Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Executive summary

Trams with a high capacity transport and minimal environmental impact are an efficient mean for mass transport in cities like Craiova. The trams fleet from Craiova consists in 34 trams and the rolling tracks are 36 kms long. Of the 34 trams, 27 trams are available for passenger's transportation, from East to West in the city. The electric network supplying power for trams and the rolling tracks of trams are 30 years old.

Most trams belonging to RAT Craiova (Public Transport Company) have huge energy consumptions and high maintenance costs due to the old contactors driving system. Thus, Craiova decided to implement this measure by which 9 old trams with contactors driving system have been equipped with chopper driving systems, in order to reduce the energy consumption and maintenance costs. At the same time, by the new tram driving system, passenger comfort was expected to be increased due to smoother starts and stops. The innovative aspects of this measure- new driving technology with low energy consumption and maintenance costs – is relevant for Transport Company in Craiova that records lower energy consumptions and maintenance costs coming from the trams endowed with chopper driving system.

The research team found the optimal implementation solution through a chopper driving system that fits the technical features of the 9 old trams to be upgraded. In this respect, the implementation team produced a technical papers specifying the technical features that the chopper systems to be purchased must meet. The 9 chopper driving systems which were tested in University's laboratories, in terms of vibrations, noise and different loads, were purchased and later they were installed on the 9 old trams, tested and evaluated.

In order to highlight the impact of the measure both the energy consumptions and maintenance costs arising from the trams with contactors driving system and the ones c arising from the trams endowed with chopper driving system were compared. The results proved that the chopper driving system leaded to low operating costs (due to energy saving) and cheaper maintenance.

In order to assess the impact of the measure on the public transport users, a survey was performed and the interviewed people stated their opinion regarding the quality of services brought by the implementation of the new driving system on the trams and in the same time, they expressed their point of view on the usefulness of the measure.

As a focused measure, Cost-Benefit Analysis (CBA) was conducted to assess the cumulated cash flow brought by the measure operation in a period of 10 years.

The key results are the following:

- Average Operating Cost shows the effectiveness of the chopper driving system due to the lower energy and maintenance cost;
- Vehicle Fuel Efficiency - The energy consumption is noticeably lower for the trams upgraded with the new chopper driving system (35% less per tram)
- Quality of service - The results of the surveys in the evaluation period shows a change of users perception on quality of service; they feel more comfortable when travelling by trams endowed with chopper driving system due to smoother start and stop (+1% service quality perceived).

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

As a conclusion, based on the results obtained from assessing the measure's indicators and the success of promotional campaigns, we can conclude that the measure was successfully implemented.

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

A Introduction

A1 Objectives

(A) High level / longer term:

- To reduce emissions in the city, through the reduction of energy consumption.
- To modify the transport attractiveness.

(B) Strategic level:

- To increase the total fleet capacity and reduce energy consumption of the trams in use.

(C) Measure level:

- To put back into service 9 trams in order to reduce the energy consumption of the used trams.
- To install the chopper driving system on the 9 trams in order to decrease up to 40% the electrical consumption of each tram.
- Increasing of PT users comfort by implementing the new tram driving system which gives smoother start and stop.

A2 Description

In circumstances of traffic congestion and pollution are the real problems of the city, to use trams with a high capacity transport and minimal environmental impact is a viable alternative for daily commuting.

The trams fleet from Craiova consists in 37 trams and the rolling tracks are 36 km long. Of the 37 trams, 27 trams are available for passenger's transportation, from East to West in the city. The electric network supplying power for trams and the rolling tracks of trams are 30 years old. So the electric public transportation of Craiova needs a lot of improvements and the target, is to reduce the operation costs, increasing at the same time the passengers' safety and comfort.

Figure A2.1 – trams in Craiova

Within this measure, the old driving systems of 9 trams (Figure A2.1) have been replaced by modern driving systems with low power consumption. The 9 old trams, upgraded with CIVITAS measure, were not in use because of high energy consumption driving systems, and they were proposed for scrapping. In order to up-grade the trams, high power transistors technology was needed, to keep the original electric engine of the trams. The new driving system, called chopper, is easier to use because it provides a better electronic control and allows an energy saving up 40%. The chopper system is assisted by software which store and processes the data from the entire running system. The software allows the online visualization and management of 4 defined electric parameters - network current, engine current, network voltage, and filter voltage.

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Modernization of the power supply systems for tram motors, using choppers, included several changes to the whole power system. In addition, it was necessary to modify the electric wiring of the trams.

Moreover these modifications were needed for an easy maintenance after implementation. Another important aspect is the fact that, the trams proposed for upgrading by RAT, have different construction features (there are 2 different types of trams from 2 different manufacturers).

These different construction features require additional working regarding the placement of the choppers and, obviously, their adjustment to the required power.

All these issues resulted in need to develop a prototype of chopper.

The measure implementation implied research activities aimed to find a good technical solution for the chopper fitting to old trams' features.

A chopper prototype was developed, as a result of technological transfer (TT) between IPA (as measure leader) and SC INDA ELTRAC SA Craiova that is an industrial company specialized in development of automatic driving system. The TT agreement between the two parties consisted of: brake recovery energy, anti-skidding of the driving wheels solution and solution for on-board computer. The prototype of chopper system was tested in terms of power connections, vibration and noise, both in IPA's and University's laboratory.

Starting from the prototype, technical requirements documentation was carried out for purchasing the chopper driving systems for the 9 old trams.

In addition, IPA Craiova manufactured specific devices for reading and storing the energy consumption and installed them on the 9 trams endowed with chopper system. In this way, the energy consumed by each tram with chopper driving system can be monitored more precisely. The system allowed a breakdown of energy use on different sections of track via monitoring equipment connected to different power supply stations. This gave a detailed picture of not only drivers' performance, but each individual's energy profile along different parts of the network.

Main characteristics of the chopper system are:

- Energy saving up to 40%,
- Decrease of maintenance cost and time
- Increase the safety and comfort of the passengers
- Provides power supply for the driving motors corresponding to the run-brake regime;
- The chopper has an unitary construction, mono-block;
- Communication of CAN open type with the board computer for receiving the commands and the permanent monitoring of the tramway's state;
- The chopper runs in a fault regime if the board computer is damaged or communication is lost; this regime is useful to drive the vehicle to the depot for troubleshooting;
- The command module of the chopper is able to store information that can easily be used for the maintenance of the vehicle (function hours, mileages, maximum speed, minor faults or critical faults, etc.).

Another advantage of chopper driving system implementation is the smooth starting and stopping of the trams, which led to increasing the comfort and safety.

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Fig. A2.2 – the chopper

Fig. A2.3 – the board computer

Fig A2.4 – a tram with chopper

B Measure implementation

B1 Innovative aspects

The innovative aspects of the measure are:

- **Use of new technology/ITS** – The chopper system is a new driving technology with low energy consumption. The monitoring software is a Windows application that works independently of equipment and has the role to store and process all data from the entire working system.
- **Up to 40% energy reduction** – If two or more trams with chopper installed are driving on the same electrical powered section the energy reduction can go up to 40%, because of the energy saving from braking and other subsystems, that injects energy into the that specific section so that other trams can use it.
- **Increasing the braking safety** – The chopper system makes the tram to brake in a safer manner, meaning that the start and the stop of the tram are more secured and comfortable.
- **Online management** – The software allows the online visualization and management of 4 defined electric measures - line current, engine current, line voltage, and filter voltage.

B2 Research and Technology Development

The purpose of the Research and Technology Development for this measure was to ensure the quality and the function into the parameters of the chopper system.

- **Planning and design of the measure**

Similar systems were studied, implemented both by Public Transport operators in Romania and from other European cities. The research team found the optimum solution of a chopper system that match to old trams' structure as described above.

During the RD activity the team developed an innovative specific technical solution for anti-skidding (anti skating in order to avoid tram derailment) of the driving wheels. This innovation developed by IPA and has been proposed as a patent to OSIM (State Office for Inventions and Trademarks).

To ensure the industrial perspective of this product, a technological transfer (TT) to an industrial company has been carried out. This transfer occurred from IPA (as measure leader) toward SC INDA Eltrac SA Craiova, an industrial company specialized in this field of activity, has been carried out. This technological transfer was made on the agreement basis between IPA and SC INDA Eltrac SA Craiova.

The Technology Offer for chopper solution is registered in the Technological Transfer Database of the Enterprise Europe Network and can be requested by anyone. For the technological transfer under EEN rules there is not about a selection process.

The transfer was focused on:

- brake recovery energy
- anti-skidding (anti skating in order to avoid tram derailment) of the driving wheels solution

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

- solution for on-board computer

Thus, IPA and RAT technicians designed the whole wiring, data communication system between choppers and the location of all the different devices of the chopper.

- **Project of electronic chopper system for trams**

Starting from the technology transfer, an optimal technology for chopper system implementation was agreed, in compliance with the best balance between quality and price. In the same time, a lot of devices for chopper system were designed and software programs (Figure B2.1 and B2.2) were developed needed for chopper operation. The chopper system was tested (Figure B2.3) in terms of power connections vibration and noise, both in IPA laboratory and in University's laboratory by the help of professors and technicians.

The chopper driving system allows to the motor using continuous current to pass in a generator regime, especially when it brakes. So, the kinetic energy of the tramway is transformed in electric energy that is recovered in the power line. This energy is consumed by the other vehicles that are powered from the same line. In the case in which there are no other consumers, the braking energy will be dissipated in the line.

There were defined technical specifications needed for public tender procedure regarding the acquisition of chopper systems for trams.

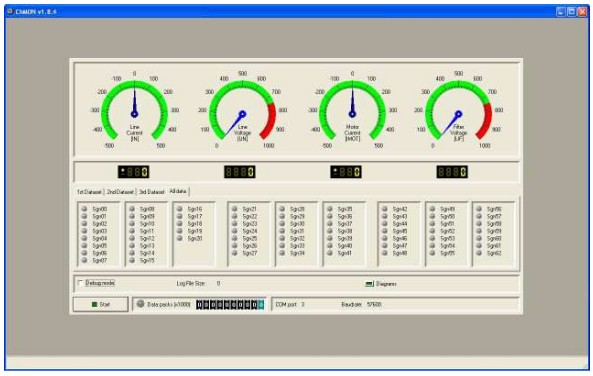

Figure B 2.1 Main window of the program

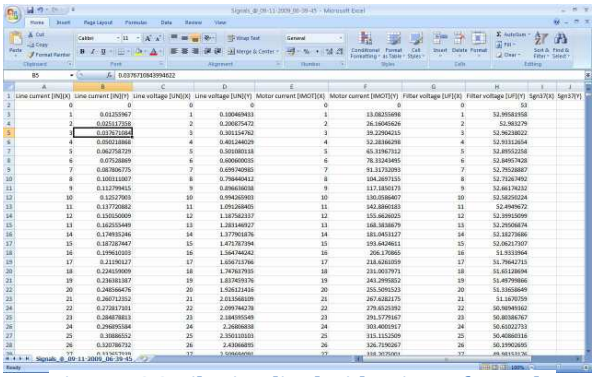

Figure B2.2 File visualized with Microsoft Excel

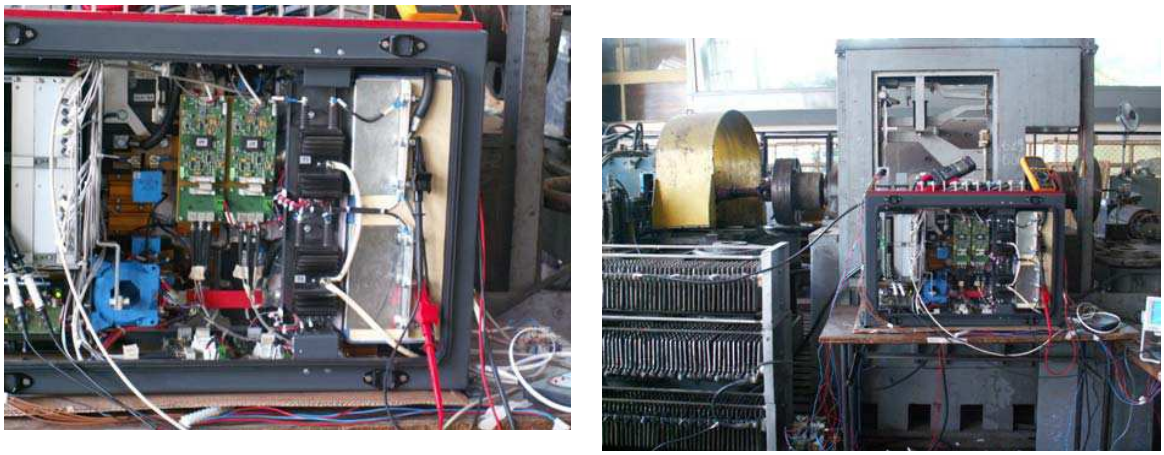

Figure B2.3 Testing of the chopper

- **Designing and prototype carrying -out of device for** reading and storing data related to the energy consumption from trams

This activity has been necessary to monitor in a more accurate way the energy consumption on each upgraded tram. In principle the following components contribute to the energy consumption:

- Electrical engine
- Air conditioner
- Lighting system
- Safety equipment
- Braking system

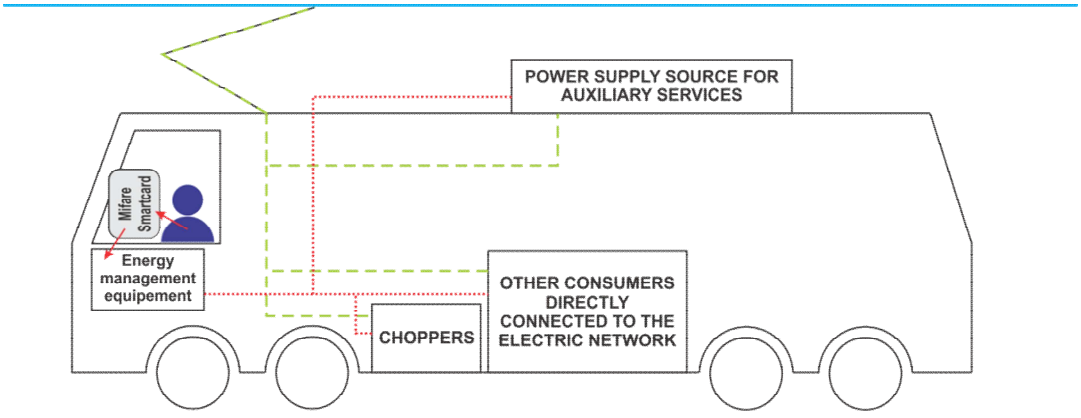

Figure B2.4 Position of the storage device (with Smartcard) for total energy consumption

The carrying -out of the device for reading and storing electrical data included the following steps

- Definition of the device's technical features
- Designing of the device and the PCB (Printed Circuit Board- Fig. B 2.5)

Figure B2.5

- Definition of the technical features of the firmware (a special program which assures the control of the device)
- Definition of the data recording both in the equipment memory and Mifare identification cards of the tram drivers Designing of the software routines interfacing the specific device software package started

Testing of the communication between the main device (made with Microchip signal processor), computer card reader and chopper

Energy consumption values have been determined reading electrical data from 2 devices, at the same time:

- On-board computer (BC) providing energy consumption only from traction part (ETractiune);
- Voltage and current acquisition devices (placed next the power supply line of the trams) by reading the records from the Smartcards, in that way we obtain the entire tram energy consumption value (ET_{otal}).

Difference between the two values (E_{Totala} - $E_{Tractiune}$) represents the consumption of auxiliary services of the tram (breaking system, air conditioning system, heating, and lightning).

B3 Situation before CIVITAS

In 2008 in Craiova, at the start of the project, the trams fleet was of 37 trams. Daily, about 27 trams ran from East to West of the city. 24 trams out of 37 had old electric driving system and 13 trams had chopper driving systems by construction. 9 trams out of 24 old driving system trams were out of service because of high energy consumption.

Of the 27 trams that ran every day, 13 trams are equipped with chopper driving systems and 14 trams are equipped with old driving systems based on contactors and braking rheostats with a high consumption of energy. Of the 14 trams old driving systems trams that were running in 2009, in Craiova, some of them (Mm5 type) had a rigid construction (belonging of the year 1945) which has seriously damaged the runway and could lead to the derailment.

This is the reason for that the trams Mm5 type were not chosen to be equipped with the chopper system. RAT intention is to disable them and retire from exercise in the next future. Besides, in 2010 RAT Company decided to scrap 3 trams KT4D because they were very damaged and not good for upgrading.

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Given that the trams public transport is a viable alternative for daily commuting, RAT Craiova decided to upgrade the 9 old trams (6 trams KT4D type and 3 trams GT type) and put them back into service.

So, through MODERN project, RAT Craiova decided to replace the high energy consumption driving system of the 9 trams with low energy consumption driving system (chopper system), noting that the 9 trams does not add to the fleet that run daily but they replace other old trams with high energy consumption (see the Table B3.1)

Table B3.1 – Status of Craiova tram fleet

Trams type	Average number of trams in operation	Total no of trams	Trams type of whole fleet (%)	Comments
KT4D	1- equipped with contactors old driving system	10- equipped with contactors old driving system	25**%**	6 of these trams upgraded through MODERN project, measure 01.09
GT6	9- equipped with contactors old driving system	9- equipped with old driving system	25%	3 of these trams upgraded through MODERN project, measure 01.09
Mm5	4- equipped with contactors old driving system	5 - equipped with old driving system	14%	
T4DMTTB	13- with different chopper systems by construction	13- with different chopper systems by construction	36%	
Total	27	37	100%	

The trams fleet structure in 2008 is shown in the figure B3.2

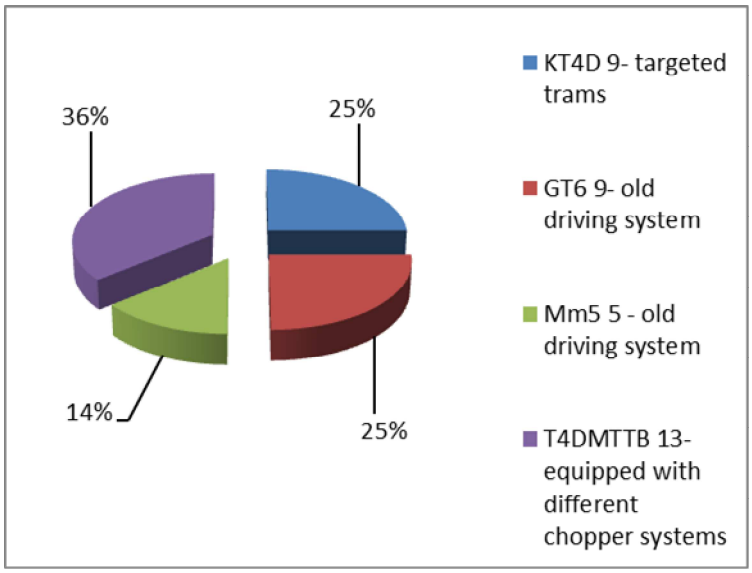

Figure B 3.2 – share of tram types operating in Craiova

B4 Actual implementation of the measure

Stage 1: Planning and design of the measure (October 2008-January 2009)

There were studied similar systems implemented both the Public Transport operators from Romania and the Public Transport operators from other European cities. The research team found optimum solution of chopper system that match to old trams' features.

A technical solution for anti-skidding of the driving wheels was developed by IPA and proposed as a patent at OSIM (State Office for Inventions and Trademarks). The registration document at OSIM (notification) nr. A/00931 – in Romanian - was attached to the MERT(annex 3) . The technological transfer (TT) from IPA (as measure leader) toward SC INDA ELTRAC SA Craiova which is an industrial company focused on controlling systems production, has been carried out. The TT agreement between the two parties is attached to the MERT(annex 3). The technological transfer consisted of:

- brake recovery energy
- anti-skidding of the driving wheels solution
- solution for on-board computer

Thus, IPA and RAT technicians designed all type of electric cables, data communication system between chopper and found the location of the different devices of the chopper.

Stage 2: Development and testing of the chopper prototype (January 2009- May 2009)

In this stage, the chopper system was developed and every subsystem was tested and calibrated for the purpose of implementing a prototype on the tram (Fig. 6).

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Starting from the technical conditions and requirements there were agreed the optimal technologies for the chopper system implementation taking into consideration the best balance between quality and price. In the same time, a lot of devices for chopper system were designed and software programs needed for the operation of the chopper (Figure 1 and 2) were developed.

The chopper system was tested (Figure 3) in terms of power connections vibration and noise, both in IPA laboratory and in University's laboratory by professors and technicians.

The chopper driving system allows to the engine using continuous current to pass in a generator regime, especially when it brakes. So, the kinetic energy of the tramway is transformed in electric energy that is recovered in the power line. This energy is consumed by the other vehicles that are powered from the same line. In the case in which there are no other consumers, the braking energy will be dissipated on the line.

The chopper prototype was installed and tested on a tram. The final version of the equipment specification was defined.

Several tests on shape and size, installation, control and power connections, insulation resistance and endurance of both devices were made.

The equipment met all the requirements.

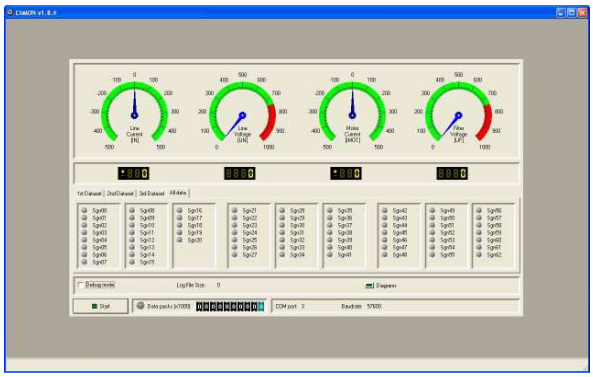

Figure 1 Main window of the program

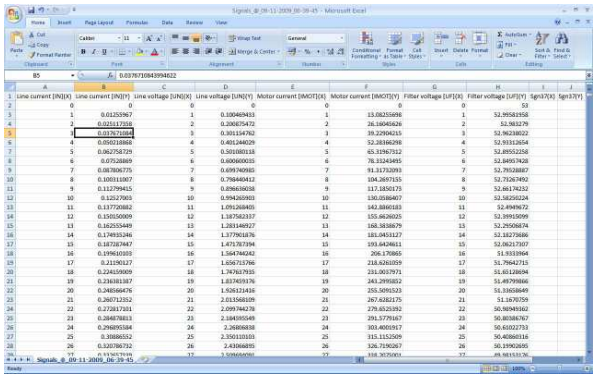

Figure 2 File visualized with Microsoft

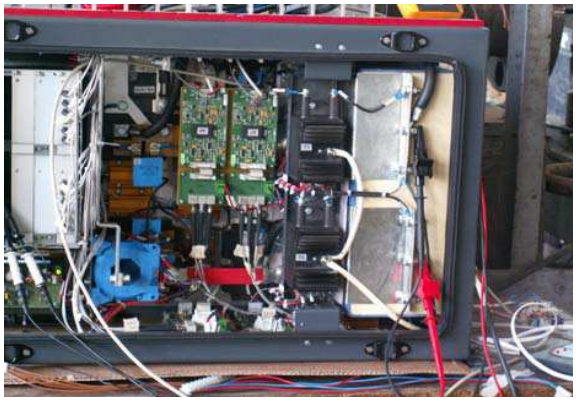

Figure 3 Prototype unit

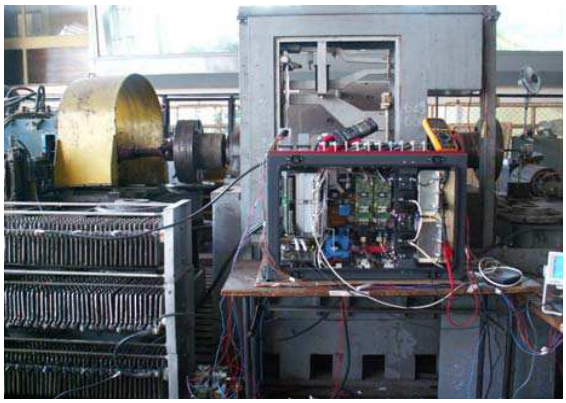

Figure 4 Testing of the chopper

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Figure 5 Energy saving on tramline

Stage 3: Subcontracting company for chopper production and installation (June 2009 - March 2011)

- **Procurement procedure carrying out (June 2009- Jan. 2010)**

Because the investment cost is high, RAT was obliged, by Romanian procurement low (34/19.04.2006 regulations,) to organize public auction to purchase 9 choppers systems.

Tender documentation was based on up-dating of electrical driving systems, according to current legislation, and following some solutions adopted by other transport operators.

The tender book contains the technical features of the equipment, the general implementation plan, the needed qualifications of the contractor etc.

Procurement procedure ended in January 2010 and the choppers delivery contract between RAT and provider, was signed.

- **Choppers delivery and installing (Feb. 2010-March 2011)**

The provider delivered the choppers in 3 steps, as following:

No. crt	Delivering date	Quantity
1	01.02.2010	3
2	15.04.2010	3
3	30.07.2010	3

Figure 7 A trams prepared for the chopper system installation process

In accordance with the delivery, the choppers were installed on trams.

In the figure 7, a tram prepared for the chopper system installation process is shown.

Stage 4: Technicians training (Sept 2009- March 2010)

The training program for drivers consisted of theoretical and practical notions about the new equipment installed on the trams, and a test drive together with the trainer.

From driving point of view, the differences between trams are not high, but the board of trams with chopper equipment is changed and provides more information and functions to the drivers and this must be known.

Stage 5: Chopper system operating (April 2011-Sept 2012)

In this stage, all 9 trams endowed with chopper systems operated in Craiova.

The upgraded 9 trams didn't record technical problems in circulation during operation in normal working hours. The trams were under continuous monitoring from the technical point of view.

This stage flags the beginning of the measurements needed in the ex-post evaluation.

Stage 6: Design and prototype for reading and storing data device, referring to the energy consumption on trams (Jul 2011-Jan 2012)

This activity was developed in addition to the initial set at the beginning of the project because an accurately monitoring of the energy consumption on each upgraded tram was necessary.

IPA Craiova manufactured specific devices for reading and storing the energy consumption and installed them on the 9 trams endowed with chopper system.

These were necessary to monitor in a more accurate way the energy consumption on each upgraded tram. In principle the following devices contribute to the energy consumption

- the converters (choppers) devoted to supply power to the traction motors
- the ancillary services supplied with energy by the source for auxiliary services
- The ancillary services directly coupled to the tram's power network (600V line).

Specific devices (Fig 4) were manufactured for reading and storing the energy consumption of trams endowed with chopper system.

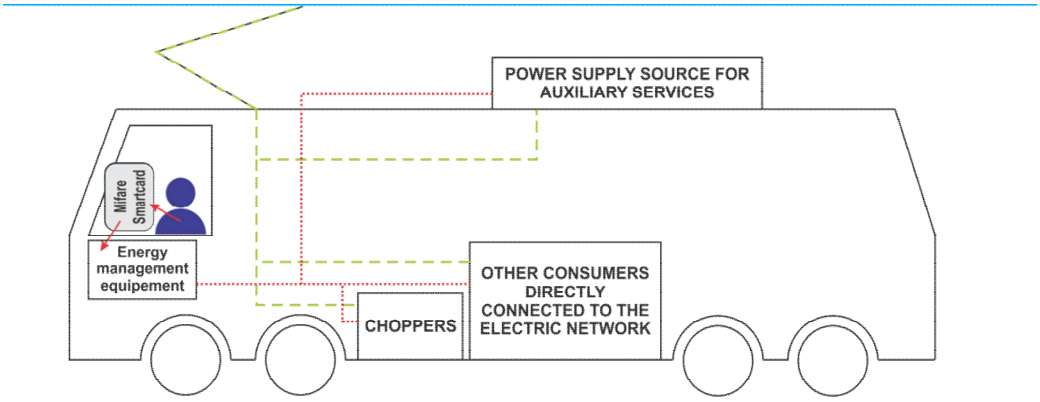

Figure 4 Specific devices for the tram

After the installation of the choppers on trams it was observed a different consumption according to the driver. The different consumption is due to the different behaviour of each driver in traffic, and to the use of ancillary services in a different ways.

Figure 5 Printed Circuit Board

To realize a more detailed analysis of different modes of use of the vehicles with electric traction (trams in our case) by human operators, it was necessary to analyse the energy consumption for each driver separately. This is the main function of the devices which provide more realistic information about the energy consumption of trams.

Thus, on the driver board a specific device was installed, capable of reading/writing Mifare cards type and of communicating with the tram driver on one side, and on the other side with the other on-board equipment, responsible for acquiring the electrical parameters necessary to evaluate the energy consumption.

The communication with the on-board computer (which is connected with the chopper equipment) is ensured by a serial port CAN, in a CANOpen protocol and by RS232 and / or RS485 port, with the Mifare card reader which selects the tram driver.

All the nine upgraded trams were equipped with these devices for reading and storing information related to energy consumption, also related to drivers' behaviour. The system is activated by each driver, using the chip card, at the beginning of his service.

Data are stored and processed for each tram but also for each driver and are used to make management decisions on the trams fleet.

The devices were installed on the on-board computers of the 9 trams already upgraded within the project.

- the technical features of the equipment have been defined

- the design of the device to acquire information about energy consumption by tram and by tram driver.
- the PCB (Printed Circuit Board - Fig. 5) for the energy consumption devices was designed in order to provide the needed functions and the electronic components were positioned
- the functional characteristics of the firmware (a special program which assures the command and control of the device) have been specified
- the data which will be recorded both in the equipment memory and in the Mifare identification cards of the tram drivers have been defined
- the design of the software routines interfacing the specific device software package started
- some tests on the communication between the main equipment (made with Microchip signal processor) and related equipment (computer card reader and choppers) have been performed.

All the 9 upgraded trams were equipped with devices for reading and storing information related to energy consumption.

Stage 7: Design and development of a pilot qualitative evaluation system of electricity, from trams distribution stations, in order to optimize energy distribution (Jan 2012- May 2012)

To measure the overall energy consumption of trams, in 3 distribution stations were made acquisition systems for voltage and current in order to calculate the electric power absorbed from each station. These devices are built with 8-bit microcontrollers.

The development of these devices and their installation in distribution stations was necessary for the following reasons:

- RAT uses in the same time both modernized trams equipped with chopper, and modernized trams. In this situation, having both entire energy consumption (in substations) and energy consumption of each modernized tram they can determine the total energy consumption of un-modernized trams;
- Having an evolution for voltage and current in each distribution station separately, they can take some decisions mainly about the distribution of the trams on different route sections in order to have a maximum use of recovered energy given by modernized trams.

To measure current flow LEM transducers and signal adjustment circuits were used. Current acquisition was performed using the current shunt from each measuring circuit which is present in each distribution station.

Finally, the on time data acquisition is made through systems with PIC18F8722 microcontroller. To avoid any perturbations the current or voltage are transformed into unified signal (4 - 20mA).

Due to this type of signal, the analogue inputs of the microcontrollers required adjustments, namely transforming current signal (20mA maximum) in voltage signal (5V max).

To view analogue measurements acquired by the microcontroller systems, in each distribution stations were made RS232 - Ethernet converters allowing serial data transmission from microcontroller systems via Ethernet network.

Data visualization can be made using virtual oscilloscope software installed on a personal computer.

Activities for the development of these systems were:

- Definition of the technical characteristics of the acquisition system.
- Establishing how to make the interconnections of the system in the existing measurement circuit of each distribution station.
- Design of the electronic circuits and printed circuit boards (PCBs).
- Physical implementation of each device.
- Development of the firmware.
- Manufacturing of the metal cabinets containing the acquisition system.
- Installation of the data acquisition system.
- Test of the data acquisition system.

Metal cabinet with acquisition system

Data acquisition system from distribution stations

B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **M 08.06** Priority traffic light regulation for PT in Craiova is implemented on the same vehicles- the 9 old trams

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

C Impact Evaluation Findings

C1 Measurement methodology

C1.1 Impacts and Indicators

The key indicators assessed within this measure are:

- electric energy consumption (%)
- quality of service
- exploitation costs

The evaluation process was supported by the availability of special purpose software which allows the online visualization and management of - network current, engine current, network voltage, and filter voltage. The following table reports the whole set of data used for the evaluation:

Table C1.1: Indicators.

No.	Impact	Indicator	Data used	Comments
2	Economy	Average Operating costs	Annual operating costs: Energy, Spare parts and maintenance	Shows the effectiveness of the chopper driving system due to the lower energy and maintenance cost
2’		Capital cost	Investments costs	The investments cost can be recuperated due to the energy saving
3	Energy	Vehicle Fuel Efficiency Energy consumption	Tram Energy consumption Number of Km travelled RAT Craiova records	The energy consumption is noticeably lower for the trams upgraded having chopper driving system
13	Society	Awareness level	Face to face and phone surveys	Perception of the increase of the awareness level for the transport with trams
19	Transport	Quality of Service	Perception of the quality of service of public transport (trams). Face to face and phone surveys	The results of the surveys in the evaluation period shows a change of users perception on quality of service; they feel more comfortable when travelling by trams equipped with chopper driving system due to smoother start and stop

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Detailed description of the indicator methodologies:

Indicator 2 (Average Operating costs) - Ratio of total operating costs, such as energy, spare parts and maintenance costs, divided by the total vehicle-km completed by the 9 trams in service per year.

A = B / C

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

B = Total operational costs coming from the 9 trams, (€)

C = Total vehicle- Km traveled by the 9 envisaged trams.

RAT provided only operating costs related to the 9 trams referring to energy consumption, spare parts and maintenance.

Indicator 2' (Capital cost) - Investment cost for the 9 chopper driving systems

The capital cost is according to the contract between the provider and RAT

Indicator 3 (Vehicle Fuel Efficiency)- The energy consumption of each tram on a given distance

The energy consumption was counted with an energy counter, for the 9 envisaged trams

A = B / C

A = Average energy consumption (KW/vKm)

B = Total energy consumed by the 9 envisaged trams (KW)

C = Total amount of vehicle-kilometers completed by the 9 trams (vKm)

Indicator 19 (Quality of Service) – Survey based perception of the quality of service

Indicator 13 (Awareness level) - Survey based perception of benefits or disadvantages of the chopper driving system

A survey was made to evaluate the impact of the 9 upgraded trams with chopper systems on public transport users. RAT Craiova considers that maximum 30% of total revenues from fares and tickets due to tram transportation.

Craiova population, consisting of 300'000 inhabitants uses public transportation (buses and trams) daily or occasionally. So, taking into consideration the contribution of trams transportation in total revenues of RAT, we considered that 30% of population, meaning 90'000 inhabitants, use trams transport. (see Annex 2 – sample size calculation)

150 questionnaires were circulated in the ex-ante period and the same number ex-post, keeping the same target group. The contact data of ex-ante respondents were kept to be in contact for the ex-post evaluation period. Feedbacks were 115 questionnaires filled in ex-ante and 110 questionnaires filled in ex-post.

The questionnaires for the ex-ante situation were disseminated face-to face to public transport users in stations, inside trams and during workshops organized by MODERN project team. The workshops were organized during the Communication Campaign and seminar presentation that took place in a pavilion located in the prefecture market (in the downtown).

C1.2 Establishing a Baseline

The baseline was assessed making reference to year 2009 when in Craiova, daily, 27 trams were running and the whole trams fleet consisted in 37 trams. 9 of these 37 trams were disabled and retired from movement because they had high energy consumption driving system. This electric driving system of the 9 trams was built in year 1985.

The results of baseline for each indicator are shown in the following tables:

Table C1.2.1 - Average operating costs

Raw data and indicator calculation	**2009 Ex-Ante values**
Total Operational Costs coming from the 9 trams	49’480.42 €
Total vehicle-km travelled by the 9 trams	297’833 Km
Average operating costs	0.1661 €/vkm

Note: These costs include the energy consumption, maintenance and spare parts

In order to evaluate the Energy efficiency technicians from IPA and RAT installed an energy meter on a tram (KT4 D type) without chopper system. It was considered a distance of 110 Km and made the ratio between total energy consumption and the considered distance in order to get the energy consumption per vKm

Table C1.2.2 - Energy consumption/vKm

Indicators and relevant parameters	**Ex-Ante values**
Energy consumption/vKm	2.80KW/vkm
Total vehicle-km	297’833 Km
Total energy consumption for the 9 trams without choppers	833’931 KWh

The questionnaires were disseminated to public transport users in trams stations and the city centre during the seminar presentation that took place in the prefecture market

115 feedbacks were received from people that expressed their opinion about the transportation by trams. In agreement with the people interviewed their contact data were kept, to evaluate the progress of the measure, using the same target group.

Table C1.2.3 – Quality of service

Questionnaire content	Ex-Ante values
How do you estimate the quality of public transport in your city?"	25% very dissatisfied 55% somewhat dissatisfied 19% Satisfied 1% don't know
How do you perceive tram journey, now, before implementing the measure	24% very uncomfortable 53%somewhat comfortable 22%confortable 1% don't know

Table C1.2.4 – Awareness Level

Questionnaire content	Ex-Ante values
Do you understand the aim of the measure and its potential benefit?	41% fairly well understand 19% well understand 36% very well understand 4% don't know

C1.3 Building the Business-as-Usual scenario

To have a real comparison of the benefit coming from the measure, the results obtained have to be compared not only with the ex-ante situation, but with the scenario which should have took place if the measure should have not been implemented. This because anyway other interventions should have been carried out anyway, with their relevant results. We have to consider, the so-called- "Business-as-Usual" (BAU) scenario.

BAU scenario is the following:

1. Only one driving system was changed in 2010 (only to test the technology); in this case there are an increase in operation costs but the capital cost is very limited.

2. RAT shall decide to replace 8 trams with new ones, starting to 2014. In this case there are relevant capital costs, and the operative costs are more or less the same as in Modern measure 1.2 implementation.

The individual energy consumption of the tram in BAU case is the same of any tram upgraded through the MODERN project, because we assume that the developed technology should have been more or less the same.

Table C1.3.1- Trams fleet in 2009

Trams type	Number of trams in operation	Total no of trams
KT4D	1 - equipped with contactors old driving system	10 - equipped with contactors old driving system
GT6	9 - equipped with contactors old driving system	9 - equipped with old driving system
Mm5	4 - equipped with contactors old driving system	5 - equipped with old driving system
T4DMTTB	13 - equipped with chopper systems, by construction	13 - equipped with chopper systems, by construction
Total	**27**	**37**

Table C1.3.2 -Trams fleet in 2010

Trams type	Number of trams in operation	Total no of trams
KT4D	2 - equipped with contactors old driving system	6 - equipped with contactors old driving system
	1 - equipped with chopper driving systems by own funds	1 - equipped with chopper driving systems by own funds
GT6	8 - equipped with contactors old driving system	9 - equipped with old driving system
Mm5	3 - equipped with contactors old driving system	5 - equipped with old driving system
T4DMTTB	13 - equipped with chopper systems, by construction	13 - equipped with chopper systems, by construction
Total	**27**	**34**

Table C1.3.3 -Trams fleet in 2011

Trams type	Number of trams in operation	Total no of trams
KT4D	6 - equipped with Chopper driving system through MODERN	6 - equipped with Chopper driving system through MODERN
	1 – equipped with chopper driving systems by own funds	1 – equipped with chopper driving systems by own funds

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Trams type	Number of trams in operation	Total no of trams
GT6	3 - equipped with chopper driving systems through MODERN project	3- equipped with chopper driving systems through MODERN project
	4 - equipped with old driving system	6- equipped with old driving system
Mm5	4 - equipped with contactors old driving system	5 - equipped with old driving system
T4DMTTB	12 - equipped with chopper systems, by construction	13- equipped with chopper systems, by construction
Total	30	34

Table C1.3.4 - Trams fleet in 2012

Trams type	Estimated number of trams in operation	Total no of trams
KT4D	6 - equipped with Chopper driving system through MODERN	6 - equipped with Chopper driving system through MODERN
	1 – equipped with chopper driving systems by own funds	1 – equipped with chopper driving systems by own funds
GT6	3 - equipped with chopper driving systems through MODERN project	3- equipped with chopper driving systems through MODERN project
	4 - equipped with old driving system	6- equipped with old driving system
Mm5	0	5 - equipped with old driving system
T4DMTTB	12 - equipped with chopper systems, by construction	13- equipped with chopper systems, by construction
Total	26	34

Evolution of the indicators in BAU is shown in the tables below:

Table C1.3.5 – Business as usual scenario: Average Operating Costs

Indicator	0nly 1 chopper	8 new trams
Average operating cost (2010)	0.1678 €/vkm	0.1474 €/vkm
Average operating cost (2011)	0.1770 €/vkm	0.1196 €/vkm
Average operating cost (2012)	0.1768 €/vkm	0.1196 €v/km

Note.: These operating costs include the energy consumption, maintenance and spares parts costs

Table C 1.3.6 – Business as usual scenario: Indicator 2' (Capital Costs)

Indicator	BAU values
Total capital cost (2010) for 1 chopper purchased by own budget	54.222 €
Total capital cost (2011)	0 €
Total capital cost (2012)	0 €

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Table C1.3.7 – Business as usual scenario: Vehicle Fuel Efficiency (Energy consumption/vKm)

Indicator	BAU values
Energy consumption/vKm (2010-11-12) consider that the 9 trams include 8 trams without chopper and 1 tram with chopper BAU Scenario 1	2.69 KW/vKm

C2 Measure results

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

C2.1 Economy

The revenues within all the scenarios (BAU and Modern) are considered the same because they seem not to be influenced by any solution implementation..

Average operating cost

The operating costs, including the energy consumption, maintenance and spare parts costs, decreased due to implementation of the chopper system. So it shall happen if 8 new trams will be implemented. The chopper system needs very few maintenance costs (around 4% of investment costs); same costs should be used for the new 8 trams.

Table C2.1.1 – Average operating costs: ex-post values

Indicator	Ex-Post Values
Average operating cost (2010)	0.1474 €/vkm
Average operating cost (2011)	0.1196 €/vkm
Average operating cost (2012)	0.1195 €/vkm

Note: These costs include the energy consumption, maintenance and spares parts

Table C2.1.2 – Evolution of Average operating cost in the operation period

Average operating cost (€/vKm)	**2009**	**2010**	**2011**	**2012**
ex-ante	0.1661			
CIVITAS	0.1661	0.1474	0.1196	0.1195
BAU 1 chopper	0.1661	0.1678	0.1770	0.1768
BAU 8 new trams	0,1661	0,1474	0,1196	0,1195

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Table C2.1.3 – Operating costs evolution between 2009 and 2012

Indicator	Before	B-a-U	After	After –Before	After– B-a-U
Indicator 2 Average Operating costs	0.1661 €/vKm (2009)	0.1678 €/vKm (2010)	0.1474 €/vKm (2010)	-0.0187 (2010)	-0.0204 (2010)
		0.1770 €/vKm (2011)	0.1196 €/vKm (2011)	-0.0465 (2011)	-0.0573 (2011)
		0.1768 €/vKm (2012)	0.1195 €/vKm (2012)	-0.0466 (2012)	-0.0573 (2012)

C2.2 Energy

In order to see the evolution of the energy consumption for the 9 targeted trams, we consider the energy consumption before and after the implementation of the measure.

In situation before we considered 9 trams without chopper system, in BAU situation we considered 8 trams without chopper system and 1 tram with chopper system and in after situation we considered 9 trams with chopper system. As seen in the following, the energy consumption (KW/vKm) decreases due to the implementation of the 9 chopper systems.

The energy consumption (KW/vKm) in 2011 and 2012 is lower by 35% than energy consumption in 2009, which is the baseline year.

In the tables below, it can be seen the evolution of indicator after the implementation of the measure.

Indicator 3 Vehicle Fuel Efficiency (Energy consumption-KW/vKm)

Indicator	Ex-Post values
Energy consumption/vKm (2010) 5 trams without choppers and 4 trams with choppers(by CIVITAS) out of the 9 envisaged trams	2.36 KW/vKm
Energy consumption/vKm (2011- 2012) 9 trams with choppers(by CIVITAS) out of the 9 envisaged trams	1.82 KW/vKm

Chopper driving systems were implemented progressively in the years 2010 and 2011. In 2010, chopper systems were installed on 4 trams, then, in 2011, chopper systems were installed on the rest of 5 trams, so that, in 2011, all 9 trams operated by chopper.

Table C2.2.2- shows a synthetic picture of the indicators evolution since situation before CIVITAS and ending with the situation after implementation of the measure

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Indicator	Before	B-a-U	After	After –Before	After – B-a-U
Indicator 3 Vehicle Fuel Efficiency Energy consumption	2.8 KW/vKm (2009)	2.69 KW/vKm (2010) 2.69 KW/vKm (2011) 2.69 KW/vKm (2012)	2.36 KW/vKm (2010) 1.82 KW/vKm (2011) 1.82 KW/vKm (2012)	-0.44 (2010) -0.98 (2011) -0.98 (2012)	-0.33 (2010) -0.87 (2011) -0.98 (2012)

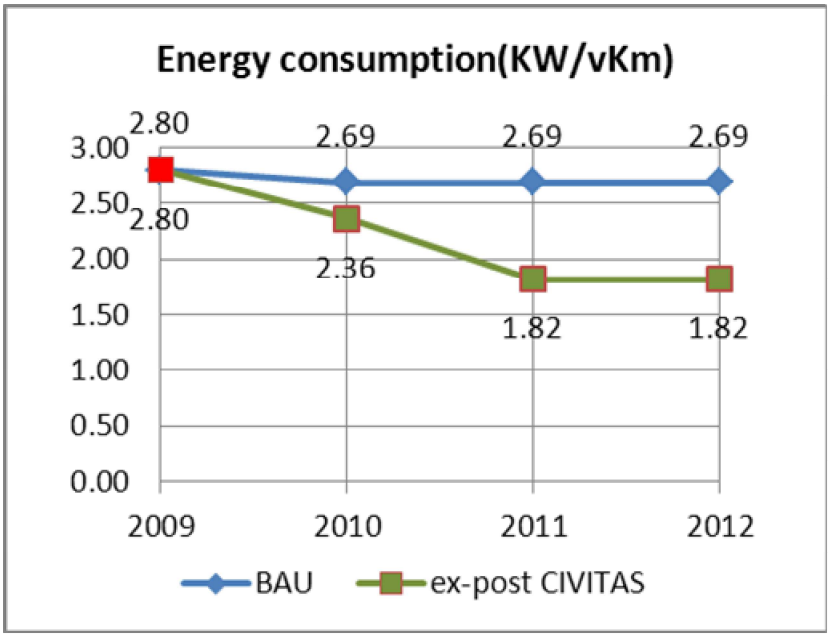

Figure C2.2.1 – Graphic representation of Energy consumption CIVITAS measure vs. BAU

C2.4 Transport

Implementation of the measure led to a change of trams users perception of service quality. The chopper driving system gives a smoother start and stop of trams and for this reason the users feel more comfortable.

Table C2.4.1- shows a synthetic image of the indicator evolution since situation before CIVITAS and ending with the situation after implementation of the measure

The survey was done on the same people interweaved in ex-ante and received 110 feedbacks.

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Indicator	Before	B-a-U	After	After –Before	After – B-a-U
Indicator 19 Quality of Service	25 % very dissatisfied 55 % somewhat dissatisfied; 19% Satisfied 1 % don't know (2009)	25 % very dissatisfied 55 % somewhat dissatisfied; 19% Satisfied 1 % don't know (2011)	23 % very dissatisfied 56 % somewhat dissatisfied; 20% Satisfied 1 % don't know (2011)	2 % (decreasing) very dissatisfied 1 % (increasing) somewhat dissatisfied; 1% (increasing) Satisfied 1 % don't know	2 % (decreasing) very dissatisfied 1 % (increasing) somewhat dissatisfied; 1% (increasing) Satisfied 1 % don't know
	24 % very uncomfortable 53%somewhat comfortable 22%confortable 1 % don't know (2009)	24% very uncomfortable 53%somewhat comfortable 22%confortable 1 % don't know (2011)	23 % very uncomfortable 53%somewhat comfortable 23%confortable 1 % don't know (2011)	1 % decreasing very uncomfortable 0%somewhat comfortable 1%increasing comfortable 1 % don't know	1 % decreasing very uncomfortable 0%somewhat comfortable 1%increasing comfortable 1 % don't know
			49 % PT services have been improved last time 25 % PT services have not been improved last time 26% don’t know (2011)		

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

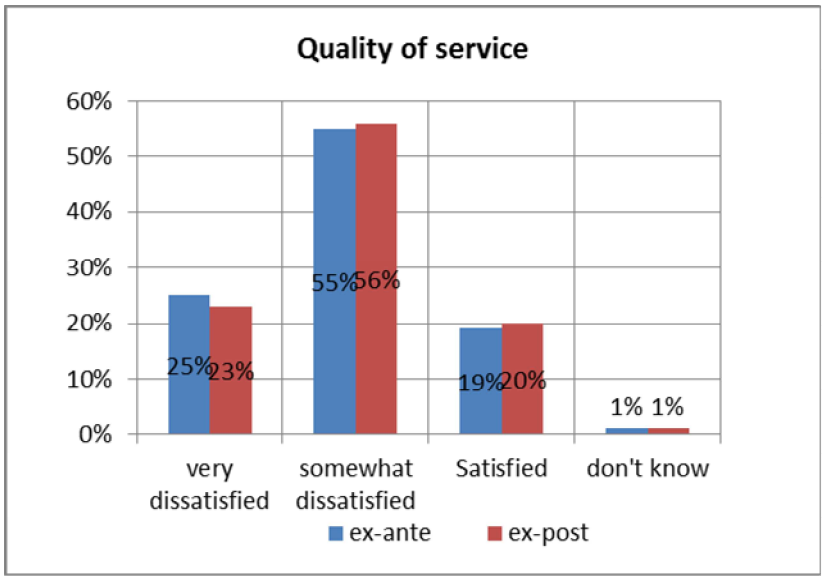

Figure C2.4.2.(1) Graphic representation of Quality service- ex-ante versus ex-post

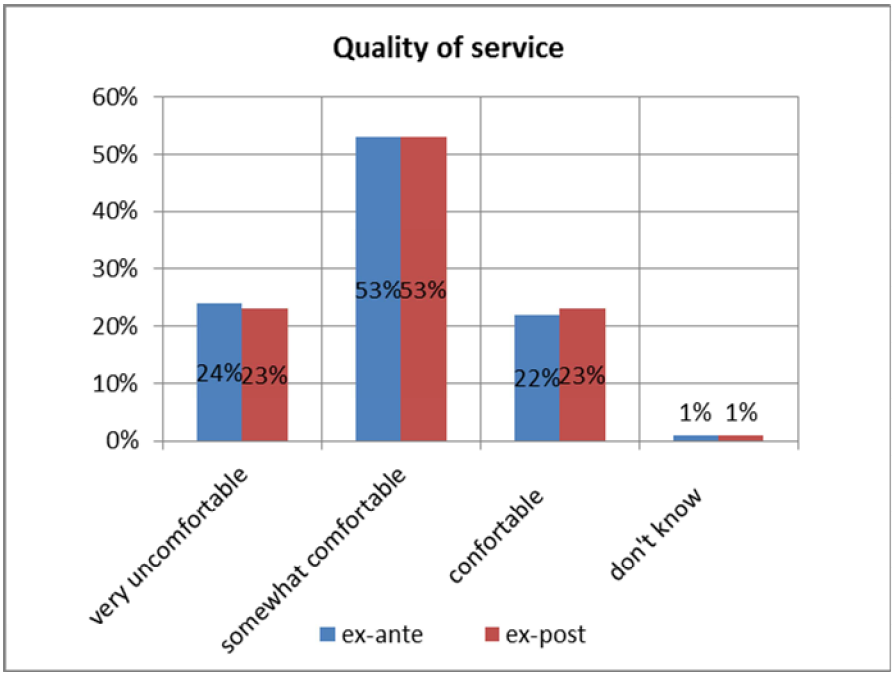

Figure C 2.4.2.(2) Graphic representation of Quality service- ex-ante versus ex-post

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

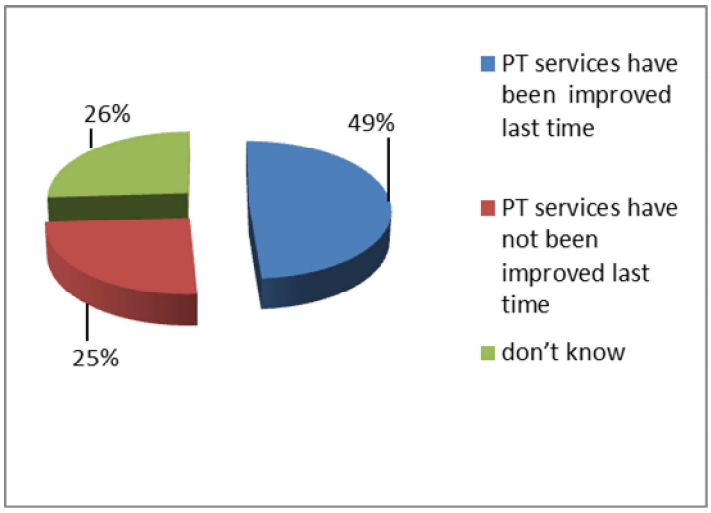

Figure C 2.4.2.(3) Graphic representation of people perception concerning on improved PT services

C2.5 Society

Table C2.5.1- shows a synthetic image of the indicator evolution since situation before CIVITAS and ending with the situation after implementation of the measure

The survey was done on the same people interweaved in ex-ante and received 110 feedbacks

Indicator	Before	B-a-U	After	After –Before	After – B-a-U
Indicator 13 Awareness level	41% fairly well understand; 19% well understand; 36% very well understand 4% don't know (2009)	41% fairly well understand; 19% well understand; 36% very well understand 4% don't know (2011)	36% fairly well understand; 25% well understand; 38% very well understand; 1% don't know (2011)	7% fairly well understand 6% well understand 2% very well understand 3% don't know	7% fairly well understand 6% well understand 2% very well understand 3% don't know

			60 % PT was more useful in the last time 38 % PT was useless in the last time 2 % don't know (2011)		

Awareness level

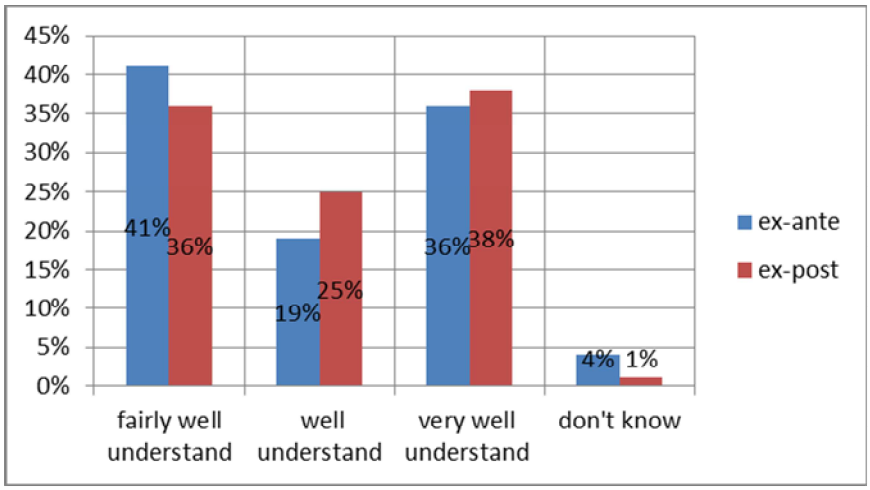

Figure C 2.5.2(1)- Graphic representation of Quality service- ex-ante versus ex-post

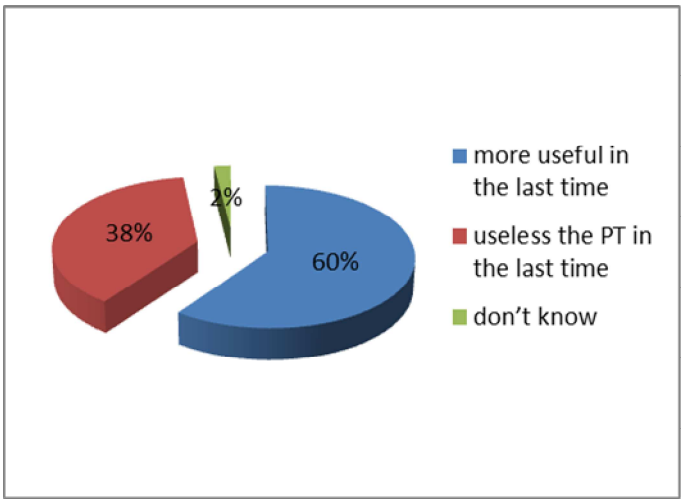

Figure C 2.5.2(2)- Graphic representation of people perception concerning on improved PT services

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

C2.6 Cost benefit analysis

C2.6.1 Evaluation period for CBA

- Defining reference case for CBA

The reference case for CBA is considered Business as usual situation which means 1 tram endowed with chopper system by own funds and 8 trams without chopper system, out of the 9 trams considered

- Defining lifetime of the measure

The implementation period of the measure is within 2010-2012 and the baseline year is 2009

The life time of the chopper driving system: 10 years

The appraisal period includes the implementation period and the operation period, within 2009-2018, in order to cover the full effect of the measure.

- Discount rate:

3.5% recommended by EC, for the 2007-2013 period

C2.6.2 Method and values for modification

- Description of how the impacts are monetized

This measure involves the installation of chopper driving system on the trams to increase their energy efficiency. The benefit, directly registered by the RAT, will be financial one, not socio-economic, because the measure is a technical one and it does not lead to long-term economic benefits, such as reductions of air pollutant emission, reductions of greenhouse gas or journey time saving. We cannot say that the implementation of the measure has attracted a greater number of passengers who previously used cars. The benefit is simply due to reduced energy and maintenance costs from the trams equipped with chopper driving system. Unfortunately, information on energy producer are not available, hence, the energy used by trams could be produced by Thermal Power Plant, Hydro Power Plant or renewable sources. Therefore, we cannot monetize the benefits brought by emissions reducing due to energy saving

Also, cannot be monetized the journey time saving because chopper system implementation does not influence the tram travel time.

- References of values used

.C2.6.3 Life time cost and benefit

Table C2.6.3-1 Capital cost in the evaluation period (not discounted)

	Cases for comparison	Cost (€)
2009	CIVITAS measure	0

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

	Cases for comparison	Cost (€)
	BAU	0
2010	CIVITAS measure	488070
	BAU	54222
2011	CIVITAS measure	0
	BAU	0
2012	CIVITAS measure	0
	BAU	0
2013	CIVITAS measure	0
	BAU	0
2014	CIVITAS measure	0
	BAU	0
2015	CIVITAS measure	0
	BAU	0
2016	CIVITAS measure	0
	BAU	0
2017	CIVITAS measure	0
	BAU	0
2018	CIVITAS measure	0
	BAU	0

Table C2.6.3-2 Operation costs(energy consumption costs) in the evaluation period (not discounted)

	Cases for comparison	Values euro
2009	CIVITAS measure	49454.05
	BAU	49454.05
2010	CIVITAS measure	40262.27
	BAU	45824.82
2011	CIVITAS measure	20908.55
	BAU	30916.06
2012	CIVITAS measure	21252.05
	BAU	31423.98
2013	CIVITAS measure	21492.35
	BAU	31779.29
2014	CIVITAS measure	22016.42

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

	Cases for comparison	Values euro
	BAU	32554.19
	CIVITAS measure	22408.69
2015	BAU	33134.22
	CIVITAS measure	22881.37
2016	BAU	33833.14
	CIVITAS measure	23326.50
2017	BAU	34491.33
	CIVITAS measure	23799.41
2018	BAU	35190.58

Table C2.6.3-3 Maintenance cost in the evaluation period (not discounted)

	Cases for comparison	Values (euro)
2009	CIVITAS measure	26.37
	BAU	26.37
2010	CIVITAS measure	6.10
	BAU	9.76
2011	CIVITAS measure	0.00
	BAU	9.84
2012	CIVITAS measure	0.00
	BAU	8.32
2013	CIVITAS measure	0.00
	BAU	8.49
2014	CIVITAS measure	11713.68
	BAU	1309.98
	CIVITAS measure	0.00
2015	BAU	8.83
	CIVITAS measure	0.00
2016	BAU	9.01
	CIVITAS measure	0.00
2017	BAU	9.19
	CIVITAS measure	3904.56
2018	BAU	443.13

Note: These costs include spare parts and maintenance costs. After chopper systems implementation, RAT have to conclude maintenance contract, every 4 years, to change the electronic devices. The maintenance contract was calculated as 4% of capital cost.

Table C2.6.3-4 Revenue in the evaluation period (not discounted)

	Cases for comparison	**Values (€)**
2009	CIVITAS measure	707247.55
	BAU	707247.55
2010	CIVITAS measure	756927.72
	BAU	756927.72
2011	CIVITAS measure	244121.91
	BAU	244121.91
2012	CIVITAS measure	219984.48
	BAU	219984.48
2013*	CIVITAS measure	772066.28
	BAU	772066.28
2014	CIVITAS measure	787507.60
	BAU	787507.60
2015	CIVITAS measure	803257.75
	BAU	803257.75
2016	CIVITAS measure	819322.91
	BAU	819322.91
2017	CIVITAS measure	835709.37
	BAU	835709.37
2018	CIVITAS measure	852423.55
	BAU	852423.55

The years 2011 and 2012 brought low revenues because of interruption of the tramline during the overpass construction (the line was cut into two separate sections, so that some passengers chose different transport solutions). Starting to 2013, RAT assumed that the revenues will have normal values as before cutting the line and will be increased by 2% inflation, from year to year.

C2.6.4 Compare the lifetime costs and benefits

Table C2.6.4-1 Lifetime cost/benefit of CIVITAS measure(Undiscounted)

	Capital cost	Operation costs	Maintenance costs	Other costs	Revenue	Total costs	Total revenues	Cumulated costs
2009	0.00	49454.05	26.37	0.00	707247.55	49480.42	707247.55	657767.13
2010	488070.00	40262.27	6.10	0.00	756927.72	528338.37	756927.72	228589.35
2011	0.00	20908.55	0.00	0.00	244121.91	20908.55	244121.91	223213.36
2012	0.00	21252.05	0.00	0.00	219984.48	21252.05	219984.48	198732.43
2013	0.00	21492.35	0.00	0.00	772066.28	21492.35	772066.28	750573.92
2014	0.00	22016.42	11713.68	0.00	787507.60	33730.10	787507.60	753777.50
2015	0.00	22408.69	0.00	0.00	803257.75	22408.69	803257.75	780849.06
2016	0.00	22881.37	0.00	0.00	819322.91	22881.37	819322.91	796441.53
2017	0.00	23326.50	0.00	0.00	835709.37	23326.50	835709.37	812382.86
2018	0.00	23799.41	3904.56	0.00	852423.55	27703.97	852423.55	824719.59
Total	488070.00	267801.67	15650.71	0.00	6798569.12	771522.38	6798569.12	6027046.74

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

	1	2	3	4	5	6	7	8	9	10
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Undiscounted cash flow										
Revenues(€)	707,248	756,928	244,122	219,984	772,066	787,508	803,258	819,323	835,709	852,424
Total costs(€)	49,480	528,338	20,909	21,252	21,492	33,730	22409	22881	23327	27704
Net cash flow (€)	657,767	228,589	223,213	198,732	750,574	753,778	780,849	796,442	812,383	824,720
Discount Factors										
Discount Rate	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Base Year	2009									
Discounted cash flow										
Revenues (€)	707,248	731,331	227,890	198,413	672,811	663,060	653,451	643,980	634,647	625,450
Costs (€)	49,480	510,472	19,518	19,168	18,729	28,400	18,229	17,985	17,714	20,327
Net cash flow (€)	657,767	220,859	208,372	179,245	654,082	634,660	635,221	625,996	616,933	605,122
Cumulative cash flow (€)	657,767	878,626	1,086,998	1,266,244	1,920,326	2,554,986	3,190,207	3,816,203	4,433,136	5,038,258

Table C2.6.4 -6 Lifetime cost/benefit of the reference case- BAU(Undiscounted)

	Capital cost	Operation costs	Maintenance costs	Other costs	Revenue	Total costs	Total revenues	Cumulated costs
2009	0.00	49454.05	26.37	0.00	707247.55	49480.42	707247.55	657767.13
2010	54222.00	45824.82	9.76	0.00	756927.72	100056.58	756927.72	656871.14
2011	0.00	30916.06	9.84	0.00	244121.91	30925.90	244121.91	213196.01
2012	0.00	31423.98	8.32	0.00	219984.48	31432.30	219984.48	188552.19
2013	0.00	31779.29	8.49	0.00	772066.28	31787.77	772066.28	740278.50
2014	1500000.00	32554.19	1309.98	0.00	787507.60	1533864.17	787507.60	-746356.57
2015	3000000.00	33134.22	8.83	0.00	803257.75	3033143.05	803257.75	-2229885.30
2016	3000000.00	33833.14	9.01	0.00	819322.91	3033842.15	819322.91	-2214519.24
2017	3000000.00	34491.33	9.19	0.00	835709.37	3034500.51	835709.37	-2198791.15
2018	1500000.00	35190.58	443.13	0.00	852423.55	1535633.71	852423.55	-683210.15
Total	12054222.00	358601.65	1842.90	0.00	6798569.12	12414666.56	6798569.12	-5616097.43

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

	1	2	3	4	5	6	7	8	9	10
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Undiscounted cash flow										
Revenues(€)	707247.55	756927.72	244121.91	219984.48	772066.28	787507.60	803257.75	819322.91	835709.37	852423.55
Total costs(€)	49480.42	100056.58	30925.90	31432.30	31787.77	1533864.17	3033143.05	3033842.15	3034500.51	1535633.71
Net cash flow (€)	657767.13	656871.14	213196.01	188552.19	740278.50	-746356.57	-2229885.30	-2214519.24	-2198791.15	-683210.15
Discount Factors										
Discount Rate	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Base Year	2009									
Discounted cash flow										
Revenues (€)	707,247.55	731,331.13	227,890.42	198,413.40	672,811.15	663,060.27	653,450.70	643,980.40	634,647.35	625,449.56
Costs (€)	49,480.42	96,673.02	28,869.66	28,350.13	27,701.21	1,291,472.47	2,467,463.83	2,384,572.51	2,304,434.76	1,126,742.01
Net cash flow (€)	657,767.13	634,658.11	199,020.76	170,063.27	645,109.95	-628,412.20	-1,814,013.13	-1,740,592.11	-1,669,787.41	-501,292.45
Cumulative cash flow (€)	657,767.13	1,292,425.24	1,491,446.00	1,661,509.26	2,306,619.21	1,678,207.01	-135,806.12	-1,876,398.22	-3,546,185.63	-4,047,478.08

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Table 2.6.4-11 Changes in cost

		1	2	3	4	5	6	7	8	9	10
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Capital cost (€)	CIVITAS measures	0.00	488070.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	BAU	0.00	54222.22	0.00	0.00	0.00	1500000.00	3000000.00	3000000.00	3000000.00	1500000.00
Operating cost (€)	CIVITAS measures	49454.05	40262.27	20908.55	21252.05	21492.35	22016.42	22408.69	22881.37	23326.50	23799.41
	BAU	49454.05	45824.82	30916.06	31423.98	31779.29	32554.19	33134.22	33833.14	34491.33	35190.58
Maintenance cost (€)	CIVITAS measures	26.37	6.10	0.00	0.00	0.00	11713.68	0.00	0.00	0.00	3904.56
	BAU	26.37	9.76	9.84	8.32	8.49	1309.98	8.83	9.01	9.19	443.15
Total (€)	CIVITAS measures	49480.42	528338.37	20908.55	21252.05	21492.35	33730.10	22408.69	22881.37	23326.50	27703.97
	BAU	49480.42	100056.80	30925.90	31432.30	31787.77	1533864.17	3033143.05	3033842.15	3034500.51	1535633.72
	Changes	0.00	428281.57	-10017.35	-10180.24	-10295.42	-1500134.08	-3010734.36	-3010960.77	-3011174.01	-1507929.76

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Table 2.6.4 -12 Changes in benefit

			1	2	3	4	5	6	7	8	9	10
			2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Revenue		CIVITAS measures	707247.55	756927.7	244121.9	219984.48	772066.28	787507.6	803257.75	819322.9	835709.37	852423.55
		BAU	707247.55	756927.7	244121.9	219984.48	772066.28	787507.6	803257.75	819322.9	835709.37	852423.55
		Changes (€)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External cost/benefit	Journey time savings	CIVITAS measures	0	0	0	0	0	0	0	0	0	0
		BAU	0	0	0	0	0	0	0	0	0	0
		Changes (€)	0	0	0	0	0	0	0	0	0	0
	Accident savings	CIVITAS measures	0	0	0	0	0	0	0	0	0	0
		BAU	0	0	0	0	0	0	0	0	0	0
		Changes (€)	0	0	0	0	0	0	0	0	0	0
	Reductions of air pollutant emission	CIVITAS measures	0	0	0	0	0	0	0	0	0	0
		BAU	0	0	0	0	0	0	0	0	0	0
		Changes (€)	0	0	0	0	0	0	0	0	0	0
	Reductions of green house gas emission	CIVITAS measures	0	0	0	0	0	0	0	0	0	0
		BAU	0	0	0	0	0	0	0	0	0	0
		Changes (€)	0	0	0	0	0	0	0	0	0	0
Changes in total benefit (€)			0	0	0	0	0	0	0	0	0	0

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Table 2.6.4-13 NPV calculation

	1	2	3	4	5	6	7	8	9	10
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Undiscounted cash flow										
Changes in total cost (€)	0	428,282	-10,017	-10,180	-10,295	-1,500,134	-3,010,734	-3,010,961	-3,011,174	-1,507,930
Changes in total benefit (€)	0	0	0	0	0	0	0	0	0	0
Net cash flow (€)	0	-428,282	10,017	10,180	10,295	1,500,134	3,010,734	3,010,961	3,011,174	1,507,930
Discount Factors										
Discount Rate	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Base Year	2009									
Discounted cash flow										
Changes in total cost (€)	0	413,799	-9,351	-9,182	-8,972	-1,263,073	-2,449,234	-2,366,588	-2,286,720	-1,106,415
Changes in total benefit (€)	0	0	0	0	0	0	0	0	0	0
Net cash flow (€)	0	-413,799	9,351	9,182	8,972	1,263,073	2,449,234	2,366,588	2,286,720	1,106,415
Cumulative cash flow (€)	0	-413,799	-404,447	-395,265	-386,293	876,779	3,326,014	5,692,601	7,979,322	9,085,737

Changes in NPV (€)	9,085,737

C2.6.5 Summary of CBA results

The BAU scenario has been compared with the actual one.

The BAU scenario has been compared with the actual one.

In the reference case (BAU), RAT would make 1 Chopper replacement (54'222 Euro) and buy 8 brand new trams; because the value of each new tram should be estimated in 1.5 Million Euro, the total investment costs Is around 12'050'000 €.

With the financial support CIVITAS, RAT Craiova was able to invest in 9 choppers driving systems to replace all the old contactors driving systems of the 9 trams analysed. The capital cost, in this case, is 488'070€.

The results of CBA should be summarized as follows:

1. Modern implementation presented a positive cumulated cash flow around 5.03 Million Euros, that means the investment can be recovered within the period (10 years) by RAT;
2. BAU scenario – only one chopper- and the huge investment for 8 trams were not recovered within the period (10 years) taken into consideration the Cost – Benefit Analysis. The cumulated cash flow in this case is negative one, -4.04 Million Euro.

It seems evident that if the cost of energy is going to grow the recovery of Modern implementation is going to be recovered faster than in the considered case; moreover during the considered period it seems not so easy to take in operation the old trams as they were, so refurbishment or substitution were be necessary in any case.

For the time being the implementation of the measure as it was done seems the best solution, because RAT cannot afford the total fleet renew investment costs.

C3 Achievement of quantifiable targets and objectives

No.	Target	Rating
1	To put back into the service 9 trams	★★
2	To install the chopper driving system on the 9 trams in order to decrease up to 40% the electrical consumption of each tram The energy consumption by the trams equipped with chopper system decreased by 35 %	★★
3	Increasing of PT users comfort by implementing the new tram driving system which gives smoother start and stop The conclusion of survey was the people awareness increased by 31% and the quality of service perception increased by 1 %. Taking into consideration that the measure is a technical one, these results are satisfactory.	★★
NA = Not Assessed O = Not Achieved ★ = Substantially achieved (at least 50%) ★★ = Achieved in full ★★★ = Exceeded		

C4 Up-scaling of results

The results of the nine choppers installed thought this measure are very good and the reduction of energy consumption is according our expectations, RAT Craiova takes into account the up-scaling of the measure to the 6 trams GT6 type that remained with contactors driving system in Craiova. The installment of the chopper system is taken into consideration but the investment depends on the budget of Municipality.

C5 Appraisal of evaluation approach

The evaluation strategy focused on a couple of key elements like: economy, energy, transport and society. The indicators for every key element were chosen so that the evaluation of the measure could demonstrate the necessity of the chopper system in Craiova. In order to highlight the impact of the measure on economy, energy consumption, transport and society, we have compared, yearly, CIVITAS measure with reference case(BAU), and note the evolution of the 9 trams which have been equipped with the chopper system. After ex-post measurements we noticed a decreasing of energy consumption and maintenance costs of the trams equipped with the chopper system.

The environmental indicators, CO, CO2, NOx ,and Pm, that initially had been included in evaluation plan, were cancelled because the information on energy producer was not available, hence, the energy used by trams could be produced by Thermal Power Plant, Hydro Power Plant or renewable sources.

The indicator Fuel efficiency was renamed as Energy consumption because it was more suitable to the measure

To carry-out the CBA, the operating revenues and costs from the 9 trams were needed. Therefore, based on the total operating revenues, we calculated the revenue per tram, then we multiplied by the number of trams which gradually were equipped with chopper systems. To calculate operating costs we considered only the costs related to driving system, namely: energy consumption and maintenance costs.

C6 Summary of evaluation results

The key results are as follows:

- In order to highlight the impact of the measure on economic state of RAT Craiova, the energy consumption and maintenance costs arising from the trams with contactors driving system and the same costs arising from the trams endowed with chopper driving system were compared. The results proved that the chopper driving system led to lower operating costs due to energy saving and cheaper maintenance.
- In order to assess the impact of the measure on the public transport users, a survey was carried out and the interviewed people stated their opinion regarding the quality of services after by the implementation of the new driving system on the trams and in the same time, they expressed their point of view on the usefulness of the measure.
- This measure demonstrated that one way to save energy and reduce pollution is not just to scrap the old trams. Application of new technologies can re-vitalize old products Trams from

past generations can be maintained (or returned) to circulation avoiding high investments in the fleet renewal with almost the same results and preserving the “charm” of the old trams.

- In order to optimize the energy efficiency of its tram service, the city of Craiova implemented an electronic system that monitored the energy performance of its drivers. The system relies on temporary data storage on the drivers' own chip-card IDs, making it easy and inexpensive to implement.
- The chopper system is easy to use and provides a better electronic control. The chopper system is a new driving technology assisted by software which store and processes the data from the entire running system. The software allows the online visualization and management of 4 defined electric parameters - network current, engine current, network voltage, and filter voltage.
- The public transport operator RAT rolled out a system that monitored the energy performance of drivers. It was meant to complement a modest capital investment in chopper technology that had been made on the braking systems of nine trams.
- Together with the new chopper technology installed on the nine trams, the monitoring measure was shown to produce energy savings of up to 40%. It is clear that expanding these measures to cover the rest of the city's fleet would be much cheaper than buying new trams.
- Through savings of energy, manual labour and spare parts, one can estimate that the investments required by our solution are covered within 3 years.
- For an unmodified tram, even during normal operation, the speed regulation and braking in rheostat steps causes shocks felt by passengers. The new equipment eliminates the shocks corresponding to start, stop and speed regulation regimes, directly influencing the travellers comfort.
- The high price of new trams (or the necessity to have old trams in historical cities, with modern characteristics) led some public transport operators to upgrade existing vehicles with more efficient driving technologies. However, this equipment doesn't eliminate inefficient driving habits -- another source of wasted energy.
- Based on a study on the trams regarding the dissipation of the heat energy, we concluded that it is necessary to improve the thermal coefficient by changing the windows and the doors with a doubles one. In same time the modernization of the trams means mechanical and electrical improvements and specially the security, safe conditions and traffic/quality conditions for the passengers.
- Given to the good results achieved from the measure they will be of course be maintained in the time and this kind of technology could be applied to other trams which could need upgrade.
- The system has been developed specifically and led to a market product which has an industrial perspective. This solution has, as already mentioned some technical advantage, and also acceptable costs, so that can be convenient in a significant number of cases. The chopper solution has been promoted in the neighbouring countries Bulgaria, Slovakia, Albania and Macedonia on different events, economic missions or partnerships between cities. Following these actions, public transport company from Pleven, Bulgaria and the Pleven Municipality decided to apply this solution to the trolleys fleet to reduce energy consumption. Public transport companies from Pleven made already an assessment of costs and developed a first draft implementation plan.
- The developed system, as seen, has a potential application interest for many other cities at European level, mainly where the lack of resources to completely renew the electrical public transport vehicles fleet. In fact this system gives the possibility to extend the life time of the old vehicles, ensuring anyway performances and travel comfort comparable with those of a modern vehicle. For this reason probably the outcomes of this measure will have further application in other contexts.
- This measure led to a new patent regarding the anti-skating system.

- Taking into consideration the results of the surveys in the evaluation period we can see a change of users perception on quality of service; they feel more comfortable when travelling with trams endowed with chopper driving system due to smoother start and stop The conclusion of survey was the people awareness increased by 31% and the quality of service perception increased by 1 %. Taking into consideration that the measure is a technical one, these results are satisfactory.

C7 Future activities relating to the measure

The results of the measure will be further disseminated inside of country and in the neighboring countries Bulgaria, Slovakia, Albania and Macedonia in different events, economic missions or partnerships between cities.

Public Transport Company from Pleven, Bulgaria and the Pleven municipality decided to apply this solution to the trolleys fleet to reduce energy consumption. Public transport companies from Pleven made already an assessment of costs and developed a first draft implementation plan.

D Process Evaluation Findings

D.0 Focused measure

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

	0	No focused measure
2	1	Most important reason
4	2	Second most important reason
6	3	Third most important reason

D.1 Deviations from the original plan-

The deviations from the original plan comprised:

- **Deviation 1** – The only deviation was the development of new ITC equipment (not originally foreseen) for the acquisition, monitoring, storage and processing of the electrical parameters from power distribution stations of trams. This system completes the electric system of the trams and provides real time or off-line information and statistics about the power consumption quality, enabling the identification of solutions for energy and costs saving.

D.2 Barriers and drivers

D.2.1 Barriers

Preparation phase

- **Technological barrier** – Trams of different building ages have been used. For this reason it has been necessary to adapt the system to each of the refurbished vehicles.

Implementation phase

- **Technological barrier** - The technical implementing team has faced a really problem because of constructive difference of the trams on which the choppers will be installed.

Operation phase: No barriers encountered

D.2.2 Drivers

Preparation phase

- **Technological driver** –IPA has adapted the chopper system to its own tram fleet by taking advantage of similar applications used worldwide.

- **Positional drivers** – The implementing team exchanged the experience with M08.06 team because these measures will be implemented on the same trams**.**

Planning drivers – An effective planning was carried out for exploiting the results of a previous study on the advanced chopper system technology**.**

Implementation phase

- **Organizational actions** – A good arrangement has been established between the company developing the chopper system and measure team in charge of developing, engineering and installing the chopper system
- **Technological drivers** – The measure was completed with an additional device for reading and storing data referring to the energy consumption on trams. The new device keeps an evidence of the energy consumption by each driver. The new device allows a deeper analysis of the energy consumption and provides more realistic information about the energy consumption of trams which is closer on the main objective of the measure which is energy saving. Data will be stored and processed for each tram but also for each driver and will be used to make management decisions on the trams fleet

Operation phase

- **Driver 1** – No driver encountered

D.2.3 Activities

Preparation phase

- **<u>Organizational actions</u>** – Different types of trams to be tested in order to choose the most appropriate for chopper installation. Some technical documents needed to be produced and cabling re-built.

- **<u>Involvement / communication actions</u>** - The measure was also illustrated by the Local Dissemination Manager who organized conferences and face-to-face interviews bringing together key stakeholders to discuss the sustainability problems to be solved.
- **<u>Technological actions-</u>** Different types of trams to be tested in order to choose the most appropriate for chopper installation. Some technical documents needed to be produced and cabling re-built. Technical implementation team attempt to raise additional technical resources collaborating with professionals in this field of activity or experts that have experience in chopper system driving. The development of anti-skidding of the driving wheels developed by IPA has been proposed as a patent at OSIM (State Office for Inventions and Trademarks).

Implementation phase

- **Technological barriers** – Technical implementation team attempt to raise additional technical resources collaborating with professionals in this field of activity or experts that have experience in chopper system driving

Operation phase

No activities encountered.

D.3 Participation

D.3.1. Measure Partners

- **Measure partner 1** – IPA – Leading role
  IPA SA is a 47 years old Romanian industrial R & D company and 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.
  IPA was responsible for the dissemination activities and carrying out the research activity and technical studies in the measure. Since 2011 IPA took over the evaluation activity

- **Measure partner 2** – RAT – Principal participant

  RAT Craiova is main Public Transportation Company in Dolj county. It provides the citizen transportation by trams, buses and micro-buses. RAT Craiova was responsible for the technical specification, acquisition and installation of the chopper systems, as well as the training of the trams users (drivers and maintenance staff). Also, RAT managed the operation and monitoring activities.

- **Measure partner 3** – LCM Occasional participant

  The Local Council of Craiova Municipality (Primaria Municipiului Craiova) was organized and functions according to Law No. 215/2001 regarding Local Public Administration with the subsequent modification and completion.

  Municipality as local government institution has, under the conditions imposed by the public administration law, the decisional right in all matters of local interest: political, social, cultural, educational and technical. Through their structures, the municipality is a complex mechanism which can produce major changes in the quality of urban life under an effective management and coordination.
  The competencies of these bodies related to the project covers both the services provided to the local community (i.e. Public transport service in various forms) and the technical interventions (the urban infrastructure, constructions) that together change the image of the city and bring added value to the quality of life in the areas where they act.
  LCM was the coordinator of the project and since 2009 and assumed the responsibility for the management and administration activity in the MODERN project. Between 2009-2011, LCM carried out the evaluation activity in the project.

D.3.2 Stakeholders

- **Stakeholder 1 – Electric Faculty of Craiova –** It was set up in 1951 being an important and famous technical center of the country. The faculty has a good collaboration with a lot of industrial entity from the region. Here was elaborated the theoretical study and the technical analyze of the chopper system used by Craiova trams.
- **Stakeholder 2 – Indaeltrac Company** – This is the company which produce, test and install the choppers on the trams foreseen in the project. The company is specialized in production of trams and trains automatic and electro – mechanic devices.
- **Stakeholder 3 – Craiova Electrical Company –** Is the regional provider for electric power. We have a good collaboration in terms of different electric measurements helping us to obtain accuracy data regarding energy consumption and distribution.

D.4 Recommendations

D.4.1 Recommendations: measure replication

- **Recommendation 1 –** Do not scrap the old trams, upgrade and use them. Trams from past generations can be returned to circulation by performing upgrades to improve energy consumption parameters and the quality of the service. Also performing the upgrades on internal and external parts, the old trams can be turned into modern ones with much lower costs than investment costs in new trams

- **Recommendation 2** –Collaboration between implementation team and experts can be regarded as a success because the studies and designing must be finished in time.

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

- **Recommendation 1 -** The measure leader need to organize round tables and meeting, bringing together key stakeholders and project partners to explain the importance of the measure and to share different point of view. Must keep a good communication among partners and ensure all the measure aspects are understood so that the involvement in the activities of the measure could be 100%
- **Recommendation 2** – Technical implementation team must attempt to raise additional technical resources from the collaboration with professionals in this field.

Annex 1

Calculation of energy consumption costs

In 2009, all the 9 trams operated without chopper systems

In 2010, 4 trams were equipped with chopper systems and 5 trams continued to operate without chopper systems(CIVITAS case)

In 2010, RAT assumed that 1 tram would operate with chopper system and 8 trams would operate without chopper systems(BAU case)

In 2011, all the 9 trams operated with chopper systems(CIVITAS case)

In 2011, the situation remained the same with 2010(BAU case)

From 2012, the situation remains unchanged both for CIVITAS and BAU

	Cases for comparison	Energy consumption of 1 tram (KW/vKm)	Km traveled by trams	Total energy Consumption of the 9 trams (KW)	price/Kwh (euro)	Total cost partially (euro)	Total general (euro)
2009	CIVITAS measure	2.8	297833	833931	0.0593	49454.05	49454.05
	BAU	2.8	297833	833931	0.0593	49454.05	49454.05
2010	CIVITAS measure	2.8	151786	424999	0.0623	26488.33	
		1.82	121428	221000	0.0623	13773.93	40262.27
	BAU	2.8	242857	679999	0.0623	42381.34	
		1.82	30357	55250	0.0623	3443.48	45824.82
2011	CIVITAS measure	1.82	174750	318046	0.0657	20908.55	20908.55
	BAU	2.8	155334	434934	0.0657	28592.89	
		1.82	19417	35338	0.0657	2323.17	30916.06
2012	CIVITAS measure	1.82	177781	323561	0.0657	21252.05	21252.05
	BAU	2.8	158027	442476	0.0657	29062.64	
		1.82	19753	35951	0.0657	2361.34	31423.98

2013	CIVITAS measure	1.82	176265	320803	0.0670	21492.35	21492.35
	BAU	2.8	156680	438705	0.0670	29391.25	
		1.82	19585	35645	0.0670	2388.04	31779.29
2014	CIVITAS measure	1.82	177023	322182	0.0683	22016.42	22016.42
	BAU	2.8	157354	440591	0.0683	30107.92	
		1.82	19669	35798	0.0683	2446.27	32554.19
2015	CIVITAS measure	1.82	176644	321493	0.0697	22408.69	22408.69
	BAU	2.8	157017	439648	0.0697	30644.37	
		1.82	19627	35721	0.0697	2489.85	33134.22
2016	CIVITAS measure	1.82	176834	321837	0.0711	22881.37	22881.37
	BAU	2.8	157185	440119	0.0711	31290.77	
		1.82	19648	35760	0.0711	2542.37	33833.14
2017	CIVITAS measure	1.82	176739	321665	0.0725	23326.50	23326.50
	BAU	2.8	157101	439884	0.0725	31899.49	
		1.82	19638	35741	0.0725	2591.83	34491.33
2018	CIVITAS measure	1.82	176786	321751	0.0740	23799.41	23799.41
	BAU	2.8	157143	440001	0.0740	32546.20	
		1.82	19643	35750	0.0740	2644.38	35190.58

Starting from 2013, considered the energy price increase by 2% inflation rate

Calculation of spare parts

The trams equipped with chopper systems do not need spare parts or maintenance provided by technicians from RAT. Every 4 years, in 2014 and 2018, for CIVITAS case, RAT concluded with the provider, a maintenance contract. The value of contract is 4% of capital cost.

Starting to 2013, in BAU, the maintenance costs increase by 2% inflation rate

	Cases for comparison	Cost/unit of spare parts (euro)	No of trams	Total cost partially (euro)	Total general (euro)

2009	CIVITAS measure	2.93	9	26.37	26.37
	BAU	2.93	9	26.37	26.37
2010	CIVITAS measure	1.22	5	6.10	
		0.00	4	0.00	6.10
	BAU	1.22	8	9.76	
		0.00	1	0.00	9.76
2011	CIVITAS measure	0.00	9	0.00	0.00
	BAU	1.23	8	9.84	
		0.00	1	0.00	9.84
2012	CIVITAS measure	0.00	9	0.00	0.00
	BAU	1.04	8	8.32	
		0.00	1	0.00	8.32
2013	CIVITAS measure	0.00	9	0.00	0.00
	BAU	1.06	8	8.49	
		0.00	1	0.00	8.49
2014	CIVITAS measure			11713.68	11713.68
	BAU	1.08	8	8.66	
				1301.33	1309.98
2015	CIVITAS measure			0.00	0.00
	BAU	1.10	8	8.83	
				0.00	8.83
2016	CIVITAS measure			0.00	0.00
	BAU	1.13	8	9.01	
				0.00	9.01
2017	CIVITAS measure			0.00	0.00
	BAU	1.15	8	9.19	
				0.00	9.19
2018	CIVITAS measure			3904.56	3904.56
	BAU	1.17	8	9.37	
				433.78	443.13

Revenues calculation in evaluation period (not discounted)

The revenues per unit are multiplied by number of trams to get the annual revenues from the 9 trams in CIVITAS and BAU. The revenues are the same for both situations, because the chopper systems installation do not influence the revenues. The years 2011 and 2012 brought low revenues because of interruption of the tramline during the overpass construction (the line was cut into two separate sections, so that some passengers chose different transport solutions). Starting to 2013, RAT assumed that the revenues will have normal values as before cutting the line and will be increased by 2% inflation(related to year 2010), from year to year.

	Cases for comparison	revenues/unit(euro)CIVITAS	No of unit(trams)	Total revenues per 9 trams (euro)
2009	CIVITAS measure	78583.06	9	707248
	BAU	78583.06	9	707248
2010	CIVITAS measure	84103.08	9	756928
	BAU	84103.08	9	756928
2011	CIVITAS measure	27124.66	9	244122
	BAU	27124.66	9	244122
2012	CIVITAS measure	24442.72	9	219984
	BAU	24442.72	9	219984
2013	CIVITAS measure	85785.14	9	772066
	BAU	85785.14	9	772066
2014	CIVITAS measure	87500.84	9	787508
	BAU	87500.84	9	787508

2015	CIVITAS measure	89250.86	9	803258
	BAU	89250.86	9	803258
2016	CIVITAS measure	91035.88	9	819323
	BAU	91035.88	9	819323
2017	CIVITAS measure	92856.60	9	835709
	BAU	92856.60	9	835709
2018	CIVITAS measure	94713.73	9	852424
	BAU	94713.73	9	852424

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
no of vehicles	27	27	27	27	27	27	27	27	27	27
total revenues from fares and tickets (lei)	35,090,359	37,555,260	24,337,077	22,336,886	38306365.2	39072492.5	39853942.4	40651021.2	41464041.6	42293322.46
trams revenues (lei)	9123493.34	9764367.6	3163820.01	2903795.18	9959654.952	10158848.05	10362025	10569265.5	10780650.8	10996263.84
currency lei/euro	4.3	4.3	4.32	4.4	4.36	4.38	4.37	4.38	4.37	4.37
trams revenues (euro)	2121742.64	2270783.16	732365.74	659953.45	2316198.83	2362522.80	2409773.26	2457968.72	2507128.10	2557270.66
revenues/unit(euro)CIVITAS	78583.06	84103.08	27124.66	24442.72	85785.14	87500.84	89250.86	91035.88	92856.60	94713.73
mileage per unit in CIVITAS	33092	30357	19417	19753	25655	23796	22155	22840	23611	23100
mileage per unit in reference case	33092	30357	19417	19753	25655	23796	22155	22840	23611	23100
revenues/unit(euro)in BAU	78583.06	84103.08	27124.66	24442.72	85785.14	87500.84	89250.86	91035.88	92856.60	94713.73

Annex 2 – Ex-ante questionnaire

This survey is part of an European project - MODERN (Mobility, development and reducing energy consumption) and aims to collect your experiences in traveling by tram. **The main objective of the measure is to reduce electricity consumption 40% by installing chopper system on 9 old trams.**

Your answers will be treated confidentially

Thank you for your participation!

Ex-ante questionnaire

M 01.09 ENERGY CONSUMPTION ON TRAMLINE

1. Gender: F ☐ M ☐

2. Age:

Up to 15	15-24	25-45	45-54	55-65	over 65

3. Background (the last education institution graduated):

· master	· faculty	· secondary school	· primary school

4. Labor market status:

employed	unemployed	student

5. Public transport user

☐ ☐

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

yes no

Awareness level

6. Do y**ou know the MODERN project and measure?**

☐ ☐ ☐

yes no Don't know

7. How important are the following sources of information concerning to install chopper system on the tram, in order to reduce energy consumption?

	un-important	Rather un-important	Rather important	Very important	I don't know
Transport Company of Craiova- RAT website	☐1	☐2	☐4	☐5	☐6
Media	☐1	☐2	☐4	☐5	☐6
Colleagues/acquaintances	☐1	☐2	☐4	☐5	☐6
Forums or similar on the internet	☐1	☐2	☐4	☐5	☐6
Other, please specify below:	☐1	☐2	☐4	☐5	☐6

8. Do you understand the aim of the measure and its potential benefit?

fairly well understand	well understand	very well understand	Don't know

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Quality of service

9. **How would you evaluate the quality of public transport in Craiova, now, before implementing the measure?**

Very dissatisfied	Somewhat dissatisfied	satisfied	Very satisfied	Don't know

10. **How do you perceive tram journey, now, before implementing the measure?**

uncomfortable	Somewhat Comfortable	Comfortable	very Comfortable	Don't know

11. **You would extend the measure to all trams of Transport Company?**

yes	no	Don't know

12. Have you ever filled questionnaires for the project -MODERN?

☐ 1	Yes
☐ 2	no

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Ex-post questionnaire

This survey is part of an European project - MODERN (Mobility, development and reducing energy consumption) and aims to collect your experiences in traveling by tram.

The main objective of the measure is to reduce electricity consumption 40% by installing chopper system on 9 old trams

Your answers will be treated confidentially

Thank you for your participation!

Ex-post questionnaire

M 01.09 ENERGY CONSUMPTION ON TRAMLINE

1. Gender: F ☐ M ☐

2. Age:

Up to 15	15-24	25-45	45-54	55-65	over 65

3. Background (the last education institution graduated):

· master	faculty	· secondary school	· primary school

4. Labor market status:

employed	unemployed	student

5. Public transport user

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

yes ☐ no

☐

Awareness level

6. Do y**ou know about the measure progress?**

☐ ☐ ☐

yes no Don't know

8. How important are the following sources of information concerning to measure progress?

	Very un-important	Rather un-important	Rather important	Very important	I don't know
Transport Company of Craiova- RAT website	☐1	☐2	☐4	☐5	☐6
Media	☐1	☐2	☐4	☐5	☐6
Colleagues/acquaintances	☐1	☐2	☐4	☐5	☐6
Forums or similar on the internet	☐1	☐2	☐4	☐5	☐6
Other, please specify below:	☐1	☐2	☐4	☐5	☐6

8. Do you understand the benefits of the measure after implementation and for the next future?

fairly well understand	well understand	very well understand	Don't know

9. Do you notice the usefulness of the measure in the last time?

yes ☐ no ☐ don't know ☐

Measure title: ENERGY SAVING ON TRAMLINE IN CRAIOVA

City: Craiova Project: MODERN Measure number: 01.09

Quality of service

10. **How would you evaluate the quality of tram public transport in Craiova, now, after implementation of the measure?**

Very dissatisfied	Somewhat dissatisfied	satisfied	Very satisfied	Don't know

11. **How do you perceive tram journey, now, after implementation of the measure?**

uncomfortable	Somewhat Comfortable	Comfortable	very Comfortable	Don't know

12. **Do you think the tram public transport has been improved in the last time?**

yes	no	Don,t know

13. Have you ever filled questionnaires for the project -MODERN?

☐1	Yes
☐2	no

female	male
45 %	55%

Up to 15	15-24	25-45	45-54	55-65	over 65
5%	5%	26%	31%	23%	10%

Daily user of public transport	Occasional user of public transport
91%	9%

Determination of sample size for a population of 90000 people using trams in Craiova

Variables name and explanations		Variables values
		01.09
n	Sample size	106
t	z-score: the abscissa of the Normal distribution for probability α	1.53
α	**confidence level**, is a percentage and represents how often the true percentage of the population who would pick an answer lies within the **confidence interval** (margin of error).	87.50%
P	percentage of your sample that picks a particular answer	0.87
Q	(1-P)	0.13
d	**confidence interval** (also called margin of error)	0.05
N	population total (if N is enough large the term in the denominator tends to 1 and the formula is reduced to the numerator)	90’000

we consider the confidence level between 85 and 90% (average 87.5%)