Output factsheet: ICT tool for planning the city bus transport electrification

Project index number and acronym	CE243
Lead partner	City of Vicenza
Output number and title	O.T2.3 ICT tool for planning the city bus transport electrification
Responsible partner (PP name and number)	UNIZAG PP3 – University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture
Project website	http://www.interreg-central.eu/SOLEZ
Delivery date	01.2018.

Summary description of the key features of the tool (developed and/or implemented)

This project output relates to the developed software tool aimed at planning of city bus transport electrification. The tool consists of four modules:

- Driving cycle data post-processing module (DPPM),
- E-bus simulation module (EBSM),
- Charging optimization module COM) and
- Techno-economic analysis module(TEAM).

The tool is written in Python programming language, with computationally demanded routines coded in C language. It is designed in a user-friendly way (based on a graphical user interface (GUI) including windows, tabs, input/output data interfaces etc.), where different modules share the same database open for the user.
The DPPM serves for postprocessing of on-line recorded driving cycle data, where the outputs include smooth trajectories of vehicle velocity and road slope, as well as statistical indices characterizing the city bus transport driving behaviour.
The EBSM provides computer simulation of different types of city buses (conventional ones and different types of electric buses: hybrid, plug-in hybrid and fully-electric buses) over the driving cycles generated in the DPPM. The module outputs include the energy consumption (fuel and/or electricity), the battery state-of-charge trajectory, engine and e-motors operating points plotted over their operating maps, and similar.
The COM utilises the outputs of DPPM and EBSM to simulate the overall city bus transport over the given driving routes and optimises the e-bus charging management for the cases of fast chargers placed at end stations and/or slow chargers installed in depot. This module provides the number of buses and chargers required to fulfil the driving schedules, as well as fuel and/or electricity consumption for the bus fleet and electricity consumption for charging.
The TEAM uses the output data from the COM and EBSM modules, as well as the data on bus transport investment and exploitation/maintenance cost, in order to calculate the total cost of ownership related to city bus transport electrification.

NUTS region(s) where the tool has been developed and/or implemented (relevant NUTS level)

The tool has been developed in the following NUTS (sub-regional/NUTS3 level): HR041 – Grad Zagrb
and is being tested and implemented in the following NUTS (sub-regional/NUTS3 level): HR037, Dubrovacko-neretvanska županija - SK031, Žilinský kraj

Expected impact and benefits of the tool for the concerned territories and target groups

The developed software tool can be exploited by different users to deliver a number of benefits for the concerned territories and various target groups.
First, the city bus transport companies can use the tool for planning of future introduction of different types of electric buses and related charging infrastructure. As explained above, the tool is designed to use real/recorded driving cycles and techno-economic data, which the transport companies are at disposal of, to calculate the optimal type and number of e-buses and chargers, as well as prediction of total cost of ownership including investment and exploitation cost. The calculation also includes savings in energy consumption, and equally important reduction of pollutant gases and CO2 emissions in the concerned cities/territories.
The public administrators can use the tool to analyse the benefits of city bus transport electrification for different techno-economic scenarios, and shape the incentives for end users to proliferate such green technologies for the benefits of citizens.
The tool can also be used by research and development institutions (e.g. universities) for various projects aimed at greening the city transport of future, as well as for education purposes.

Sustainability of the tool and its transferability to other territories and stakeholders

The tool has originally been designed to have an open architecture.
The user is approached through a graphical user interface as well as through an open database shared by different tool modules, so that different input data characteristic for different users and territories can be properly inputted to obtain representative output data for the given scenario and city. As a part of subsequent project activities to be conducted in 2019, the tool will further be extended and refined to maximise its transferability and sustainability. For instance, currently the user can set the powertrain data of different e-bus types of parallel architecture, while in the final version it would be beneficial to enable the user to specify other powertrain architectures such as series one. Also, different transport companies can record the driving cycles by using different bus tracking devices. Therefore, an input filter should be designed or specified, which would transfer the recorded driving cycle data into a unique format required by the tool.

Lessons learned from the development/implementation process of the tool and added value of transnational cooperation

The main lessons learned through a direct cooperation with the two cities involved and interactions with other cities participating in the project were related to realising that different cities have rather specific characteristic of city bus transport systems, internal processes and requirements/preferences. This posed the requirement on making the tool transferable to different users/territories, which at the end yielded a multi-layer modular tool architecture (in its core and in specific input modules) to satisfy that requirement.
Apart from the specifics already mentioned in the previous section, as an another example it is worth recalling that the tool provides e-bus fleet charging optimisation by using different types of chargers (fast, slow) installed at different city locations, so that various charging scenarios can be tested by the user to maximise the benefits in terms of investment cost and energy savings.

References to relevant deliverables and web-links
If applicable, pictures or images to be provided as annex

The four major software tool modules described above were documented in the deliverables/reports designated as:

- ***D.T2.3.1****: Tool for post-processing and analysis of recorded driving cycles of city bus transport*
- **D.T2.3.2:** *Computer simulation model of conventional and e-bus fleets*
- **D.T2.3.3**: *Optimisation tool for e-bus fleet charging management*
- **D.T2.3.4**: *Computer model for techno-economic analysis of city bus electrification cost*

When verified through two pilot studies being conducted, the tool demo is anticipated to be available via the project website.