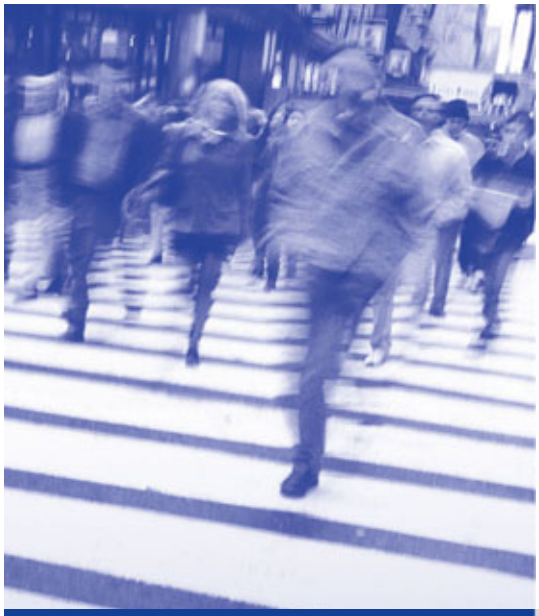

CiViTAS
Cleaner and better transport in cities

ELAN
BRNO • GENT • LJUBLJANA • PORTO • ZAGREB

Report on energy audit results and future energy use optimizing plans

ELAN Deliverable No. 1.13-D1

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Work package links

X	WP1 Alternative fuels & clean vehicles		WP7 Energy-efficient freight logistics
	WP2 Collective transport & intermodal integration		WP8 Transport telematics
	WP3 Demand management		WP9 Project coordination
	WP4 Influencing travel behaviour		WP10 Project management
	WP5 Safety, security & health		WP11 Research and Technological Development
	WP6 Innovative mobility services		WP12 Impact and process evaluation
			WP13 Dissemination, citizens' engagement, training and knowledge transfer

Document history

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[2] *Circulation*: PC = Project Coordinator; PM = Project Manager; SC = Site Coordinators; EM = Evaluation Manager; DM = Dissemination Manager; SEM = Site Evaluation Managers; SDM = Site Dissemination Managers; SCo = Scientific Coordinator, P = partners, ML = Measure Leaders

CONTENT

1. Measure 1.13-GEN Clean Public Transport Strategies

Measure 1.13-GEN Clean Public Transport Strategies is being implemented with the CIVITAS-ELAN project that runs from September 2008 to October 2012. The strategic objective of measure 1.13-GEN is to contribute to a shift towards clean PT fleets by optimising the energy consumption on trams. The specific operational objectives of this measure are to:

- Conduct an energy audit on a tram, to get more insight on the use of energy on the trams
- Propose a consistent package of new actions towards less energy consumption on trams, also to be introduced in new tendering procedures

It is envisaged that the measure will contribute to knowledge about realising energy efficiency in public transport and will reduce emissions on a large scale, and human exposure to air pollution.

2. Introduction

To optimise the energy consumption of De Lijn's trams, within CIVITAS-ELAN measure 1.13-GEN an energy audit of a modern tram is performed during one year. Included in this audit is an analysis on the heating and ventilation of trams.

Adaptations following the audit were executed on all of the 40 trams of De Lijn in Ghent from September 2011 to December 2011, and will be executed on all similar trams operating in Flanders during 2012, so that at the end of 2012 all of the 112 low-floor tram will run with optimized heating and ventilation.

3. Energy audit of tram

The main objective of the energy audit is to monitor the major consumers of electricity in a tram. Conventional cars, trucks or buses are powered by petrol or diesel engines, which have an efficiency of roughly 30 % (petrol) and 40 % (diesel). The other 70 % or 60 % of the energy is converted into heat, which can be used partly to heat the vehicle interior.

A modern tram is driven by electric motors, which have an efficiency of up to 97 %. There are thus very few thermal losses, which means that it is technically very difficult and insufficient to use the 3 % thermal energy that is produced as a source of heat for the interior in cold weather.

Therefore, the energy for heating the interior has to come almost 100 % from the (expensive) electricity derived from the overhead wire.

The advantages of an energy evaluation of a modern tram can be summarised as follows:

- If De Lijn would be able to measure precisely all the major users of electricity in a tram during one year and link these figures with factors such as speed, acceleration, outside and inside temperatures, and optimise for instance the interior heating, De Lijn could save a lot of electricity in its present tram fleet.
- The results of undertaking such a measuring session can help De Lijn to write an adequate book of tenders for the next generation of even more energy-efficient trams. In fact, De Lijn did this. Before the end of 2011 De Lijn wants to order more than 100 brand new low-floor trams.
- De Lijn can then rely on the measuring results to compose a correct eco comparison between passenger cars, buses and tramcars, including soot, fine dust, CO_2, and energy price per kilometre, to help politicians make the right decisions.

The Flemish Institute for Technological Research (VITO, *Vlaamse Instelling voor Technologisch Onderzoek*) prepared the measurement specifications, created embedded software for data acquisition in the diverse electricity users of one tramcar, delivered the apparatus (such as sensors, GPS, GPRS, and controllers) and supervised the installation of all the equipment.

The installation of the hardware, cables and antennae was executed by De Lijn, which also verified the incoming data received during the measurement sessions.

VITO is scheduled to deliver a report with the final conclusions derived from the analysis of the data, with suggestions on how to reduce energy consumption.

From November 2010 onwards one tram (N° 6309) was fully equipped with loggers for inside and outside temperatures, loggers for measuring electric currents and tensions, weight loggers, GPS antennae, a data computer, and a GPRS antenna for wireless transmitting the measured data.

From then on De Lijn regularly obtained measuring results to be able to easily compare the consumption of electricity between the measuring tram and the modified other low-floor trams running on the same line.

A final report "**On-Board monitoring of a Hermelijn Tram in Ghent: Energy saving through the optimization of heating and ventilation in light rail vehicles**" is included as Annex.

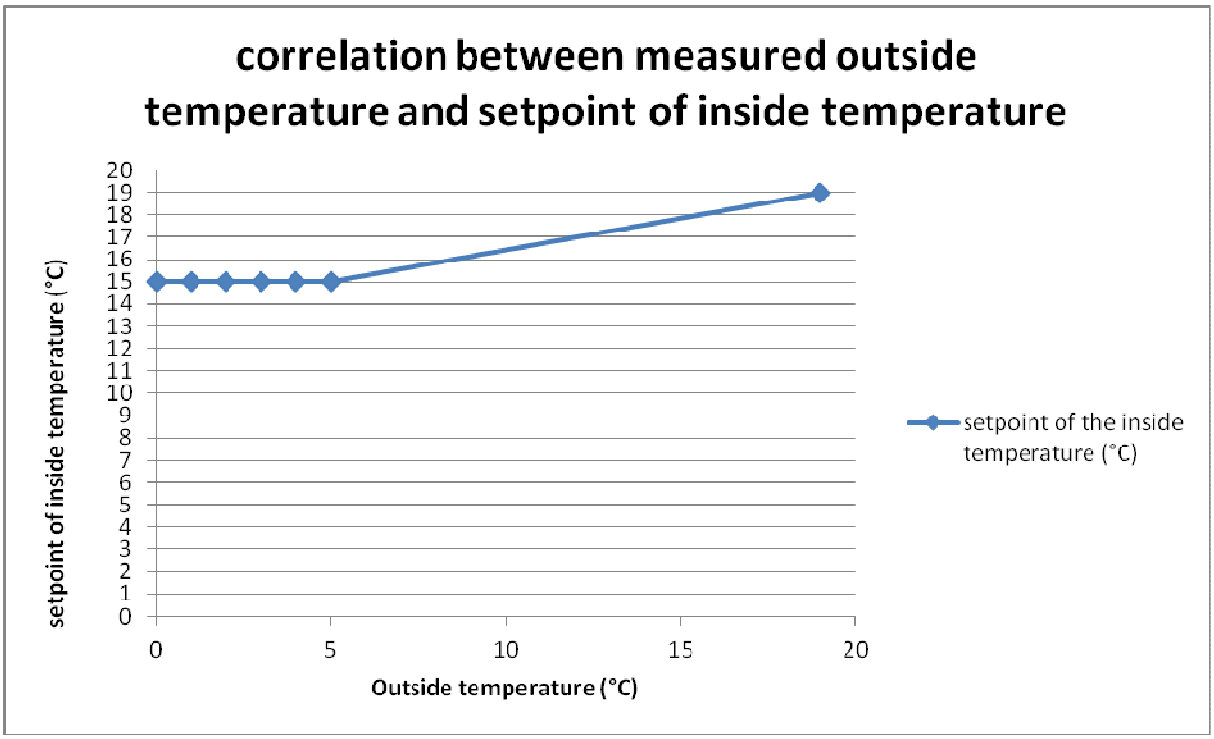
4. Research activities

The trams were modified as follows:

1. Originally the thermostat of the interior of the tram is fixed at 19 °C given independently of the outside temperature.

De Lijn proposed lowering this established point, depending on the outside temperature, and according to the scale shown in the diagramme below.

Software modification: if the outside temperature is below +5 °C, De Lijn lowered the setpoint of the minimum interior temperature to 15 °C. Above +5 °C, De Lijn intrapolated linearly until the maximum fixed setpoint of the interior temperature of 18°C was reached.



2. While the tram is in heating mode, and at least one entrance door is open, the number of revolutions of the big roof-mounted ventilators is reduced, to lose less heated air with a newly installed 3-phase relay.

3. De Lijn wanted to reduce the volume of (cold) fresh air which is sucked into the interior of the tramcar by mounting a brand new controlled 'outside air valve'. All the fresh (cold) air that is sucked into the interior of each tram has to be heated by powerful electrical resistances. By decreasing these volumes while continuously measuring the concentration of CO_2, De Lijn considerably reduces the need to heat this cold air, although remaining within international norms.

5. Results

Using those relatively small measures, De Lijn realised that it is possible to reduce the consumption of electricity annually by 20 %, which for De Lijn's 40 low-floor trams corresponds to an annual saving of 200,000 EUR. The CEO and the board of Directors of De Lijn decided on 8 April 2011 to carry out this energy saving strategy on all 112 of the low-floor 'hermelijn' trams, including all the trams of Antwerp and of the north coast, a strategy which will save ca. 500,000 EUR annually for De Lijn.

All these trams are scheduled for modification, according to the propositions approved by the board of directors, before the start of winter 2011, enabling De Lijn to maximise the reduction in electricity consumption before the onset of the really cold winter weather.

Therefore De Lijn has now started modifying the software on board the trams. All necessary hardware required (new valves, electric motors for driving these valves, CO_2 sensors, relays, and the controllers) was already installed until mid-October 2011 in all of the trams in Ghent; the trams of Antwerp and the north coast will follow soon. In Ghent De Lijn is currently cabling all the hardware to a perfect functioning saving system. The payback time of the investment costs (labour and material) is less than one year.

Regarding the possible weaknesses on the modified tramcars, only a few were identified:

- Is during low outside temperatures the setpoint of 15°C too low for De Lijn's passengers?

  Until mid-March 2012 De Lijn didn't receive any complaints from its customers. For the colleagues of the driving school, which can stay for several hours inside one tramcar, De Lijn developed some basic hardware that they can plug into a specific electric circuit, which increases the inside temperature of one of the five sections.

- Could De Lijn receive complaints from passengers who declare having headaches, complaining from drowsiness and so on because of the lack of fresh air?

  De Lijn anticipated this question and hence is saving all the important measured data such as the concentration of CO_2, the state of the new outside air valves and the outside temperatures. These measured data are stored electronically during at least 4 months so that De Lijn can research and argue the possible complaints.

  Bringing too much (cold) outside air into the interior of a vehicle which is driven electrically is too expensive as all this air needs to be heated. Bringing to little fresh outside air can cause physiological problems with our passengers. The only solution is bringing the correct quantity of fresh air inside the tramcar by measuring constantly and exactly the concentrations of CO_2.

This is tram no. 6309 – the measuring tram – at the Koning Albertbrug stop on 17 December 2010, en route from Sint Pieters station. These are Siemens/ Bombardier-built type MGT6 70% low-floor trams, which De Lijn refers to as "Hermelijn" (which is Dutch for "ermine" – a particularly flexible "low-floor" creature, and "Lijn" simply means "Line" trams). De Lijn has a fleet of 112 MGT6 trams (MGT6 means in German "Meterspur Gelenktriebwagen", i.e. a meter gauge articulated six-axle tram). The text on the tram translates as follows: Nog groener – greener, Zuiniger – more economic, Weten – knowledge, Meten – measuring, Meettram – measuring tram.

6. Annex

Final Report: “On-Board monitoring of a Hermelijn Tram in Ghent: Energy saving through the optimization of heating and ventilation in light rail vehicles.”