2.MITEA GABRIEL	113.40	136.08	08:55	00:00	08:55	08:30		08:30			0		42.57
13	42687	1.FOTA FLORIN	92.90	111.48	07:15	00:25	07:40	07:15		07:15			0		34.95
13	42687	2.MITEA GABRIEL	68.10	81.72	05:20	00:00	05:20	05:15		05:15			0		25.72
14	42183	1.MITEA GABRIEL	92.90	111.48	07:10	00:35	07:45	07:15		07:15			0		34.95
14	42183	2.FOTA FLORIN	68.10	81.72	05:15	00:00	05:15	05:15		05:15			0		25.72
15	42042	1.MITEA GABRIEL	87.10	104.52	07:20	00:40	08:00	06:45		06:45			170		32.79
15	42042	2.FOTA FLORIN	74.50	89.40	05:45	01:45	07:30	06:15		06:15			0		28.10
TOTAL DECADA 2			796.00	955.20	62:40	05:55	68:35	61:00		61:00			290		299.99
TOTAL PERIOADA			1256.70	1508.04	101:35	08:55	110:30	95:05		95:05			520		473.69

CONSUM COMBUSTBIL RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
160.00	520	473.69	0.000	206.31	0	206.31	680.00

BCF
0

Numar de zile si imobilizari pe cauze 1134,6 1329 235

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot	CO	CM	CFS	Altele
15	15	0	0	0	0	0	0	0	0					0

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	531963.00	620610.60							
Luna curenta	1256.70	1508.04							
Total	533219.70	622118.64							

BABOLEA DANIELA-FLORENTINA

FROM :RAT CRAIOVA FAX NO. :0251506077 24 Oct. 2012 13:42 P11

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 416, sectia: 1 in perioada 05.10.2012 - 15.10.2012

Pag. 1

Ziua	Nr.foaie	Sofer	KM Efectivi	KM Echiv.	Timp efectiv Circul.	Timp efectiv Station.	Timp efectiv Total	Timp normat Circul.	Timp normat Station.	Timp normat Total	Trafic aglom.	Porniri motor	Combustibil Alim.	Combustibil Restit	Combustibil Consum normat
5	42338	1.CAPRA SILVIAN	50.40	60.48	03:41	00:09	03:50	03:30		03:30			44		19.14
5	42338	2.CAPRA SILVIAN	49.40	59.28	03:53	00:35	04:28	03:30		03:30			18		18.76
6		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
7		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
8	42844	1.CAPRA SILVIAN	50.60	60.72	03:45	00:05	03:50	03:30		03:30			36		19.21
8	42844	2.CAPRA SILVIAN	62.20	74.64	05:15	00:20	05:35	04:30		04:30			0		23.53
9	42957	1.CAPRA SILVIAN	37.00	44.40	02:43	00:31	03:14	02:30		02:30			36		14.15
9	42957	2.CAPRA SILVIAN	61.80	74.16	05:10	00:10	05:20	04:30		04:30			0		23.38
10	42736	1.CAPRA SILVIAN	37.00	44.40	02:40	00:20	03:00	02:30		02:30			37		14.15
10	42736	2.CAPRA SILVIAN	74.60	89.52	06:05	00:30	06:35	05:30		05:30			0		28.14
TOTAL DECADA 1			423.00	507.60	33:12	02:40	35:52	30:00		30:00			171		160.46
11	42638	1.CAPRA SILVIAN	37.00	44.40	02:43	00:27	03:10	02:30		02:30			49		14.15
11	42638	2.CAPRA SILVIAN	62.20	74.64	04:55	00:25	05:20	04:30		04:30			0		23.53
12	42543	1.CAPRA SILVIAN	37.00	44.40	02:40	00:20	03:00	02:30		02:30			38		14.15
12	42543	2.CAPRA SILVIAN	61.80	74.16	05:12	00:13	05:25	04:30		04:30			0		23.38
13		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
14		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
15		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0		0.00
TOTAL DECADA 2			198.00	237.60	15:30	01:25	16:55	14:00		14:00			87		75.21
TOTAL PERIOADA			621.00	745.20	48:42	04:05	52:47	44:00		44:00			258		235.67

CONSUM COMBUSTBIL RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
183.00	258	235.67	0.000	205.33	0	205.33	441.00

BCF
0

Numar de zile si imobilizari pe cauze

Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot	CO	CM	CFS	Altele
15	10	0	0	0	0	0	0	0	4					1

	Parcurs realizat (km) de la introducerea in exploatare: KM efectivi	KM echivalenti	KM. ECHIVALENTI: rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	631646.80	730630.76							
Luna curenta	621.00	745.20							
Total	632267.80	731375.96							

BABOLEA DANIELA-FLORENTINA

Measure title: **Alternative fuels in Craiova**

City: **Craiova** *Project:* **MODERN** *Measure number:* **01.02**

FROM :RAT CRAIOVA FAX NO. :0251506077 24 Oct. 2012 13:44 P13

FISA ACTIVITATII ZILNICE PENTRU MASINA ROMAN UDM 112 cu numarul de inventar 417, sectia: 1 in perioada 05.10.2012 - 15.10.2012

860

Pag. 1

Ziua	Nr.foaie	Sofer	KM		Timp efectiv			Timp normat			Trafic aglom.	Porniri motor	Combustibil		
			Efectivi	Echiv.	Circul.	Station.	Total	Circul.	Station.	Total			Alim.	Restit	Consum normat
5	42339	1.GHITA FLORICA-IONUT	49.40	59.28	03:36	00:09	03:45	03:30		03:30			43		18.76
5	42339	2.GHITA FLORICA-IONUT	62.20	74.64	04:50	00:25	05:15	04:30		04:30			44		23.53
6		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
7		*LIBER			00:00	00:00	00:00	00:00		00:00			0		0.00
8		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0	+8.	0.00
9		I:Alte cauze			00:00	00:00	00:00	00:00		00:00			0		0.00
10	42737	1.GHITA FLORICA-IONUT	49.40	59.28	03:35	00:00	03:35	03:30		03:30			50		18.76
10	42737	2.GHITA FLORICA-IONUT	62.20	74.64	05:00	00:45	05:45	04:30		04:30			0		23.53
TOTAL DECADA 1			223.20	267.84	17:01	01:19	18:20	16:00		16:00			137		84.58
11	42639	1.GHITA FLORICA-IONUT	49.40	59.28	03:27	00:11	03:38	03:30		03:30			50	+7	18.76
11	42639	2.GHITA FLORICA-IONUT	61.80	74.16	04:50	00:55	05:45	04:30		04:30			0		23.38
12	42544	1.GHITA FLORICA-IONUT	49.40	59.28	03:29	00:01	03:30	03:30		03:30			45	+3.	18.76
12	42544	2.GHITA FLORICA-IONUT	62.20	74.64	05:10	00:35	05:45	04:30		04:30			0		23.53
13	42689	2.GHITA FLORICA-IONUT	111.40	133.68	08:40	00:00	08:40	08:30		08:30			0		42.22
14	42181	1.GHITA FLORICA-IONUT	114.60	137.52	08:30	00:00	08:30	08:30		08:30			0	-7	43.41
15	42043	1.GHITA FLORICA-IONUT	41.80	50.16	03:05	00:00	03:05	03:00		03:00			118		15.94
15	42043	2.GHITA FLORICA-IONUT	29.40	35.28	02:15	00:00	02:15	02:00		02:00			0		11.32
TOTAL DECADA 2			520.00	624.00	39:26	01:42	41:08	38:00		38:00			213		197.32
TOTAL PERIOADA			743.20	891.84	56:27	03:01	59:28	54:00		54:00			350		281.90

CONSUM COMBUSTBIL 665							
RRi	Alimentat	Normat	Restituit	Rest calculat	RRf	Dif	Consum efectiv
155.00	350	281.90	25.000	198.10	0	198.10	480.00
	BCF						
	0						

798.

Numar de zile si imobilizari pe cauze														
Zile luna	Zile efective	Lipsa piese	Lipsa mater	Lipsa anvel	Rep. curente	Rep.tehn2	Rep. capitale	Rodaj	Libere	Nemot.	CO	CM	CFS	Altele
15	11	0	0	0	0	0	0	0	2					2

	Parcurs realizat (km) de la introducerea in exploatare		KM. ECHIVALENTI						
	KM efectivi	KM echivalenti	rt1	rt2	rc	rk	anv	ulei	motor
Inceput luna	507371.70	597296.64							
Luna curenta	743.20	891.84							
Total	508114.90	598188.48							

BABOLEA DANIELA-FLORENTINA

Annex 3 – Calculation sheets for ex-ante evaluation

Fuel type: diesel oil

Data provided by RAT

2011 / monthly data			
Buses type	**Number of buses in operation**	**Total fuel consumption (liters)**	**Total mileage (km)**
Roman UDM (section 1)	17	16677	41502
Roman UDM (section 2)	17	18619	50210
Mercedes	12	19243	36407
MAN	8	15083	38719
Bredabus (section 1)	23	26517	61774
Bredabus (section 2)	4	4861	11486

Total

Roman UDM	34	35296	91712
Mercedes	12	19243	36407
MAN	8	15083	38719
Bredabus	27	31378	73260

Diesel oil price

Fuel type	**Acquisition date**	**Quantity (tons)**	**Price (RON/ ton)**	**Costs (RON)**	**Density (kg/liter)**	**Quantity (liters)**	**Price (RON/ liter)**	**Currency (RON/ EURO)**	**Price (EURO/ liter)**
Diesel oil	Apr-11	7.311	4847.55	35440	0.8415	8688	4.08	4.1120	**0.99**
Diesel fuel price according to the RAT invoices									
Source of currency: http://cursvalutar.dailybusiness.ro/curs-valutar-mediu-lunar									

Data provided by RAT						**Data calculated for 10 buses**				
Buses type	Number of buses in operation	Total fuel consumption per month (liters)	Total mileage per month (km)	Number of buses with biodiesel filters for demonstration	Average speed of buses in the city (km/h)	Fuel consumed by demonstration buses (liters)	Mileage for demonstration buses (km)	Fuel consumption per unit of activity (l/vkm)	Specific consumption (liters/h)	Specific consumption (kg/h)
0	1	2	3	4	5	6=2x7/1	7=3x7/1	8=6/7	9=8x5	10=9x fuel density
Roman UDM	34	35296	91712	7	18	7267	18882	0.38	6.93	5.83
Mercedes	12	19243	36407	1	18	1604	3034	0.53	9.51	8.01
MAN	8	15083	38719	1	18	1885	4840	0.39	7.01	5.90
Bredabus	27	31378	73260	1	18	1162	2713	0.43	7.71	6.49
Total				**10**	**18**	**11918**	**29469**	**0.404**	**7.28**	**6.13**

Average operating costs

Average operating costs					**Data calculated**		
Buses type **Source: RAT**	**Number of buses for demonstration** **Source: RAT**	**Price (EURO/liter)** **Source: RAT**	**Fuel consumed by demonstration buses (liters)** **Source: RAT**	**Mileage for demonstration buses (km)** **Source: RAT**	**Total fuel price (EURO)**	**Operational costs for the demonstration buses (EURO)***	***Average Operating costs (EURO/vkm)***
0	1	2	3	4	5=3x2	6=5	7=6/4
Roman UDM	7	0.99	7267	18882	7209	7209	
Mercedes	1	0.99	1604	3034	1591	1591	
MAN	1	0.99	1885	4840	1870	1870	
Bredabus	1	0.99	1162	2713	1153	1153	
TOTAL	**10**		**11918**	**29469**	**11823**	**11823**	**0.4012**

* The operational costs were limited to the fuel cost, this being the only cost element that changes; detailed explanation in the chapter C1.1

Vehicle Fuel Efficiency (MJ/vkm)

Fuel Type	***Energy content of fuel (MJ/kg)***	***Fuel density (kg/l)****	***Energy content of fuel, calculated (MJ/l)****	**Number of buses for demonstration** **Source: RAT**	**Fuel consumed by demonstration buses (liters)** **(calculated table above)**	**Mileage for demonstration buses (km)** **(calculated table above)**	***Energy content of fuel consumed by 10 buses (MJ)***	***Vehicle Fuel Efficiency (MJ/vkm)***
0	1	2	3=1x2	4	5	6	7=5x3	8=7/6
Diesel fuel	**45.862**	**0.84**	**38.59**	**10**	**11918**	**29469**	**459947**	**15.61**

* Data from the study: Researches concerning the analysis of pollutant emissions level produced by buses operating with biodiesel fuel in Craiova / agreement no. 5C/27.02.2012

** According to the fuel supplier specified on the invoice

Emissions calculation

(to transform the emissions concentration measured in the exhaust gases in quantity of emissions per unit of activity)

The method of calculation is presented in the chapter C1.1

	CO	**CO2**	**CO2**	**NOx**	Air to fuel ratio lambda calculated *	Exhaust gas mass flow rate Gexhw kg/h ** calculated
Emissions in the exhaust gases measured	Concentration of CO (ppm) measured	Concentration of CO2 (%) measured	Concentration of CO2 (ppm) calculated	Concentration of NOx (ppm) measured		
	970.64	1.78	17787	84.30	7.776	693
Instantaneous flow of gas i in exhaust gases Gas $(i)_{mass}$ (kg/h) calculated	0.8409		24.21	0.112		
Specific emissions g/l fuel calculated	115.51		3,326.39	15.330		
Specific emissions g/vkm calculated	46.7		1345.3	6.2		

*lambda was calculated with formula from chapter C1.1

**Gexhw (kg/h) was calculated with lambda calculated

Table of data for emissions density calculation

Gas	**Molar weight / molar volume**	**Density (kg/m3)**	**Comments**
CO2	44 / 22.4	1.96	
CO	28 / 22,4	1.25	
O2	32 / 22,4	1.43	
HC ($H_{1.85}C_1$)	(1,85+1*12)/22,4	0.62	average carbon to hydrogen ratio: 1: 1.85 (EC Directive 26/2004)
NOx (x=1.8)	(14+1,8*16)/22.4	1.91	considered as a mixture of equal parts of NO, NO2, NO3 si N2O3 (supposition)

Calculation of stoichiometric ratio air / fuel (A/Fst) for standard diesel fuel which is a blend of 5% biodiesel in diesel oil

Stoichiometric ratio air / fuel (A/Fst) **for different fuels**	
Diesel oil	***14,530***
Biodiesel fuels	***12,300***

		Biodiesel	Diesel oil	Biodiesel 5% (B5)
Quantity used for fuels mixture	[liters]	5	95	100
density	[kg/l]	0,819	0,84	
Quantity used for fuels mixture	[kg]	4,095	79,8	83,895
air for combustion	[kg]	50,3685	1159,494	1209,8625
A/Fst for B5				**14,42**

Annex 4 – Calculation sheets for BAU evaluation

Fuel type: diesel oil

Data provided by RAT

2011 / monthly data			
Buses type	**Number of buses in operation**	**Total fuel consumption (liters)**	**Total mileage (km)**
Roman UDM (section 1)	17	16677	41502
Roman UDM (section 2)	17	18619	50210
Mercedes	12	19243	36407
MAN	8	15083	38719
Bredabus (section 1)	23	26517	61774
Bredabus (section 2)	4	4861	11486

Total

Roman UDM	34	35296	91712
Mercedes	12	19243	36407
MAN	8	15083	38719
Bredabus	27	31378	73260

2012 / monthly data			
Buses type	**Number of buses in operation**	**Total fuel consumption (liters)**	**Total mileage (km)**
Roman UDM (section 1)	14	14432	38102
Roman UDM (section 2)	15	14570	39487
Mercedes	12	17399	37874
MAN	11	16709	43401
Bredabus (section 1)	4	7386	17182
Bredabus (section 2)	7	7793	18020
Bredabus (section 2)	16	18053	42987

Total

Roman UDM	29	29002	77589
Mercedes	12	17399	37874
MAN	11	16709	43401
Bredabus	27	33232	78189

Fuel type	**Acquisi-tion date**	**Quantity (tons)**	**Price (RON/ ton)**	**Costs (RON)**	**Density (kg/litre)**	**Quantity (litres)**	**Price (RON/ litre)**	**Currency (RON/ EURO)**	**Price (EURO/ litre)**
Diesel oil	Apr-11	7.311	4847.55	35440	0.8415	8688	4.08	4.1120	**0.99**
Diesel oil	Sep-12	7.197	5668.41	40796	0.819	8788	4.64	4.5007	**1.03**
Diesel fuel prices according to the RAT invoices									
Source of currency: http://cursvalutar.dailybusiness.ro/curs-valutar-mediu-lunar									

Data provided by RAT for 2011						**Data calculated for 10 buses**				
Buses type	Number of buses in operation	Total fuel consumption per month (liters)	Total mileage per month (km)	Number of buses with biodiesel filters for demonstration	Average speed of buses in the city (km/h)	Fuel consumed by demonstration buses (liters)	Mileage for demonstration buses (km)	Fuel consumption per unit of activity (l/vkm)	Specific consumption (liters/h)	Specific consumption (kg/h)
0	1	2	3	4	5	6=2x7/1	7=3x7/1	8=6/7	9=8x5	10=9x fuel density
Roman UDM	34	35296	91712	7	18	7267	18882	0.38	6.93	5.83
Mercedes	12	19243	36407	1	18	1604	3034	0.53	9.51	8.01
MAN	8	15083	38719	1	18	1885	4840	0.39	7.01	5.90
Bredabus	27	31378	73260	1	18	1162	2713	0.43	7.71	6.49
Total				**10**	**18**	**11918**	**29469**	**0.404**	**7.28**	**6.13**

Data provided by RAT for 2012						**Data calculated for 10 buses**				
Buses type	Number of buses in operation	Total fuel consumption per month (liters)	Total mileage per month (km)	Number of buses with biodiesel filters for demonstration	Average speed of buses in the city (km/h)	Fuel consumed by demonstration buses (liters)	Mileage for demonstration buses (km)	Fuel consumption per unit of activity (l/vkm)	Specific consumption (liters/h)	Specific consumption (kg/h)
0	1	2	3	4	5	6=2x7/1	7=3x7/1	8=6/7	9=8x5	10=9x fuel density
Roman UDM	29	29002	77589	7	18	7000	18728	0.37	6.73	5.66
Mercedes	12	17399	37874	1	18	1450	3156	0.46	8.27	6.96
MAN	11	16709	43401	1	18	1519	3946	0.38	6.93	5.83
Bredabus	27	33232	78189	1	18	1231	2896	0.43	7.65	6.44
Total				**10**	**18**	**11200**	**28726**	**0.390**	**7.02**	**5.91**

Average operating costs

Average operating costs 2011					**Data calculated**		
Buses type **Source: RAT**	**Number of buses for demonstration** **Source: RAT**	**Price (EURO/liter)** **Source: RAT**	**Fuel consumed by demonstration buses (liters)** **Source: RAT**	**Mileage for demonstration buses (km)** **Source: RAT**	**Total fuel price (EURO)**	**Operational costs for the demonstration buses (EURO)***	***Average Operating costs (EURO/vkm)***
0	1	2	3	4	5=3x2	6=5	7=6/4
Roman UDM	7	0.99	7267	18882	7209	7209	
Mercedes	1	0.99	1604	3034	1591	1591	
MAN	1	0.99	1885	4840	1870	1870	
Bredabus	1	0.99	1162	2713	1153	1153	
TOTAL	**10**		**11918**	**29469**	**11823**	**11823**	**0.4012**

Average operating costs 2011					**Data calculated**		
Buses type **Source: RAT**	**Number of buses for demonstration** **Source: RAT**	**Price (EURO/liter)** **Source: RAT**	**Fuel consumed by demonstration buses (liters)** **Source: RAT**	**Mileage for demonstration buses (km)** **Source: RAT**	**Total fuel price (EURO)**	**Operational costs for the demonstration buses (EURO)***	***Average Operating costs (EURO/vkm)***
0	1	2	3	4	5=3x2	6=5	7=6/4
Roman UDM	7	1.03	7000	18728	7221	7221	
Mercedes	1	1.03	1450	3156	1496	1496	
MAN	1	1.03	1519	3946	1567	1567	
Bredabus	1	1.03	1231	2896	1270	1270	
TOTAL	**10**		**11200**	**28726**	**11553**	**11553**	**0.4022**

* The operational costs were limited to the fuel cost, this being the only cost element that changes; detailed explanation in the chapter C1.1

Vehicle Fuel Efficiency (MJ/vkm)

Data for 2011

Fuel Type	***Energy content of fuel (MJ/kg)****	***Fuel density (kg/l)*****	***Energy content of fuel, calculated (MJ/l)****	**Number of buses for demonstration Source: RAT**	**Fuel consumed by demonstration buses (liters) (calculated table above)**	**Mileage for demonstration buses (km) (calculated table above)**	***Energy content of fuel consumed by 10 buses (MJ)***	***Vehicle Fuel Efficiency (MJ/vkm)***
0	1	2	3=1x2	4	5	6	7=5x3	8=7/6
Diesel fuel	**45.862**	**0.84**	**38.59**	**10**	**11918**	**29469**	**459947**	**15.61**

Data for 2012

Fuel Type	***Energy content of fuel (MJ/kg)****	***Fuel density (kg/l)*****	***Energy content of fuel, calculated (MJ/l)****	**Number of buses for demonstration Source: RAT**	**Fuel consumed by demonstration buses (liters) (calculated table above)**	**Mileage for demonstration buses (km) (calculated table above)**	***Energy content of fuel consumed by 10 buses (MJ)***	***Vehicle Fuel Efficiency (MJ/vkm)***
0	1	2	3=1x2	4	5	6	7=5x3	8=7/6
Diesel fuel	**45.862**	**0.84**	**38.59**	**10**	**11200**	**28726**	**432248**	**15.05**

* Data from the study: Researches concerning the analysis of pollutant emissions level produced by buses operating with biodiesel fuel in Craiova / agreement no. 5C/27.02.2012

** According to the fuel supplier; specified on the invoice

Emissions calculation

(to transform the emissions concentration measured in the exhaust gases in quantity of emissions per unit of activity). The method of calculation is presented in the chapter C1.1

Data for 2011	**CO**	**CO2**	**CO2**	**NOx**	Air to fuel ratio lambda calculated *	Exhaust gas mass flow rate Gexhw kg/h ** calculated
Emissions in the exhaust gases measured	Concentration of CO (ppm) measured	Concentration of CO2 (%) measured	Concentration of CO2 (ppm) calculated	Concentration of NOx (ppm) measured		
	970.64	1.78	17787	84.30	7.776	693
Instantaneous flow of gas i in exhaust gases Gas $(i)_{mass}$ (kg/h) calculated	0.8409		24.21	0.112		
Specific emissions g/l fuel calculated	115.51		3,326.39	15.330		
Specific emissions g/vkm calculated	***46.7***		***1345.3***	***6.2***		
Data for 2012	**CO**	**CO2**	**CO2**	**NOx**	Air to fuel ratio lambda calculated *	Exhaust gas mass flow rate Gexhw kg/h ** calculated
Emissions in the exhaust gases measured	Concentration of CO (ppm) measured	Concentration of CO2 (%) measured	Concentration of CO2 (ppm) calculated	Concentration of NOx (ppm) measured		
	970.64	1.78	17787	84.30	7.776	668
Instantaneous flow of gas i in exhaust gases Gas $(i)_{mass}$ (kg/h) calculated	0.8107		23.35	0.108		
Specific emissions g/l fuel calculated	115.51		3,326.39	15.33		
Specific emissions g/vkm calculated	***45.04***		***1296.96***	***5.98***		

*lambda was calculated with formula from chapter C1.1

**Gexhw (kg/h) was calculated with lambda calculated

Table of data for emissions density calculation

Gas	Molar weight / molar volume	Density (kg/m3)	Comments
CO2	44 / 22.4	1.96	
CO	28 / 22,4	1.25	
O2	32 / 22,4	1.43	
HC ($H_{1.85}C_1$)	(1,85+1*12)/22,4	0.62	average carbon to hydrogen ratio: 1: 1.85 (EC Directive 26/2004)
NOx (x=1.8)	(14+1,8*16)/22.4	1.91	considered as a mixture of equal parts of NO, NO2, NO3 si N2O3 (supposition)

Calculation of stoichiometric ratio air / fuel (A/Fst) for standard diesel fuel which is a blend of 5% biodiesel in diesel oil

Stoichiometric ratio air / fuel (A/Fst **) for different fuels**	
Diesel oil	***14,530***
Biodiesel fuels	***12,300***

		Biodiesel	Diesel oil	Biodiesel 5% (B5)
Quantity used for fuels mixture	[liters]	5	95	100
density	[kg/l]	0,819	0,84	
Quantity used for fuels mixture	[kg]	4,095	79,8	83,895
air for combustion	[kg]	50,3685	1159,494	1209,8625
A/Fst for B5				**14,42**

Annex 5 – Calculation sheets for ex-post evaluation

Fuel type: biodiesel 20% (B20)

Demonstration period: 04 – 15.10.2012

Data provided by RAT

2012 / demonstration period				
Buses type	**Number of buses in operation**	**Total fuel consumption (liters)**	**Total mileage (km)**	**Average buses speed (km/h)***
Roman UDM	7	2810	7569	13.28
Mercedes	1	420	930	16.45
MAN	1	141	302	6.96
Bredabus	1	326	754	14.17
TOTAL	**10**	**3697**	**9555**	**13**

* vehicle speed resulted from buses activity records during the demonstration with biodiesel B20

Diesel oil price

Fuel type	**Acquisition date**	**Quantity (tons)**	**Price (RON/ ton)**	**Costs (RON)**	**Density (kg/liter)**	**Quantity (liters)**	**Price (RON/ liter)**	**Currency (RON/ EURO)**	**Price (EURO/ liter)**
Diesel oil	Sep-12	7.197	5668.41	40796	0.819	8788	4.64	4.5007	**1.03**
Diesel fuel price according to the RAT invoices									
Source of currency: http://cursvalutar.dailybusiness.ro/curs-valutar-mediu-lunar									

Biodiesel price

Fuel type	**Acquisition date**	**Costs (RON)**	**Density (kg/ liter)**	**Quantity (liters)**	**Price (RON/ liter)**	**Currency (RON/ EURO)**	**Price (EURO/liter)**
Biodiesel	02.10.2012	2400		600	4.00	4.5583	**0.88**
Biodiesel	10.10.2012	800		200	4.00	4.5583	**0.88**

Biodiesel fuel price / October 2012 according to the RAT invoices

Source of currency: http://cursvalutar.dailybusiness.ro/curs-valutar-mediu-lunar

Calculation of the B20 price

	Price (EURO/liter)
Diesel fuel price / September 2012	1.03
Biodiesel price / October 2012	0.88
B20 (20% biodiesel mixture) price calculation	1.02

Note: The current diesel fuel is a mixture with 5% biodiesel. To prepare a mixture of 20% biodiesel it should be added 18.75 liters of biodiesel to 100 liters of diesel B5

The B20 price is calculated with the following formula:

*B20 price = (100*diesel B5 price+18.75*biodiesel price)/118.75*

Data provided by RAT					Data calculated for 10 buses		
Buses type	Number of buses in operation	Fuel consumed by demonstration buses (liters)	Mileage for demonstration buses (km)	Average speed of buses in the city (km/h)	Fuel consumption per unit of activity (l/vkm)	Specific consumption (liters/h)	Specific consumption (kg/h)
0	1	2	3	4	5=2/3	6=5x4	7=6x fuel density
Roman UDM	7	2810	7569	13.28	0.37	4.93	4.04
Mercedes	1	420	930	16.45	0.45	7.43	6.08
MAN	1	141	302	6.96	0.47	3.25	2.66
Bredabus	1	326	754	14.17	0.43	6.13	5.02
Total	**10**	**3697**	**9555**	**13**	**0.387**	**4.92**	**4.03**

Average operating costs

Average operating costs					Data calculated		
Buses type **Source: RAT**	**Number of buses for demonstration** **Source: RAT**	**Price (EURO/liter)** **Calculated**	**Fuel consumed by demonstration buses (liters)** **Source: RAT**	**Mileage for demonstration buses (km)** **Source: RAT**	**Total fuel price (EURO)**	**Operational costs for the demonstration buses (EURO)***	***Average Operating costs (EURO/vkm)***
0	1	2	3	4	5=3x2	6=5	7=6/4
Roman UDM	7	1.02	2810	7569	2875	2875	
Mercedes	1	1.02	420	930	430	430	

Average operating costs					**Data calculated**		
Buses type **Source: RAT**	**Number of buses for demonstration** **Source: RAT**	**Price (EURO/liter)** **Calculated**	**Fuel consumed by demonstration buses (liters)** **Source: RAT**	**Mileage for demonstration buses (km)** **Source: RAT**	**Total fuel price (EURO)**	**Operational costs for the demonstration buses (EURO)***	***Average Operating costs (EURO/vkm)***
MAN	1	1.02	141	302	144	144	
Bredabus	1	1.02	326	754	334	334	
TOTAL	**10**	**1.02**	**3697**	**9555**	**3783**	**3783**	**0.396**

* The operational costs were limited to the fuel cost, this being the only cost element that changes; detailed explanation in the chapter C1.1

Vehicle Fuel Efficiency (MJ/vkm)

Fuel Type	***Energy content of fuel (MJ/kg)****	***Fuel density (kg/l)***	***Energy content of fuel, calculated (MJ/l)****	**Number of buses for demonstration** **Source: RAT**	**Fuel consumed by demonstration buses (liters)** **(calculated table above)**	**Mileage for demonstration buses (km)** **(calculated table above)**	***Energy content of fuel consumed by 10 buses (MJ)***	***Vehicle Fuel Efficiency (MJ/vkm)***
0	1	2	3=1x2	4	5	6	7=5x3	8=7/6
B20	**45.245**	**0.819**	**37.06**	**10**	**3697**	**9555**	**136995**	**14.34**

* Data from the study: Researches concerning the analysis of pollutant emissions level produced by buses operating with biodiesel fuel in Craiova / agreement no. 5C/27.02.2012

Emissions calculation

(to transform the emissions concentration measured in the exhaust gases in quantity of emissions per unit of activity)

The method of calculation is presented in the chapter C1.1

	CO	**CO2**	**CO2**	**NOx**	Air to fuel ratio lambda calculated *	Exhaust gas mass flow rate Gexhw kg/h ** calculated
Emissions in the exhaust gases measured	Concentration of CO (ppm) measured	Concentration of CO2 (%) measured	Concentration of CO2 (ppm) calculated	Concentration of NOx (ppm) measured		
	852.76	1.63	16316	98.23	8.491	486
Instantaneous flow of gas i in exhaust gases Gas $(i)_{mass}$ (kg/h) calculated	0.5182		15.58	0.091		
Specific emissions g/l fuel calculated	105.34		3,167.03	18.540		
Specific emissions g/vkm ***calculated***	***40.76***		***1225.38***	***7.17***		

*lambda was calculated with formula from chapter C1.1

**Gexhw (kg/h) was calculated with lambda calculated

Table of data for emissions density calculation

Gas	**Molar weight / molar volume**	**Density (kg/m3)**	**Comments**
CO2	44 / 22.4	1.96	
CO	28 / 22,4	1.25	
O2	32 / 22,4	1.43	
HC ($H_{1.85}C_1$)	(1,85+1*12)/22,4	0.62	average carbon to hydrogen ratio: 1: 1.85 (EC Directive 26/2004)
NOx (x=1.8)	(14+1,8*16)/22.4	1.91	considered as a mixture of equal parts of NO, NO2, NO3 si N2O3 (supposition)

Calculation of stoichiometric ratio air / fuel (A/Fst) for standard diesel fuel which is a blend of 5% biodiesel in diesel oil

Stoichiometric ratio air / fuel (A/Fst) **for different fuels**	
Diesel oil	***14,530***
Biodiesel fuels	***12,300***

		Biodiesel	Diesel oil	Biodiesel 5% (B5)
Quantity used for fuels mixture	[liters]	20,00	80,00	100
density	[kg/l]	0,819	0,84	
Quantity used for fuels mixture	[kg]	16,38	67,2	83,58
air for combustion	[kg]	201,474	976,416	1177,89
A/Fst for B5				**14,09**