smartCEM

Smart connected electro mobility

D4.4. smartCEM Assessment Tools

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Abbreviations

Abbreviation	Definition
CDB	Central Data Base
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
EEA	European Environment Agency
EV	Electric vehicle
GHG	Greenhouse gas
GUI	Graphical User Interface
ICE	Internal Combustion Engine
LPG	Light Petroleum Gas
NHV	Net Heating Value
NMVOC	Non-Methane Volatile Organic Compounds
OCGT	Open Cycle Gas Turbine
MJfuel	MegaJoule fuel
QT	Questionnaire
sCEET	smartCEM CO_2 emissions evaluation tool
SoC	State of Charge
TTW	Tank-to-Wheel
TCO	Total Cost of Ownership
VOC	Volatile Organic Compounds
WTB	Well-to-Battery
WTT	Well-to-Tank
WTW	Well-to-Wheel

Executive Summary

D4.4 smartCEM assessment tools is the result of Task 4.4 *Tool development*. Within this task, three subtasks have been carried out: subtask 4.4.1 Tools for the evaluation of the impact on carbon emissions, subtask 4.4.2 Questionnaires for the assessment of the impact on user acceptance/user experience, and subtask 4.4.3 Modelling influencing factors for the usage of EVs.

The aim of this deliverable is to present these assessment tools which have been developed in order to evaluate the performance indicators defined in Task 4.2 and 4.3 to validate the efficiency and success of the smartCEM services.

The present document is divided into three main parts. The first is related to the tool for the evaluation of the impact of carbon emissions. This tool determines the amount of emitted CO_2 emissions based on the vehicles' charging information and energy mixes, in the case of EVs, and based on fuel consumption and the well-to-tank information in the case of hybrid buses. Chapter 2 describes the selection process and criteria to determine how and which existing software (provided by the partners of the smartCEM project) have been adapted and integrated to generate the smartCEM estimator of CO_2 emissions for the EV fleets, located in the four smartCEM pilot sites.

The second is the development of several questionnaires to determine the user-uptake of electro-mobility services. The questionnaires assess the usability of the ICT-services including user acceptance, range-anxiety, willingness to pay and other items related to the end users' experience. Chapter 3 describes the questionnaire development, together with the response scales and the services evaluated with each question.

Finally, and to support final conclusions on smartCEM services and to know the effect of some indicators in others, a model has been developed. This model is presented in Chapter 4.

The results of this task 4.4., i.e. the present deliverable and the developed tools, directly feed into task 4.5 *Data analysis*. In particular, work carried out within subtask 4.4.1 affects future results obtained in subtask 4.5.1 *Fleet carbon footprint data analysis*; results from 4.4.2 will influence subtask 4.5.2 *Data analysis concerning the impact on user acceptance/user experience*; and results of subtask 4.4.3 will be used by subtask 4.5.3 *Data analysis concerning influencing factors for the usage of EVs*.

1. INTRODUCTION

The smartCEM project is focused on the deployment of electro-mobility ICT services that facilitate and enhance the user experience of electric vehicles (EVs). Through the integration of these ICT systems, smartCEM intends to increase awareness of electro-mobility and to encourage the use of EVs as part of everyday life.

Consequently, the smartCEM pilots aim to demonstrate the potential for EVs in urban and interurban contexts and to encourage the uptake of EVs through advanced and heterogeneous mobility services (refer to smartCEM deliverable D2.1). In this perspective, pilots and trials are aimed at testing and understanding consumer patterns and behaviour, thus influencing this behaviour in order to manage a more effective service.

As a consequence, smartCEM must evaluate the influence of the services in certain categories, such as environment or user uptake, evaluating the CO_2 emissions or acceptance of EVs, respectively. For this purpose different evaluation tools have been developed.

1.1. Purpose of the deliverable

The main purpose of the present report is to describe the developed tools and questionnaires to evaluate the influence of the smartCEM services. Those services will be evaluated under different categories taking into account several performance indicators (refer to D4.1 and D4.2). With this purpose the evaluation tools developed and explained within this report are:

- <u>smartCEM CO_2 emissions evaluation tool</u>: this tool has been mainly developed to calculate the released CO_2, during baseline's and functional operation's phases, by the recharging, consumed fuel during a trip and refuelling.
- <u>User uptake questionnaires</u>: these questionnaires have been developed to assess how users accept and use EVs and the smartCEM services. The questionnaires cover three main concepts: acceptance, range-anxiety and willingness-to-pay.
- <u>The model</u>: finally, the developed model to support smartCEM is explained. This model allows smartCEM partners to look directly at which performance indicators have the strongest influence on user uptake and then to decide which means would be most suitable for tracking and evaluating these performance indicators and especially useful in setting priorities for data collection and evaluation.

1.2. Structure of the document

The main body of the present document is divided into three chapters:

- Chapter 2: Tool for the evaluation of the impact of carbon emissions, related to objective measures, presents the followed procedure to establish the requirements of smartCEM CO_2 emissions evaluation tool. As well, this chapter presents the selection process and criteria to determine how and which existing software (provided by the partners of smartCEM project), have been adapted and integrated to generate the smartCEM estimator of CO_2 emissions for the EV fleets, located in the four smartCEM pilot sites.

- Chapter 3: Questionnaires for the assessment of user-uptake, related to subjective measures, presents the development process and the questionnaires to be used in order to evaluate the users' uptake.
- Chapter 4: Modelling influencing factors for the usage of EVs presents the developed model to support smartCEM, e. g. support 'developing' the services (how do the services influence EV-uptake) or prioritizing the performance indicators as well as the evaluation criteria.

Finally, some relevant conclusions from the evaluation tools and the best practices to be used are included at the end of the document. Annexes include further information on document discussions and contents.

1.3. Related smartCEM documents

This section contains internal documents produced within the smartCEM project. All documents are available for download on the smartCEM project collaboration portal on ProjectPlace: http://www.projectplace.com/. All partners in the consortium have access to the portal, whose account management is owned by ERTICO.

Table 1. Related smartCEM documents

FINALISED smartCEM DELIVERABLES		
Reference	**Name**	**Version**
D4.1	Evaluation framework	v2.0
D4.2	Evaluation criteria and performance indicators	v2.0
D4.3	smartCEM experimental design	v2.0
D6.2	Agreed set of indicators	v1.0
FUTURE smartCEM DELIVERABLES		
Reference	**Name**	**Version**
D4.5	Results of the evaluation	N/A
D3.2	Common Data Exchange Protocol for smartCEM	N/A

2. Tool for the evaluation of the impact of carbon emissions

In this chapter, the smartCEM CO_2 emissions evaluation tool is presented. The aim of this tool is to evaluate the impact of carbon emissions derived from the battery charge - in the case of EVs- and the fuel consumption - in the case of the hybrid bus.

The developed tool is based on the current tools or methodologies developed and/or used by Newcastle University (UNEW), IDIADA, and Tecnalia Research and Development (Tecnalia). Within this chapter, a brief description of the available tools from UNEW and Tecnalia is included.

Furthermore, IDIADA uses a tool to estimate the CO_2 emissions derived from fuel consumption of internal combustion engine (ICE) vehicles. This tool will be also used to develop an additional study, in order to compare the carbon emissions produced by EV scooters versus equivalent ICE scooters, i.e. with the estimation of the CO_2 emitted by conventional motorcycles, doing the same trips as logged in Barcelona.

The following section presents the selection process and the obtained criteria in order to select the required features of each tool to be integrated and adapted for the smartCEM evaluation analysis. The description, functionalities and usage of the developed smartCEM CO_2 emissions evaluation tool are thus also explained within this chapter.

2.1. Tool selection process and criteria

As stated above, the smartCEM project needs a tool or procedure to take the energy (and fuel, in the case of the hybrid bus of the Gipuzkoa pilot site) consumption measured through smartCEM tests and to estimate 'Well-to-Battery/Tank' (WTB/T) CO_2 emissions through energy mix on a country-by-country basis. For the hybrid bus within the Gipuzkoa pilot site, the carbon emissions' estimation from driving cycles in fossil fuel vehicles is also required.

As a consequence, expected features of the smartCEM CO_2 emissions estimation should be as follows:

- <u>CO_2 produced during the use of the vehicle</u>, based on the fuel consumption obtained from the smartCEM baseline and operational phase's data sets (this is only required for the hybrid bus).
    - The relationship between the fuel consumption and the CO_2 production must be estimated according to the literature.
- <u>CO_2 produced by WTB</u>, i.e. the CO_2 release to produce the required energy for the batteries' recharging. The main features related to this requirement are as follows:
    - Energy mix: Latest data from European countries of energy production by generation technology.
    - Data of CO_2/kW-h emissions, by generation technology, when generating electric energy. Customization option of the energy mix is needed.

- Energy consumption obtained from smartCEM tests.
- Graphic and numerical results.

Selection criteria

Table 2 shows the requirements and each criterion defined, in order to analyse the currently available tools, to determine which parts of the mentioned applications will be used to generate the module of CO_2 emissions estimation for the smartCEM project.

Table 2.- smartCEM selection criteria specifications

REQUIREMENT	CRITERION	
Energy Mix	Scope: to be established for EU27, 4CIP countries or only for smartCEM countries	
	Level of detail:	Average energy mix by country and year
		Energy mix by time of the day for each country to estimate more accurately the produced CO_2
CO_2 emissions derived from hybrid bus	CO_2 generated by fuel consumed during the driving cycles	
	CO_2 generated WTT (fuel production cycle)	
Flexibility for integration with measures format	CO_2 calculation should be done by trip, by week, by month, total, according to representation needs	
	Flexible enough for calculation through, e.g. excel sheet	
Sources of information	Bibliography/literature	
	References of use given	
Results	Able to be exported for graphic representation	
	Able to be exported for other applications, such as Excel.	

2.2. Approaches

Within this section, the methodologies or tools provided by University of Newcastle, IDIADA and Tecnalia are presented. These are:

- A methodology for calculating the carbon content of electricity over a 24 hour period,
- The estimation of the released CO_2 coming from the generation and distribution of fuel, i.e. the WTT procedure,
- The COPERT 4 software tool to calculate road transport emissions (combustion vehicles) and,

- The Cityelec tool, to estimate the CO_2 emissions derived from the usage of EVs and/or combustion vehicles.

Then, and taking into account this information, the selection matrix will be provided, in order to know which parts could be reused for the smartCEM CO_2 emissions evaluation tool development.

2.2.1. Half-Hourly Calculation of Electricity Carbon Content

UNEW has developed a methodology for calculating the carbon content of electricity over a 24 hour period. It requires:

- Power generation data
- A power transmission loss factor
- Carbon emissions factors for the carbon content of each electricity generation power source

In the UK the power sources for electricity generation are coal, natural gas, nuclear, imports, oil and open cycle gas turbine (OCGT), pumped storage, hydro and wind.

Data supplied in 2012 provide half-hourly electricity generation figures for each power source. The power transmission loss factor is quoted as 1.10.

The carbon emissions factors in gCO_2/KWh are:

- Nuclear 0
- Coal 910
- Gas 390
- Other 540
- Renewables 0

Not all sources of power generation have their emissions quoted. Wind and hydro were classified as renewable. Oil and OCGT, imports and pumped storage were classified as 'other'.

In the UK the data required for the methodology is available from the Department of Energy and Climate Change (for further information refer to https://www.gov.uk/government/organisations/department-of-energy-climate-change).

Tool description

For each of the eight power sources total emissions can be calculated by multiplying the emissions factor by the total energy generation in a half-hourly time interval. The sum of the eight emissions totals for each power source gives the total emissions in that half-hourly time interval. This is then divided by the total output to give the average emissions in this half hourly interval. This process is then repeated for each half hourly interval throughout the day to give a typical carbon content of electricity profile across a 24 hour period.

In Robinson *et al* (2013), typical profiles from summer and winter were defined to allow the impact of recharging behaviour on carbon emissions to be compared irrespective of day-to-day fluctuations in power demand (see Figure 1).

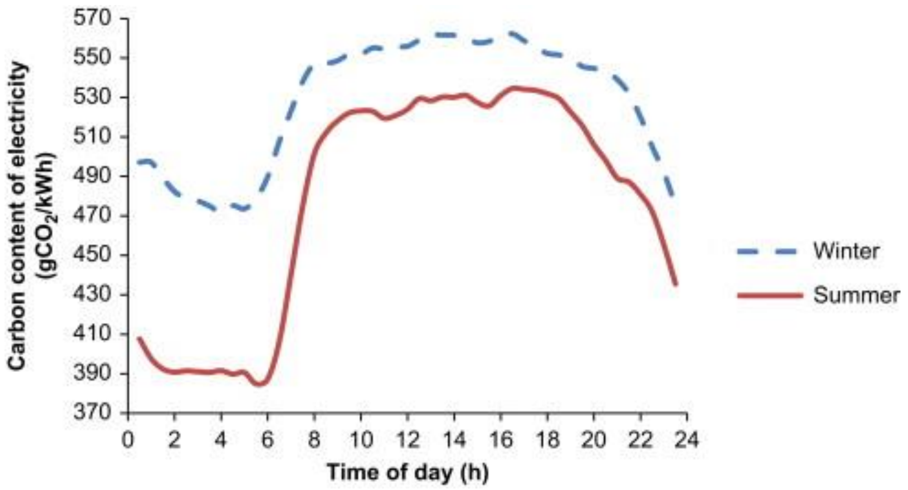

Figure 1.- summer and winter carbon emissions profiles (from Robinson *et al*, 2013)

<u>Functionalities</u>

The methodology presented above can contribute towards a detailed analysis of the carbon content of electricity. In Robinson *et al* (2013) the methodology was applied specifically to recharging events. As well as the carbon content profiles for power sources, the following data must be available relating to recharging events:

- The start and finish time of recharging events
- Duration and time of day of recharging events
- User ID
- Charge post ID

This data enables calculation of a summer and winter average carbon content for each recharging event, distinction between on-peak and off-peak charging, and between type of user (private, fleet, etc.) and location (home, work, etc.).

From Robinson *et al* (2013) calculations reveal the average carbon content of electricity during EV recharging in winter in the UK is 543 gCO_2/kWh compared to the average in summer of 505 gCO_2/kWh. The average carbon content of electricity during the off-peak hours is 482 gCO_2/kWh in winter, compared to 392/kWh in summer. If all recharging was completed off-peak, the carbon content of electricity used to recharge an EV could be reduced by approximately 11% in winter and 22% in summer (depending on precise start and finish times of the recharging events).

The carbon content of recharging an EV was generally higher in winter and lower in summer across all events monitored. This is because the higher demand for power in winter creates additional demand for power which is met predominantly through generation from coal.

2.2.2. Well-to-Tank

In order to obtain the Well-to-Tank (WTT) CO_2 equivalent emissions of the different fuels, it should be considered that fuels are made through different production pathways (from energy feedstock recovery, i.e. wells, to the fuel before being used by the vehicle, i.e. tank). This combination of steps necessary to turn a resource into a fuel and bring that fuel to a vehicle is defined as a WTT pathway. This production consists of different steps:

- Production and conditioning at source includes all operations required to extract, capture or cultivate the primary energy source. In most cases, the extracted or harvested energy carrier requires some form of treatment or conditioning before it can be conveniently, economically and safely transported.
- Transformation at source is used for those cases where a major industrial process is carried out at or near the production site of the primary energy (e.g. gas-to-liquids plant).
- Transportation to EU is relevant to energy carriers which are produced outside the EU and need to be transported over long distances.
- Transformation in EU includes the processing and transformation that takes place near the market place in order to produce a final fuel according to an agreed specification (e.g. oil refineries or hydrogen reformers).
- Conditioning and distribution relates to the final stages required to distribute the finished fuels from the point of import or production to the individual refuelling points (e.g. road transport) and available to the vehicle tank (e.g. compression in the case of natural gas).

The Greenhouse gas (GHG) of each fuel expressed as g CO_2 eq/MJfuel derive from the sum of the g CO_2 eq/MJ of each of these fuel steps. For the calculation in smartCEM these data are extracted from JEC WTW study or the most recent available information at the start of the calculation. For example, in the following figure, the GHG of the different fuels expressed as g CO_2 eq/MJfuel from the most recent data is presented:

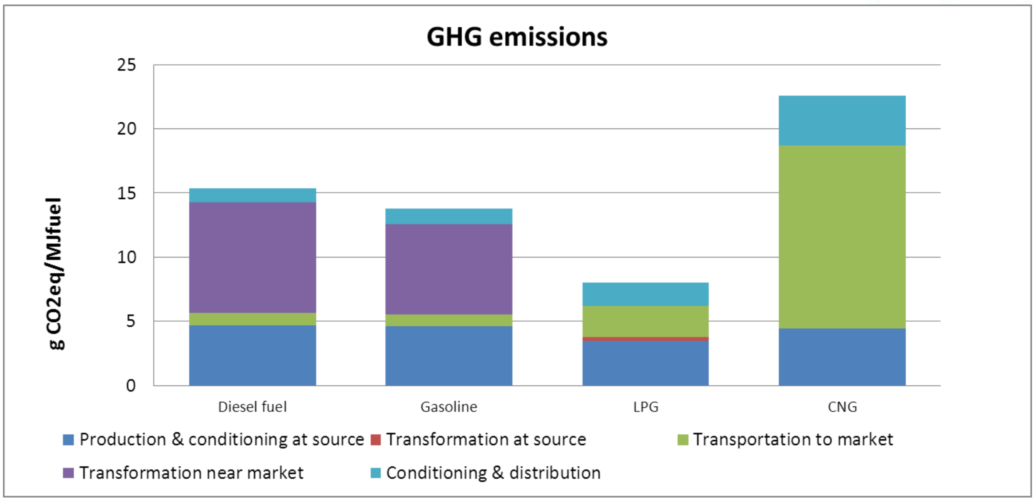

Figure 2.- GHG emissions of different fuels. Source: JEC WTW

In this JEC WTW study, the main calculations have been performed by a software program developed by LBST (L-B-System Technic) which combines a database for all input data and their references with an algorithm for the rigorous calculation of the total energy and GHG associated with a given pathway, including feedback loops. The main considerations of each fuel to estimate the g CO_2 eq /MJfuel are the following:

- Diesel fuel: Crude oil from typical EU supply, transport by sea, refining in EU (marginal production), typical EU distribution and retail.
- Gasoline: Crude oil from typical EU supply, transport by sea, refining in EU (marginal production), typical EU distribution and retail.
- CNG: Compressed natural gas, transport to EU by pipeline or Middle East, distribution through gas high pressure trunk lines and low pressure grid, compression to CNG at retail point.

With these obtained values in CO_2 eq/MJfuel and the fuel consumption we can estimate the WTT emissions in different vehicles and fuels.

The formula to obtain this estimation is:

- If the density and the net heating value (NHV) are available, the CO_2 emissions are obtained as follows:

  CO_2 emissions (g CO_2) = Fuel consumed (l) (Density (kg/m3)/1000) * NHV (MJ/kg) * X g CO_2/MJ,*

  Where X is: X= 13.04505556 g CO_2/MJ for petrol and X= 14.62463889 g CO_2/MJ for diesel.

- If the density and the net heating value (NHV) are not available, these values should be estimated.

- For petrol: Estimated density is 747.5 kg/m3 and NHV is 42 MJ/kg, and the resultant formula is:

  CO_2 emissions (g CO_2) = Fuel consumed (l)*409.5 (g CO_2/l)

- For diesel: Estimated density is 832.5 kg/m3 and NHV is 43 MJ/kg, and the resultant formula is:

  CO_2 emissions (g CO_2) = Fuel consumed (l)*523.5 (g CO_2/l)

As an example, if we have a bus with a fuel consumption of 15 l of petrol, and the density and net heating value (NHV) of this petrol are not available, we are going to consider a WTT emission of this petrol of 6142.5 g CO_2.

2.2.3. COPERT 4

COPERT 4 is the fourth update of the initial version COPERT 85 (1989). It is an informatics program coming from the WG CORINAIR (CORe INventory of AIR emissions) and a collaborative effort and draws from several large-scale European activities:

- The MEET project (Methodologies to Estimate Emissions from Transport), a European Commission sponsored project (1996-1998)
- The COST 319 action on the Estimation of Emissions from Transport (1993-1998)
- The PARTICULATES project (Characterization of Exhaust Particulate Emissions from Road Vehicles), a European Commission project (2000-2003)
- The ARTEMIS project (Assessment and Reliability of Transport Emission Models and Inventory Systems), a European Commission project (2000-2007)
- A joint JRC/CONCAWE/ACEA project on fuel evaporation from gasoline vehicles (2005-2007)

The development of COPERT is coordinated by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre for Air Pollution and Climate Change Mitigation. The European Commission's Joint Research Centre manages the scientific development of the model. COPERT has been developed for official road transport emission inventory preparation in EEA member countries. However, it is applicable to all relevant research, scientific and academic applications. The use of a software tool to calculate road transport emissions allows for a transparent and standardized, hence consistent and comparable, data collecting and emissions reporting procedure, in accordance with the requirements of international conventions and protocols and EU legislation.

Tool description

COPERT 4 is a software tool that works on Microsoft Windows platform used world-wide to calculate air pollutant and greenhouse gas emissions from road transport. The emissions calculated include regulated (i.e. CO, NOx, VOC, PM) and unregulated pollutants (i.e. N2O, NH3, SO2, NMVOC speciation) and fuel consumption. CO_2 emissions are based on fuel consumption. The exhaust emissions are dependent on the activity (e.g. number of vehicles, distance travelled), hot emissions (e.g. technology/emission standard, mean travelling speed) and cold emissions (e.g. technology/ emission standard, mean travelling speed, ambient temperature and mean trip distance).

It has a user friendly and a multi-window environment. The COPERT 4 System Architecture is illustrated in Figure 3:

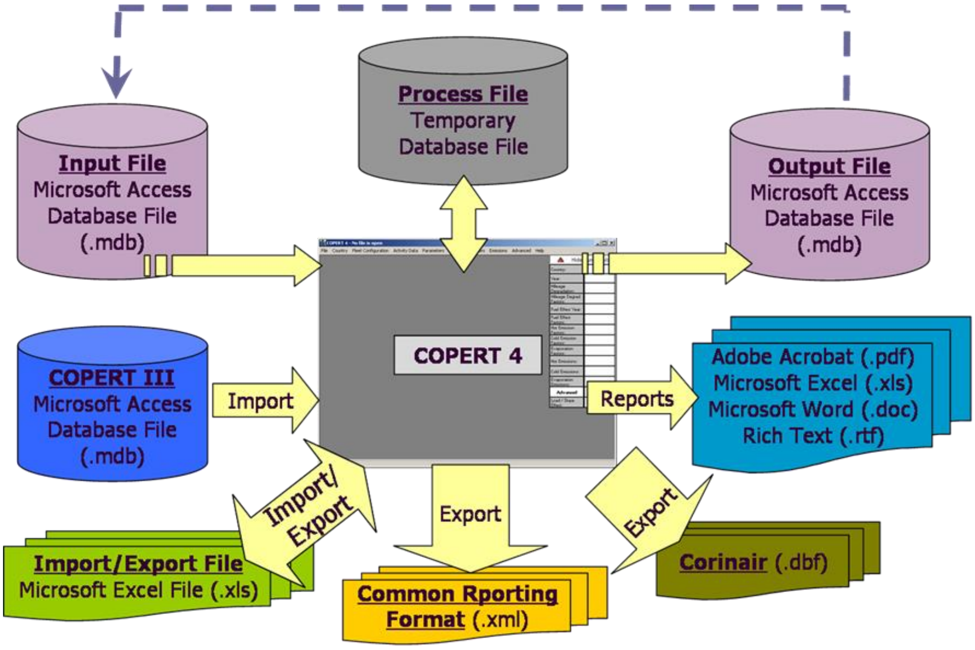

Figure 3.- COPERT 4 System Architecture

The following procedure shows how the tool can be used:

- STEP 1 – SELECT COUNTRY AND YEAR - On opening the file, an existing country and year can be selected or a new country and year created.
- STEP 2 – COUNTRY INFO - From the 'Country Info' form the temperatures, RVP of the selected country and year can be entered. Data for every year of each country can be different or the same.
- STEP 3 – FUEL INFO - From the 'Country'- 'Fuel Info' form data for the Fuel specifications and the Statistical Annual Fuel Consumption to be used in the calculations is provided. 6 fuel types are included, specifically: Leaded and Unleaded Gasoline, Diesel, Light Petroleum Gas (LPG), Compressed Natural Gas and Biodiesel.

- STEP 4 – FLEET CONFIGURATION - The next step is to configure the fleet. A list of the available vehicle categories is provided and the desired vehicles are selected. Each year of every country has a different fleet configuration. However a configuration of one year to others of the same country can be applied.
- STEP 5 –Data can be directly input or imported from Microsoft Excel.
- STEP 6 – EMISSIONS - The next step is to calculate emissions. The 'Emissions' - 'Total Emissions' form is opened and each button of the 'Recalculate' box pressed for every Emission category required (Hot, Cold, or Evaporation). All the emissions and emission factors can be calculated.
- STEP 7 –Data can be exported to Microsoft Excel.
- STEP 8 –Reports and Charts can be created.

Functionalities

Thanks to the COPERT 4 emissions estimation tool, the carbon emissions of different types of vehicles can be calculated. In particular, the functionalities of the mentioned tool are as follows:

- Select between different fuels: Leaded and Unleaded Gasoline, Diesel, Light Petroleum Gas (LPG), Compressed Natural Gas and Biodiesel.
- Select between different vehicle categories:
    - Passenger Cars
        - Gasoline (<1.4 l, 1.4-2.0 l, >2.0 l)
        - Diesel (<2.0 l, >2.0 l)
        - LPG
    - Light Duty Vehicles (Trucks & Vans)
        - Gasoline
        - Diesel
    - Heavy Duty Vehicles
        - Gasoline
        - Diesel (11 weight categories)
    - Power Two Wheelers
        - Mopeds (< 50 cc)
        - Motorcycles (2-stroke, <250 cc, 250-750 cc, >750 cc)

- Select between different vehicle technologies:
    - Passenger Cars (PRE ECE, ECE 15/…, PC Euro 1, 2, 3, 4, 5 and 6)
    - Light Duty vehicles (Conventional, LD Euro 1, 2, 3, 4, 5 and 6)
    - HDV, buses (HD Euro I, II, III, IV, V and VI)
    - Mopeds and Motorcycles (Conventional, Euro 1 and 2 (and 3 only for motorcycles))
- Estimate the CO_2 emissions based on fuel consumption

2.2.4. CO_2 emissions estimation tool of Cityelec

As a starting point, in order to develop a CO_2 estimation tool to evaluate the improvements obtained from using smartCEM applications, it is proposed to adapt and increase the functionalities of the *Cityelec CO_2 emissions estimation tool*. This tool has been developed by Tecnalia, within the Spanish national project called Cityelec.

The Cityelec project, supported by the Spanish Ministry of Science and Innovation, focused on the research of key elements both in vehicle and infrastructure for new concepts (sometimes radical) of electrified mobility in the urban environment. The main objective was to define the Cityelec system, which allows personal mobility with minimal carbon footprint by means of the following:

- Fleet of light EVs (Scooters, city cars and small buses)
- Infrastructure elements: Urban transformer station with energy storage capability, local urban energy generators (photovoltaic, windmill, etc.)
- New concepts for management of electrical power from renewable sources on the grid, focused on maximum storage of renewable energy for mobility.

Tool description

The Cityelec CO_2 emissions evaluation tool is a module of software, which allows estimating the CO_2 emissions produced by different vehicle fleets, i.e. market electric vehicles, such as Smart Electric, Reva, iMIEV, etc., and an EV customized by the user, or hybrid and combustion vehicles under different range segments, for instance MINI One D, Toyota Prius Eco, BMW X5, etc. Together with the selected type of vehicle, this tool also simulates emissions based on the vehicle characteristics (power, weight, Cx, etc.), an estimated driving cycle and the estimated daily energy mix of a maximum of three specific countries of 27 European countries, during each simulation. After calculating the fleet carbon footprint this estimation can be displayed to users (driver, fleet manager, operator, mobility public authority, etc.).

As the following figures show, this tool is divided into four screens: '*Combustion vehicles*' screen (see Figure 4), '*Electric vehicles*' screen (see Figure 5), '*Energy Mix*' screen (see Figure 6) and, finally, the '*Results*' screen (see Figure 7).

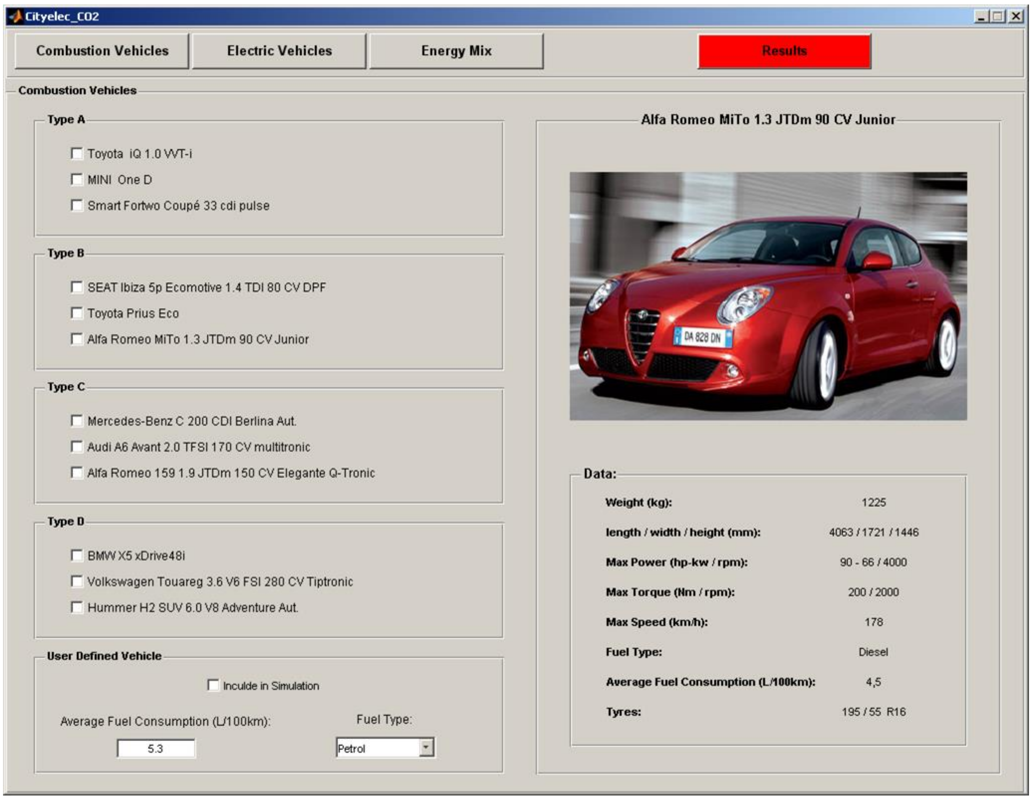

Figure 4.- Cityelec tool: '*Combustion vehicles*' screen

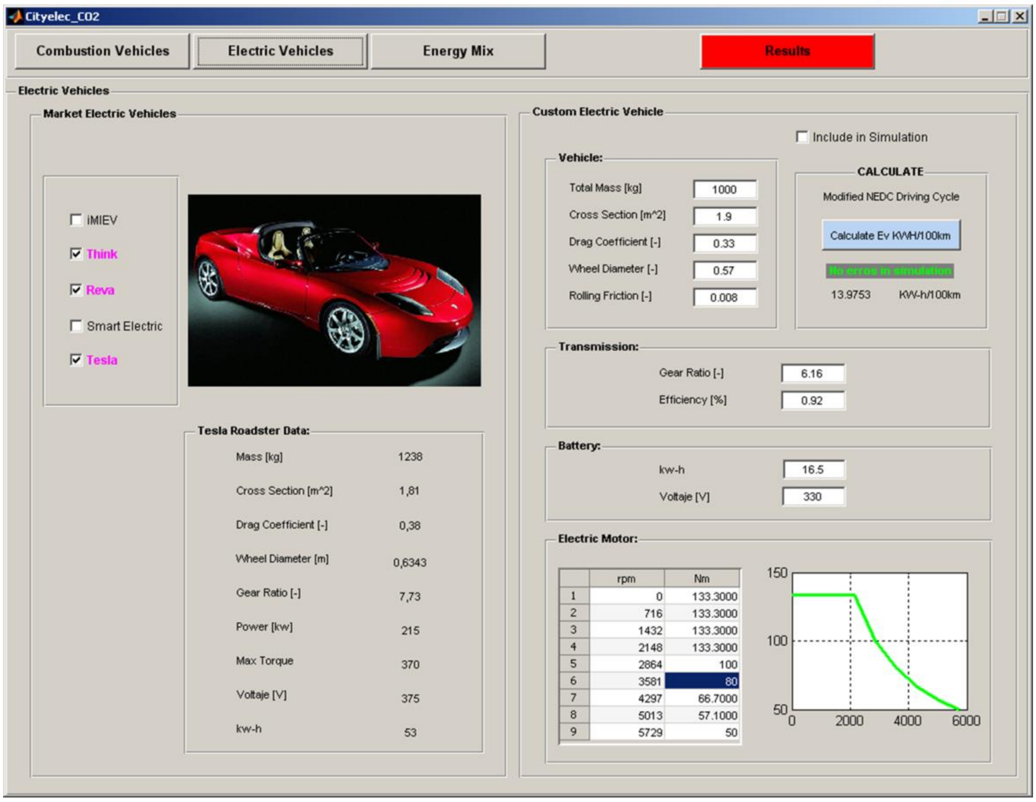

Figure 5.- Cityelec tool: '*Electric vehicles*' screen

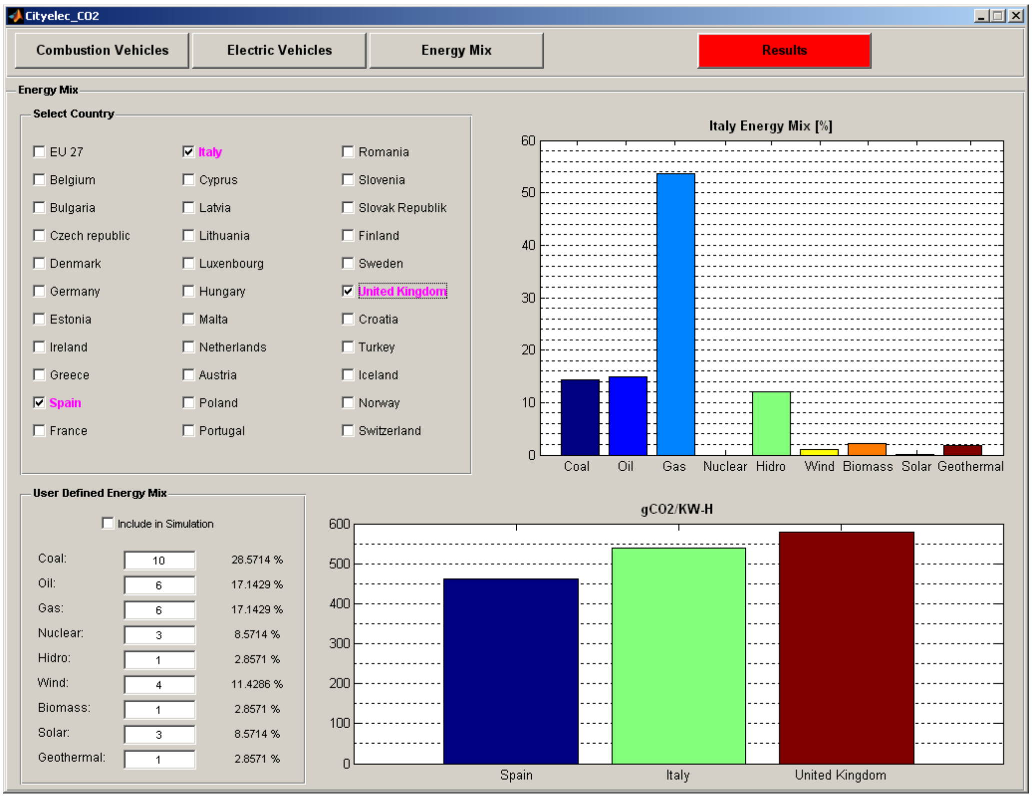

Figure 6.- Cityelec tool: '*Energy Mix*' screen

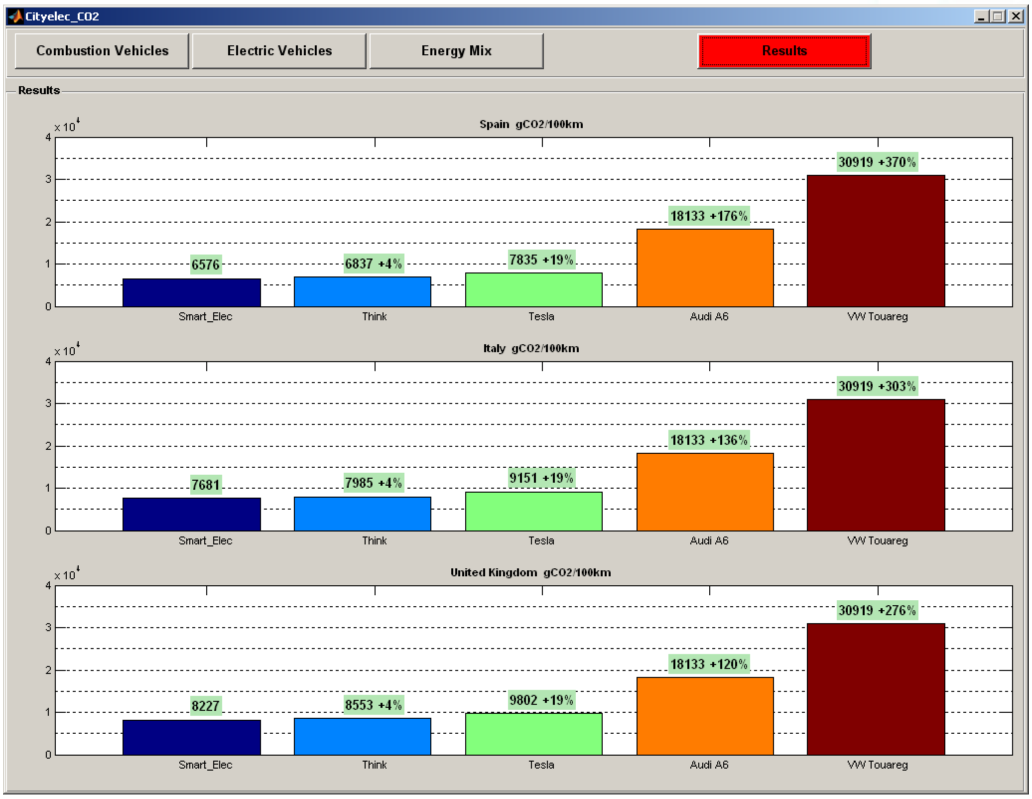

Figure 7.- Cityelec tool: '*Results*' screen

Functionalities

As stated previously, thanks to the Cityelec CO_2 emissions estimation tool the carbon emissions of different types of vehicles can be estimated. In particular, the functionalities of the mentioned tool are as follows:

- Select between different types of vehicles: combustion, hybrid or EVs.
- Include to simulation of user defined combustion vehicle, EVs or Energy mix data.
- Design user-own EV to follow a specific driving cycle, thanks to MATLAB-Simulink model.
- Estimate the CO_2 emissions based on previous selections, and create graphs with these results.

2.3. Selection matrix

As Table 3 shows, the selection matrix is a table, which allows a crosschecking between the available current tools characteristics

Table 3.- smartCEM selection matrix

REQUIREMENT	CRITERION		UNEW	IDIADA	TCNL
Energy Mix	Scope		UK	Spain and EU-27	EU-27
	Level of detail:	Average energy mix by country and year	✔ (only for UK)	✔	✔
		Energy mix by time of the day for each country to estimate more accurately the produced CO_2	✔ (only for UK)	Not available	Not available
CO_2 emissions derived from hybrid bus	CO_2 generated by fuel consumed during the driving cycles		Not available	✔ (only for combustion working mode)	✔
	CO_2 generated 'well to tank' (fuel production cycle)		Not available	✔	Not available
Flexibility for integration with measures format	CO_2 calculation should be done by trip, by week, by month, total, according to representation needs		Half-hourly data can be extrapolated as required.	✔ (for combustion vehicles only)	From here, subroutines and data to be used by Excel
	Flexible enough for calculation through, e.g. excel sheet		✔	✔ (for combustion vehicles)	✔
Sources of information	Bibliography/literature		Robinson *et al*, 2013	✔	✔
	References of use given		Robinson *et al*, 2013	COPERT 4	Cityelec
Results	Able to be exported for graphic representation		✔	✔	✔
	Able to be exported for other applications, such as Excel.		✔	✔	✔

Based on the provided information by this matrix, the usage that has been done of the available tools or methodologies to develop the smartCEM CO_2 emissions evaluation tool has been as follows:

- Cityelec tool has been used as a software architecture reference. As well, it has been used to estimate the CO_2 emissions generated by the pre-defined or user-defined vehicles.
- In order to estimate the CO_2 emissions derived from the WTT process, the explained formulas have been used.
- Finally, to evaluate the CO_2 emissions generated by TTW process, the COPERT 4 has been used as starting point.

2.4. SmartCEM CO_2 emissions evaluation tool (sCEET)

In the following section the developed tool for smartCEM project, based on available tools, is presented. The aim of this tool is to estimate the released CO_2 during baseline and functional operation, i.e. without and with smartCEM applications running, in order to evaluate the improvements obtained through the smartCEM project in terms of CO_2 emissions reduction.

For this purpose, partners involved in subtask 4.4.1 will provide the developed tool to the Pilot Site leaders, in order that they distribute the tools to the data analysers. With this tool, they will be able to estimate the CO_2 emissions generated during baseline and functional operation phases. Then, data analysers may compare the obtained results and apply the appropriate statistical method to evaluate the hypotheses and establish success criteria (refer to smartCEM deliverables D4.1, D4.2 and D4.3 for further information).

2.4.1. Tool brief description

The smartCEM CO_2 emissions evaluation tool (henceforward sCEET) is a module of software, which allows estimation of the CO_2 emissions produced by the production of the energy required for EVs recharging or by the hybrid bus, based on the acquired data in each pilot site i.e. Newcastle, Barcelona, Gipuzkoa – Donosti, and Reggio Emilia. Through the use of smartCEM data sets or others with a similar format, sCEET allows the user to estimate the CO_2 emissions for the CIP project countries i.e. Ireland, United Kingdom, Netherlands, Germany, France, Italy, Slovenia, Spain and/or Portugal. Finally, using raw data from smartCEM or the CIPs, it is possible to obtain the CO_2 emissions estimation using the Energy Mix from other European countries as an approximation for any selected country.

The GUI of sCEET is divided into several screens. Figure 8 shows the main screen of the application. Through this screen, the end user can select between two analysis procedures. The first procedure (Analysis from raw data) allows the user to estimate the CO_2 emissions based on the acquired data in each pilot site.

The second procedure (Analysis for pre-defined or user-design vehicles) allows the user to estimate the CO_2 emissions produced by different EVs i.e. market electric vehicles, an EV customized by the user, or hybrid and combustion vehicles. Together with the selected type of vehicle, sCEET also simulates emissions based on the vehicle characteristics (power, weight, Cx, etc.), an estimated driving cycle and the estimated daily energy mix of a maximum for three of 27 European countries, during each simulation. After calculating the fleet carbon footprint this estimation can be displayed to users (driver, fleet manager, operator, public authority, etc.). For further information refer to the section below: '*How to use?*'.

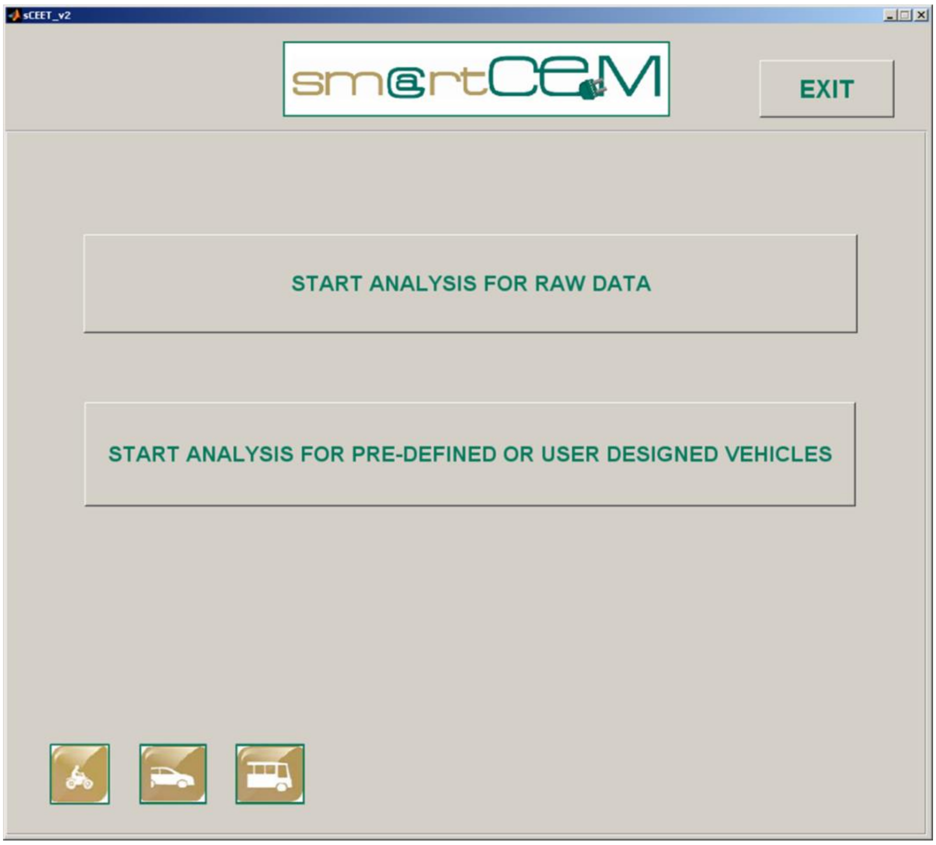

Figure 8.- sCEET main screen

2.4.2. Functionalities

The sCEET allows the user to calculate the released carbon emissions during the baseline and functional operation phase for different types of fleets. The tool allows the user to select between an estimation based on data from smartCEM sites, or from different types of vehicles (combustion, hybrid or EVs) chosen or defined by the user. In particular, the functionalities of the mentioned tool are as follows:

DATA COMING FROM smartCEM PS:

- Scope: the tool allows the user to select between different countries to estimate the CO_2 emissions based on the logged data in an Excel file[1]. These countries are those included in the European Union, including the smartCEM and CIP projects countries, as well as the other member states.
- Energy mix - Level of detail: the energy mix available is for EU-28 countries and on a monthly basis (maximum one year).
- CO_2 emissions for hybrid bus: the smartCEM validation tool can estimate the CO_2 emissions derived from the fuel consumed, i.e. from the Tank-to-Wheel (TTW)and from the WTT process.
- Measures formats and results: the tool estimates the emissions and provides an .xlsx file with the results, i.e. four new columns included in the original file: CO_2 emissions derived from EVs, CO_2 emissions derived from WTT process, from TTW process and, finally, the total amount. The resolution of those results depends on the format of the input data.

DATA COMING FROM SPECIFIC VEHICLES (pre-defined or designed by user):

- Select between different types of vehicles: combustion, hybrid or EVs.
- Include to simulation of user defined combustion vehicle, EVs or Energy mix data.
- Design user-own EV to follow a specific driving cycle, thanks to MATLAB-Simulink model.
- Estimate the CO_2 emissions based on previous selections.

2.4.3. How to use?

Following the philosophy of the previous tools, the sCEET is divided into two main parts. The first one allows the user to estimate the CO_2 emissions, analysing the datasets obtained from the pilot sites. The second one is used to analyse these emissions, starting from the information obtained from pre-defined vehicles or user-designed vehicles. As Figure 8 and Figure 9 show, the main screen of the sCEET is composed by two main push-buttons, as well as the EXIT button, used to close the application. These main buttons allow the user to select between the type of analysis he or she wants to perform.

[1] If required, the sCEET tool can be updated in order to be able to manage other types of files, such as .csv.

Figure 9.- sCEET main screen

On the one hand, if the user wants to estimate the CO_2 emissions based on the logged data in the smartCEM pilot sites, he/she has to push the '*Start analysis for raw data*' button. Then, the '*Analysis of raw data for electric vehicles*' screen appears. Figure 10 shows the mentioned screen.

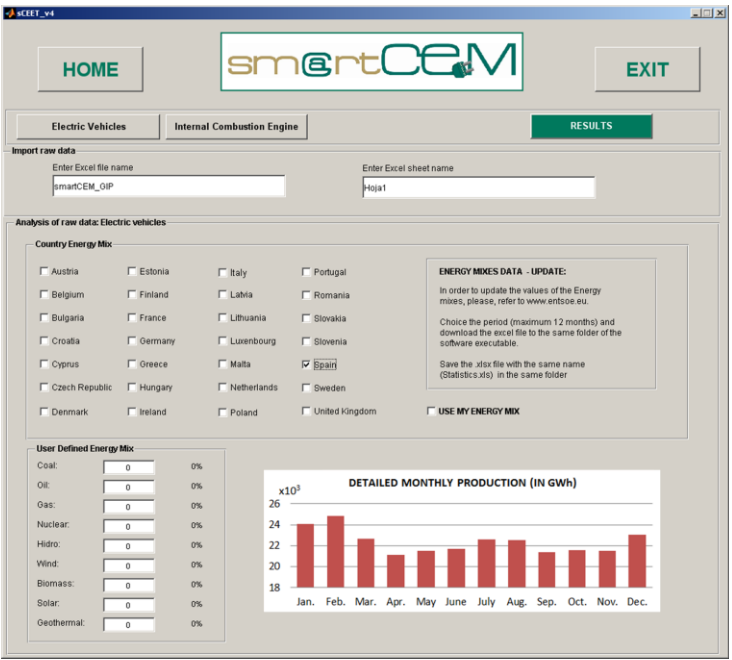

Figure 10.- '*Analysis of raw data for electric vehicles'* screen of sCEET

The content of the screen is divided into three main sections. As Figure 11 shows, the first section refers to the menu buttons at the top of the screen, from which one of the available screens can be selected.

Figure 11.- '*Analysis of raw data*': MENU

The second one is the 'Import raw data' section. As Figure 12 shows, this part helps the user to upload the logged data available at the Central Data Base. This information can be used by the sCEET in .xls or .xlsx formats. The user only has to indicate the name of the file and the name of the sheet, respectively.

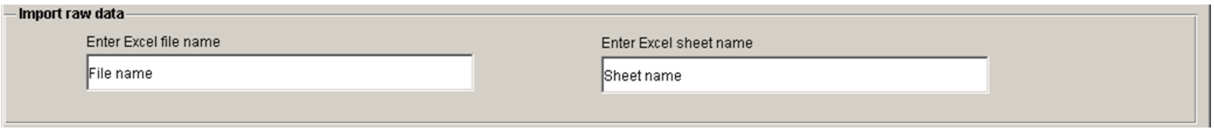

Figure 12.- '*Analysis of raw data*': IMPORT RAW DATA

These two sections are common for '*Analysis of raw data for electric vehicles*' screen and for '*Analysis of raw data for internal combustion engine*' screen, presented below (refer to Figure 16).

The third section, '*Analysis of raw data: Electric vehicles*', is divided into three subsections, related to the Energy Mix: '*Country Energy mix*', '*User defined Energy Mix*' and plotted information.

As shown, the user can select between the energy mixes of different countries[2] and update the background information (refer to Figure 13), or his/her own Energy Mix, defined by him/her (refer to Figure 14).

[2] The information related to the fixed Energy mixes per country has been updated with the information provided by the European Network of Transmission System Operators for Electricity (https://www.entsoe.eu/data/data-portal/production/)

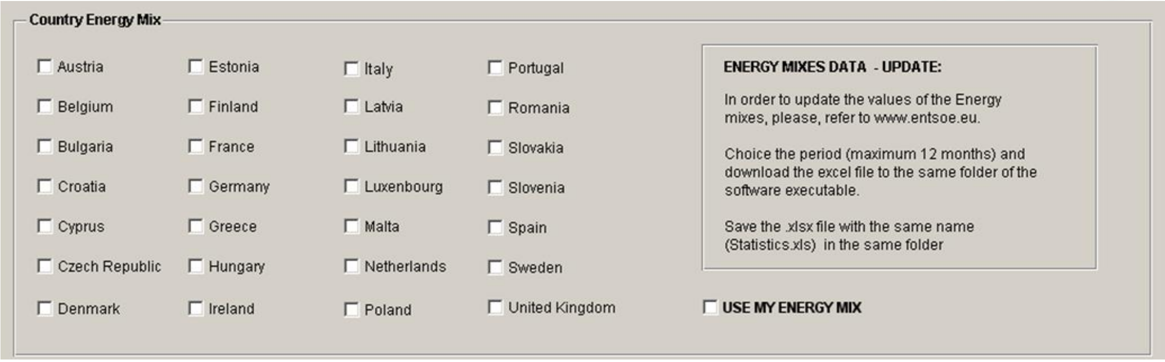

Figure 13.- '*Analysis of raw data: Electric vehicles*': Energy Mix fixed per country

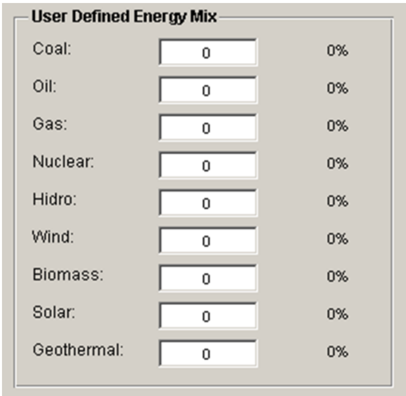

Figure 14.- '*Analysis of raw data: Electric vehicles*': Energy Mix to be defined by the end user

Finally, the third subsection within the '*Analysis of raw data: Electric vehicles*' section, displays the selected (or defined) Energy mix, as Figure 15 shows:

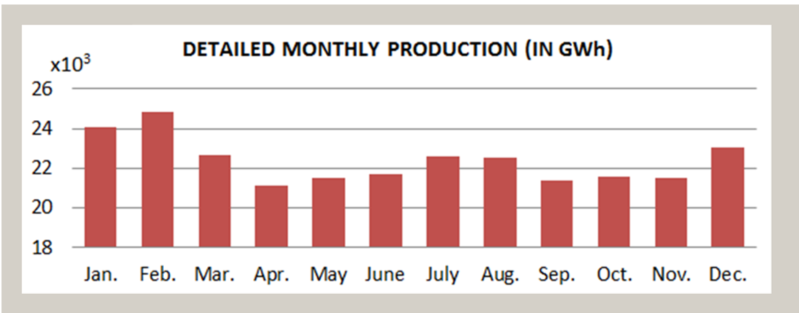

Figure 15.- '*Analysis of raw data: Electric vehicles*': Display of selected (or defined) energy mix

This part of the tool enables calculation of the CO_2 emissions released by a vehicle with an internal combustion engine. In order to select this option, as stated previously, it is only required to push the '*Internal Combustion Engine'* button at the menu (refer to Figure 11). Then, the following screen appears:

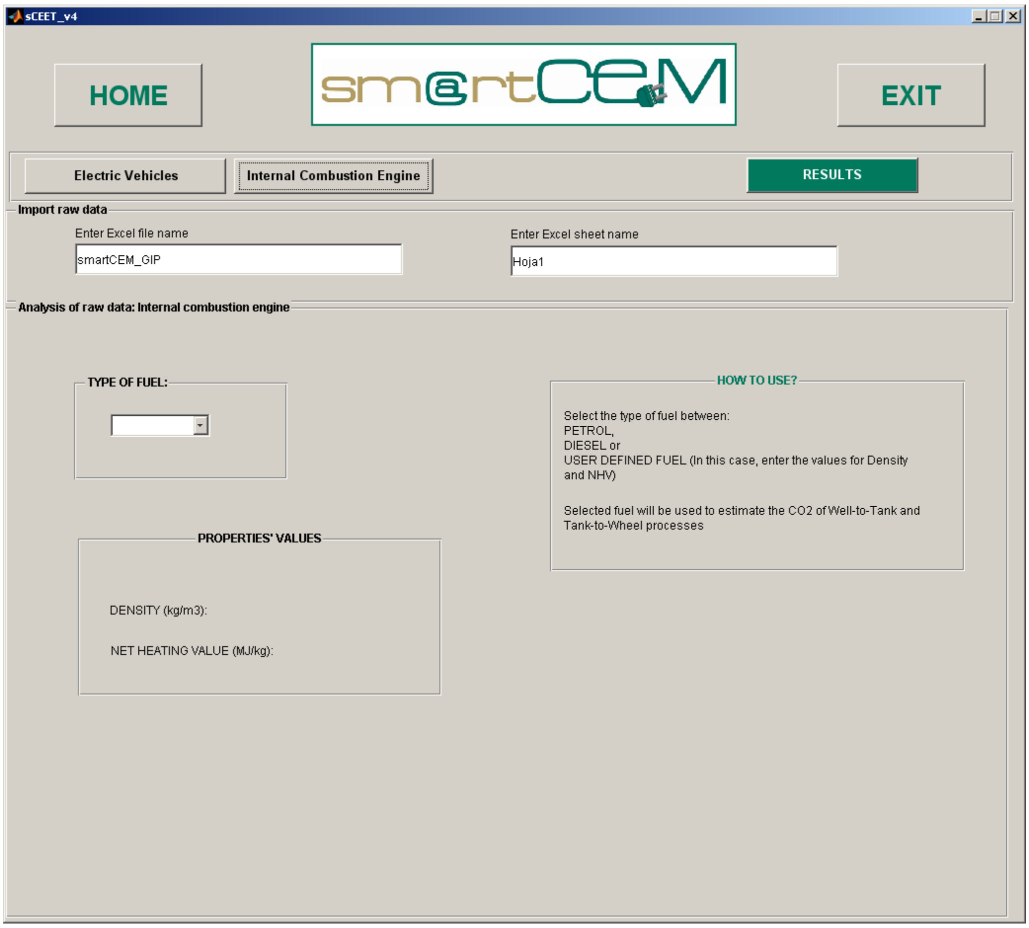

Figure 16.- '*Analysis of raw data: Internal Combustion Engine'*: Display of selected energy mixes

As Figure 16 shows, the '*Analysis of raw data: Internal Combustion Engine*' screen has also three sections: the menu, the import raw data, and the ICE section. This last section is also divided into two subsections: Type of fuel and Properties' values. As Figure 17 shows, in subsection Type of fuel, the user can choose between Petrol, Diesel or his/her own type of fuel, i.e. he/she can introduce his/her own coefficients or use the pre-defined ones.

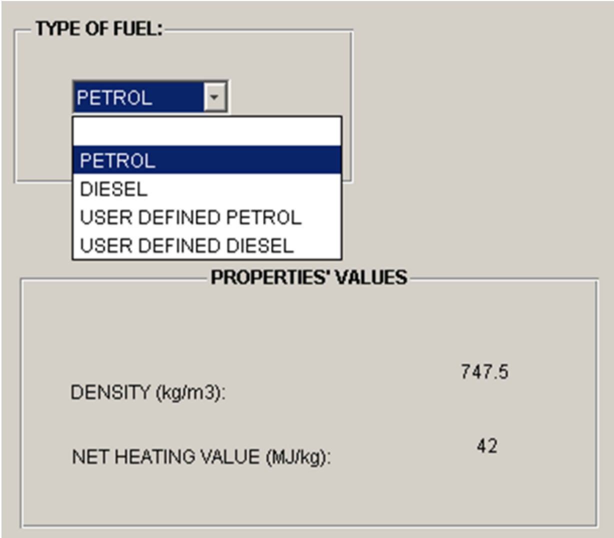

Figure 17.- sCEET: ***Analysis of raw data: ICE – Type of fuel: pre-defined values***

Regarding the option of User defined fuel, as Figure 18 shows, the user can introduce his/her own coefficients.

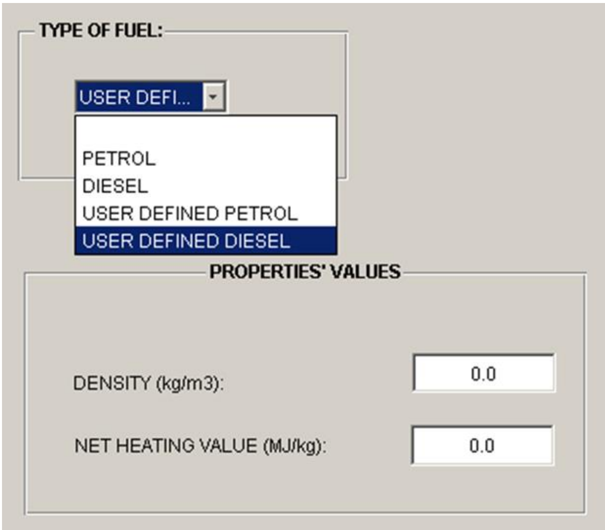

Figure 18.- sCEET: ***Analysis of raw data: ICE – Type of fuel: User defined values***

Finally, in case that he/she does not enter a numeric value, as Figure 19 shows, a warning is given to the user:

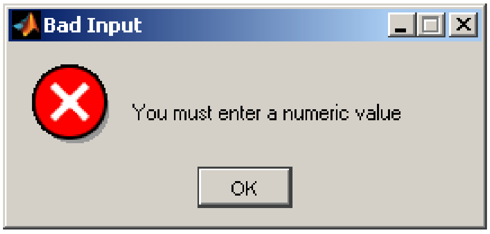

Figure 19.- sCEET: ***Analysis of raw data: ICE – Warning screen***

Furthermore, this part of the tool i.e. the option that allows user to estimate the CO_2 emissions based on raw data, has three more push buttons. An '*EXIT*' button, as in the main screen, to quit the application; the '*HOME*' button, which allows the user to go back to the beginning, i.e. to the main screen; and finally the '*RESULTS*' button, to obtain a new Excel file with four new columns, called 'CO_2 – KW*h', 'CO_2 – TTW' and 'CO_2 – WTT' and 'CO_2 – total' where the results of CO_2 obtained from the recharging, from consumed fuel during a trip and from refuelling, respectively, are added for each sample.

On the other hand, if the user wants to estimate the CO_2 emissions based on certain vehicles or his/her defined vehicle, the user should push the '*Start analysis for pre-defined or user designed vehicles'* button on the main screen. When this analysis procedure is selected the following screen appears (refer to Figure 20):

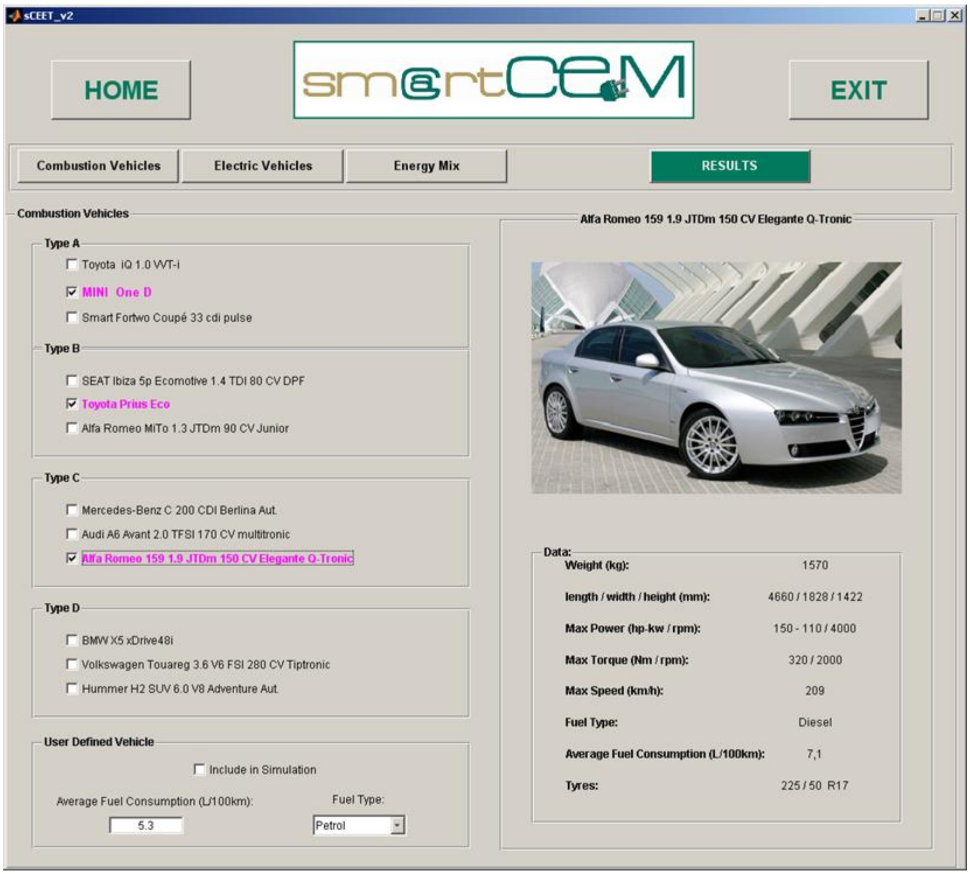

Figure 20.- sCEET: '*Combustion vehicles*' screen

As can be seen in the header section, this part is divided into four screens: Combustion vehicles screen (see Figure 20), Electric vehicles screen (see Figure 21), Energy Mix screen (see Figure 22) and, finally, the Results screen (see Figure 23).

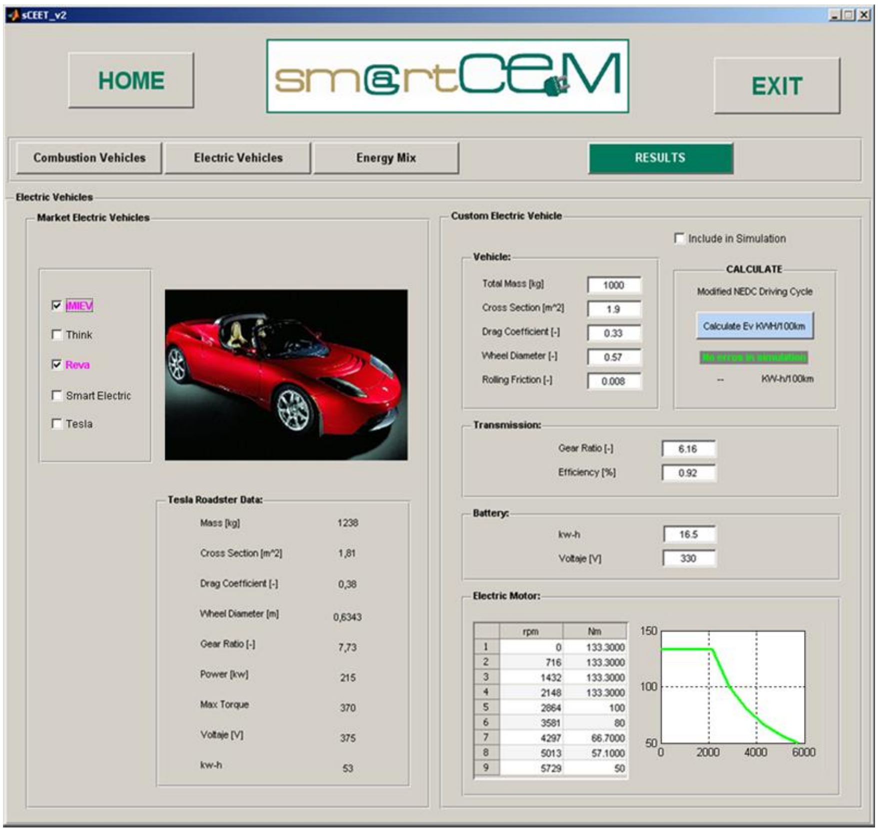

Figure 21.- sCEET: '*Electric Vehicles*' screen

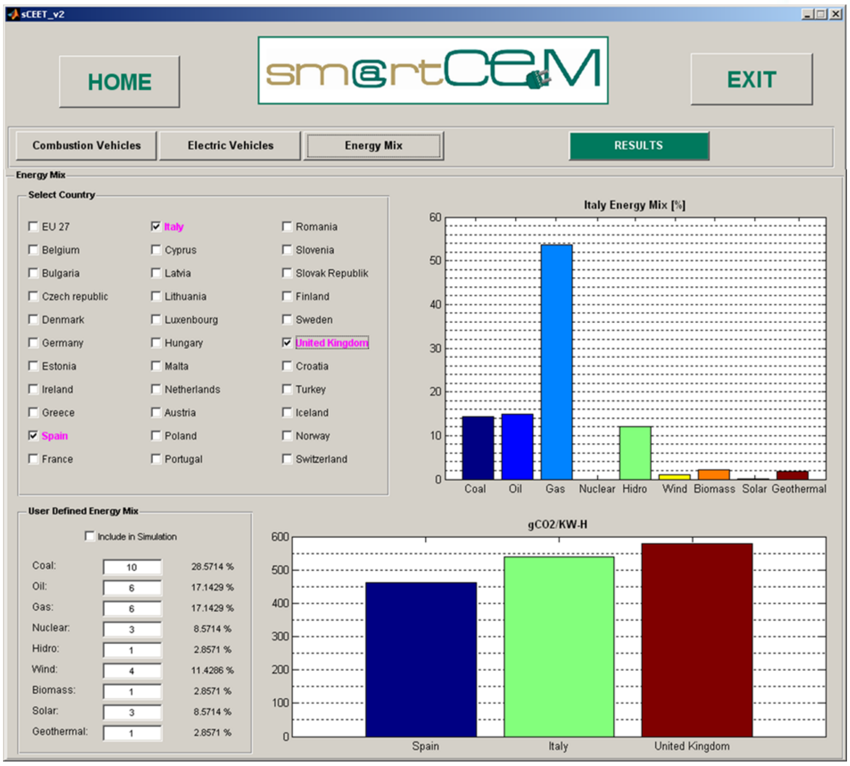

Figure 22.- sCEET: '*Energy Mix for pre-defined or user-designed vehicles*' screen

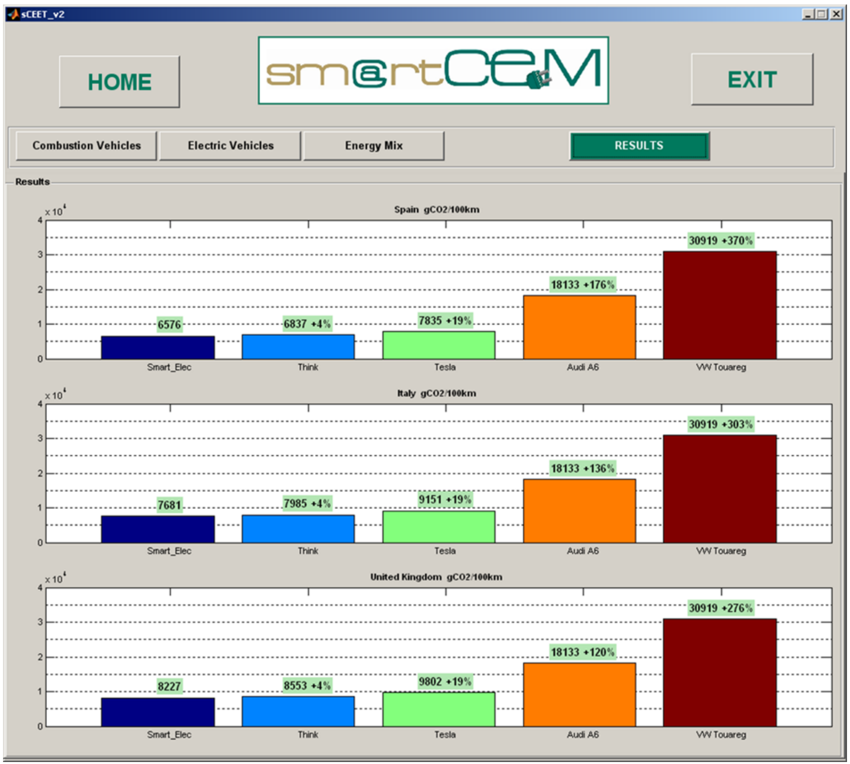

Figure 23.- sCEET '*Results of pre-defined or user-designed vehicles*' screen

Again, one of the menu buttons should be selected in order to access the appropriate screen, as the following figure shows:

Figure 24.- sCEET: menu buttons

Within the '*Combustion vehicles*' screen, it is possible to select between pre-defined vehicles whose characteristics are defined by default, or choose a user defined vehicle, introducing the average fuel consumption and the fuel type. Figure 25 and Figure 26 show these explained parts of the Combustion vehicles screen.

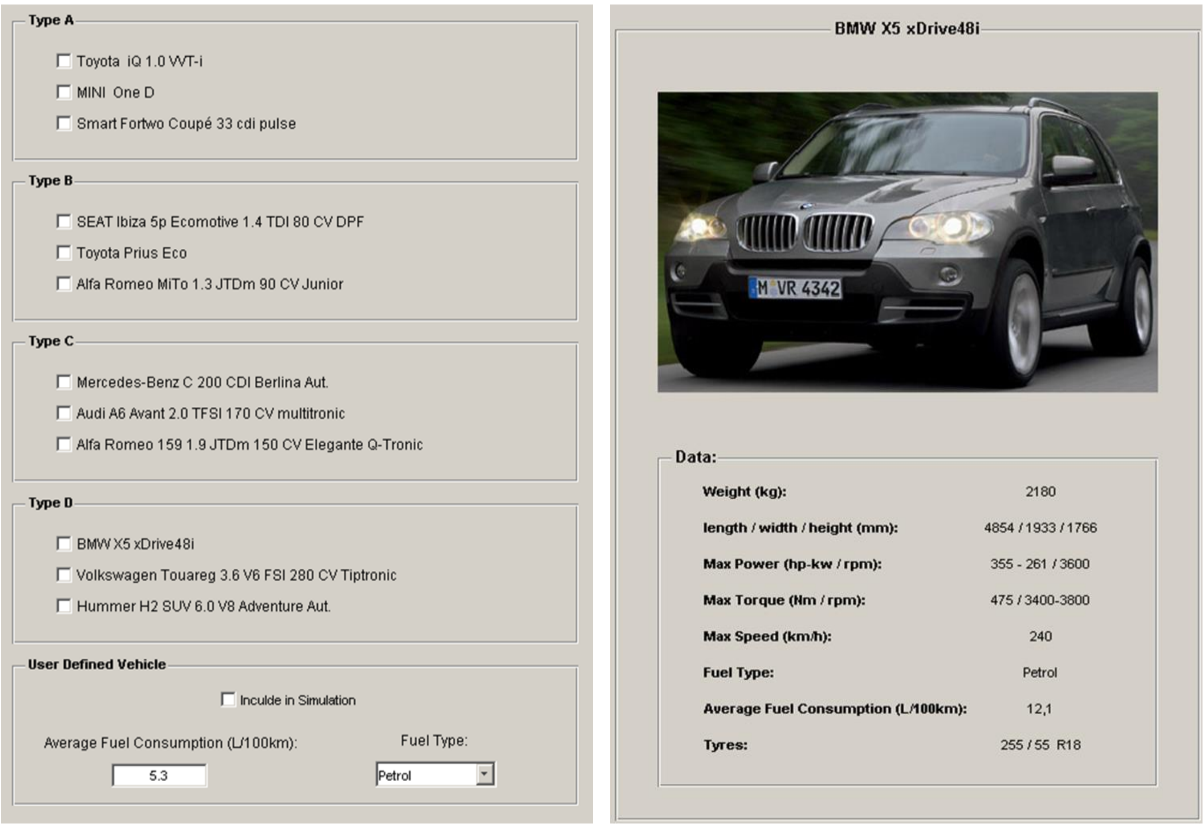

Figure 25.- '*Combustion vehicle*' screen's details (Default available vehicles on the left, Vehicle default characteristics example on the right)

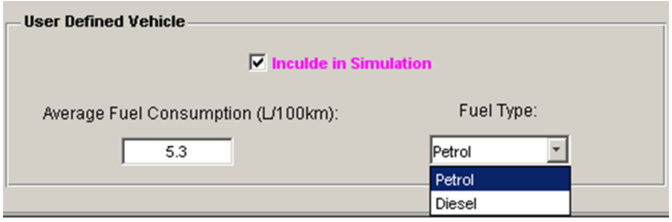

Figure 26.- User defined vehicle inputs

The '*Electric vehicles*' screen follows a similar philosophy. A choice is made between pre-defined market EVs or customising an EV.

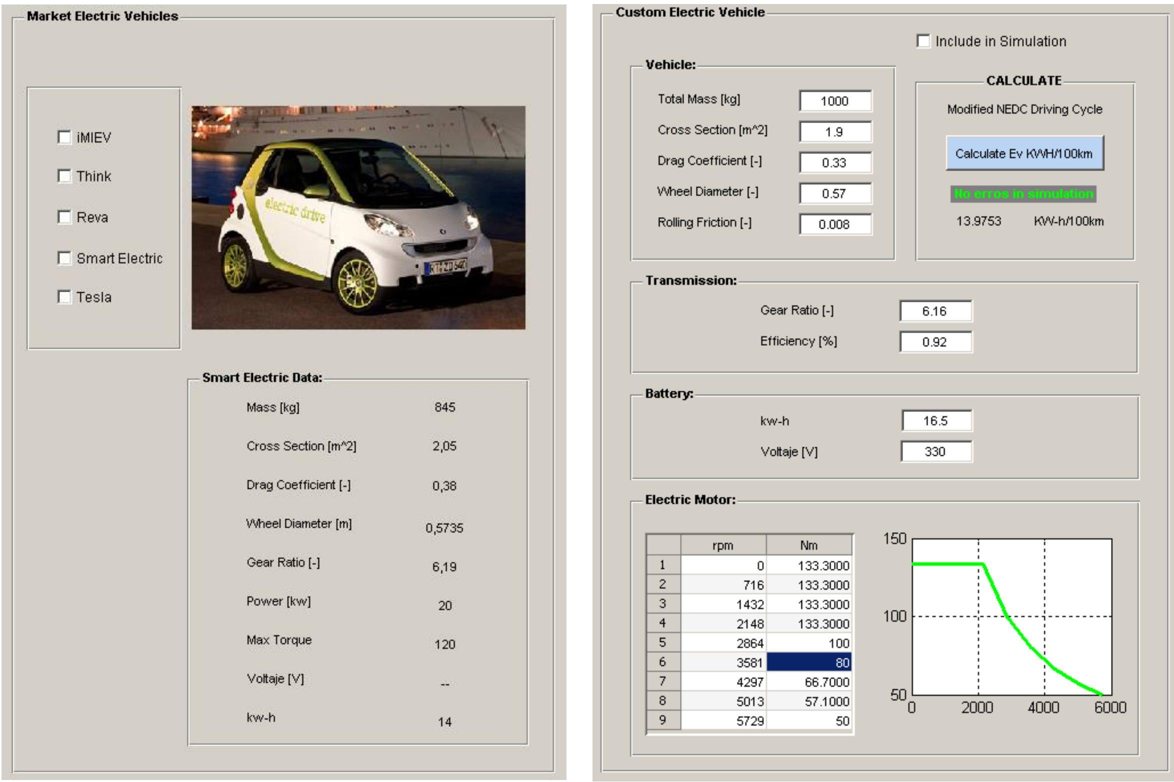

Figure 27.- '*Electric vehicles*' screen's details (Default available EVs on the left, Custom EV on the right)

In addition, the EV customization part can be considered as a tool in itself. It means in addition to the option to calculate the energy consumption, this part allows a user to design the dimensions of the customized EV, in order to be able to follow a specific driving cycle, thanks to the included MATLAB-Simulink model.

The Energy mix screen, as in the case of the analysis of raw data procedure, is divided into four main parts. The first one allows selecting the energy mix of different countries, up to a maximum of three energy mixes (see Figure 28). The second part displays the energy mix of each country when you pass the mouse over the country name (see Figure 29). The third one allows a user to define his/her own energy mix (see Figure 30), and the last one plots the selected energy mixes (see Figure 31).

Figure 28.- '*Energy mix*' screen: Selection of pre-defined Energy mixes

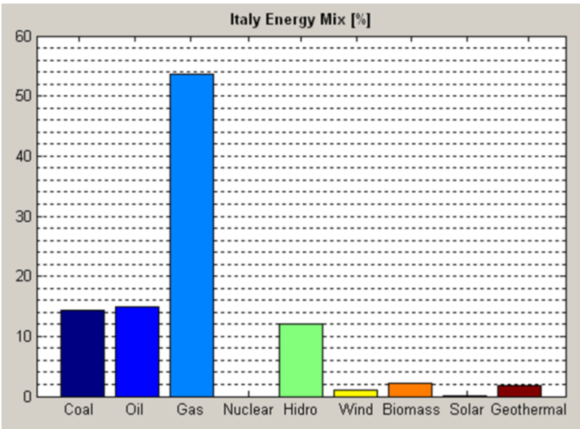

Figure 29.- '*Energy mix*' screen: display of each energy mix

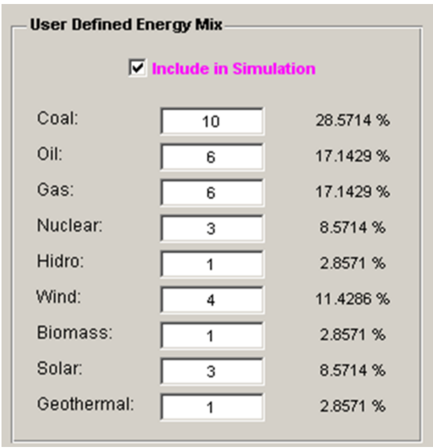

Figure 30.- .- '*Energy mix*' screen: User Defined energy Mix

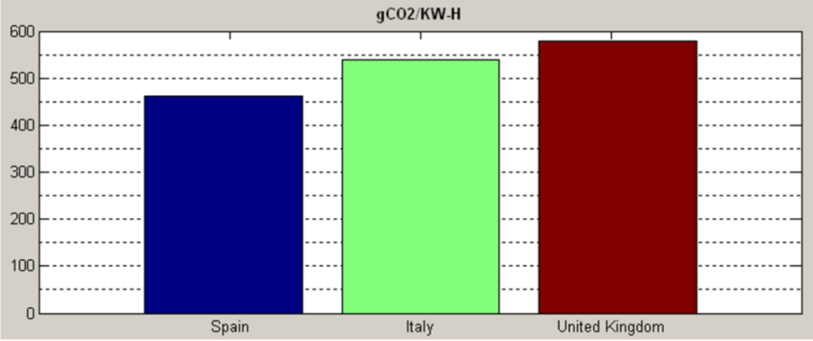

Figure 31.- .- '*Energy mix*' screen: display of selected energy mixes

Finally, Figure 32 shows a part of the results screen, where the carbon emissions estimation is plotted, for each energy mix and each selected vehicles.

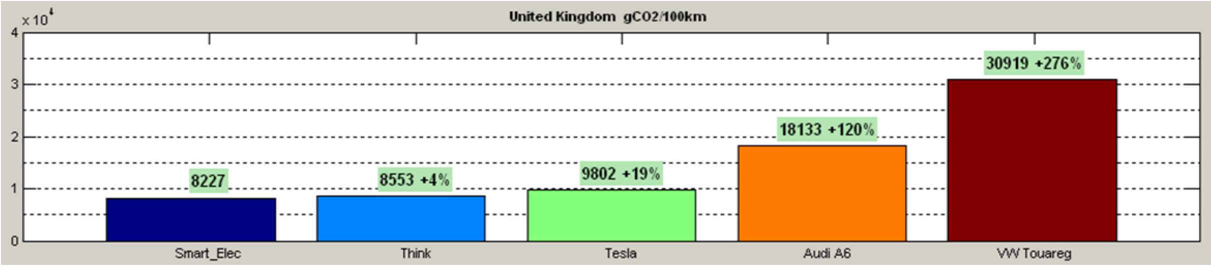

Figure 32.- '*Electric* vehicles' screen's details (Default available EVs on the left, Custom EV on the right)

3. Questionnaires for the assessment of user-uptake

In the description of work of smartCEM it is stated that one aim is ‘to prove that user acceptance of electrical vehicles can be increased by at least 15% due to the adoption of smartCEM services. Based on this, it is necessary to develop assessment tools in terms of questionnaires for acquiring relevant data for this goal. Therefore, in task 4.2.2 user-uptake questionnaires are developed to assess how users accept and use EVs and the smartCEM services.

The results of these questionnaires should be included into the CDB (refer to D2.4). With this purpose, the responses obtained thanks to the questionnaire will be provided as numbers (from 1 to 5), taking into account the type of questionnaire (van der Laan, Likert scale); except open questions, i.e. those questions where the participants can answer what they want. The elaboration of these stored results will be reported in the smartCEM deliverable D3.2., and the data contained into the CDB will be used as an input to Task 4.5 *Data analysis* and reported in the deliverable D4.5

3.1. Questionnaire concept and development process

There are two sorts of user-uptake in the smartCEM project, one is related to the uptake of EVs and the second additionally targets the uptake of the implemented services in the pilot-sites. For both aspects, three concepts are relevant for the design of questionnaire items: acceptance, range-anxiety and willingness-to-pay (see Figure 33).

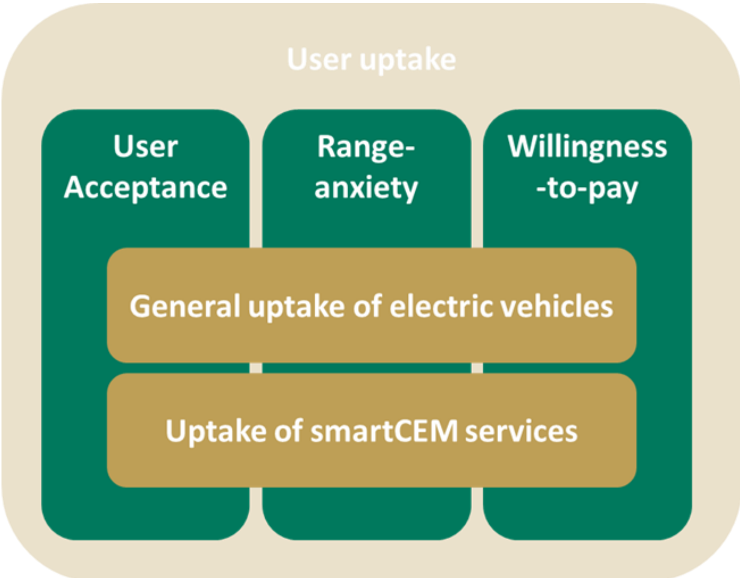

Figure 33.- smartCEM user-uptake concept

The creation of the questionnaire items for these three categories was top-down as the concepts of section 3.1.2 in this document were used to derive relevant items for the assessment of user-acceptance of the smartCEM services. In addition, a bottom-up approach was taken in terms of suggestions and input from the pilot-sites concerning relevant items in the three user-uptake categories. Furthermore, on the CIP level as part of the cooperation between the other pilot projects (Molecules, Mobi.Europe and ICT4

EVEU – see also D6.2), the evaluation expert group is still working on harmonising the user-questionnaires. Therefore, this work serves as an input to the project-wide assessment of user acceptance with the aim to create a harmonised user-questionnaire concerning *demographics*, *attitudes and technology use*, *travel and mobility, willingness-to-pay*, *range-anxiety* and *user-acceptance*. First proposals coming from the four projects have been merged and integrated and are being discussed in the expert group at the moment. The outcome of this work influences the items for this project as well and might lead to adaptations of tables presented in this document at a later stage in the project.

In the following sections the currently existing items for the three categories are presented, whilst additional questions for the users, and the concepts for the items of user acceptance, are explained.

Additionally, since there are several different vehicle types in smartCEM (electric vehicles, electric scooters, hybrid bus) slightly different questionnaire versions for each are presented in the annex: a long version of general user-uptake for EVs (1) and for electric scooters (2), a long version service user-uptake for EVs (3) and scooters (4), one combined version for the hybrid bus (5) and a short version for the direct assessment of general user-uptake right after completion of the trials for EVs (6) and electric scooters (7). The long versions of the questionnaires have additional item sections on demographics, mobility, driving experience, alternative transport modes, attitudes and technology usage. These sections were developed from partners in the CIP evaluation group, namely from Rene Kelpin (DLR) and Ana Paul (CTAG).

3.1.1. General user acceptance

The general user acceptance of EVs is assessed with two short questions concerning the direct impressions of the electric vehicle (see Table 4). With these simple questions a comparison of the baseline condition (before the smartCEM services were implemented) and the operational phase (after implementation of smartCEM services) is possible.

Table 4. General user acceptance items (electric vehicles)

Construct	Item	Response scale
Acceptance	What is your immediate impression after completing your journey in an electric vehicle/scooter?	bad impression to excellent impression
	Based on your present impression, would you consider driving electric vehicles/scooters more often in the future?	certainly-not to for-sure

3.1.2. User-acceptance of smartCEM services

The acceptance of the smartCEM services is crucial as it influences the overall acceptance of electric vehicles. Therefore, items which help to determine aspects for further improvement of the single services and to assess service-specific aspects were created.

The items are based on the concept of the technology-acceptance model (see Figure 34) which has been used in many research projects when assessing the user-acceptance of technological systems (see e.g. Bertrand & Bouchard, 2008). Whenever possible, the response scales were designed following research findings from Rohrmann (2007) on the best wording for rating scales.

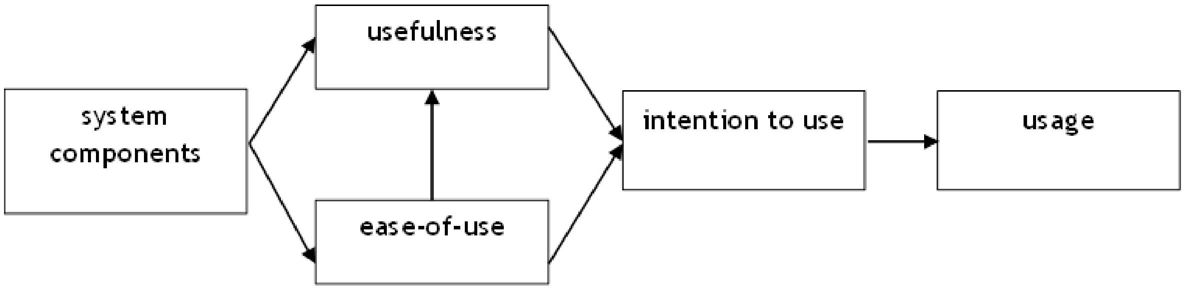

Figure 34.- Technology-Acceptance model (TAM – modified based on Davis, 1993)

This model is based on the Theory of Reasoned Action (Ajzen & Fishbein, 1980) which describes the causal relationship between attitudes, the intention to use a system and the actual usage. The intention to use is the most significant predictor for system usage which is further divided and affected by the two components of perceived usefulness and perceived ease-of-use of the system. Both aspects are, of course, dependent on specific system components. Usefulness can be described as the amount of support that the system provides in reaching a goal or completing a specific task. The ease-of-use on the contrary, describes the physical or mental effort (more specifically the lack of it) that the usage of the system requires.

In smartCEM it was decided to generate items which help to evaluate the services based on the usefulness and ease-of-use concepts as well as the intention to use category. Therefore, items were created which match the functions of the smartCEM services for the category usefulness. Additionally, existing items of the project eCoMove were utilised (e.g. Höltl *et al.*, 2012). For the category ease-of-use, existing items of the TAM (Davis, Bargozzi, & Warshaw, 1989) and other usability scales (e.g. Brooke, 1986) were used and adapted to match the smartCEM services and project specifics. The currently existing items for usefulness are presented in Table 5, the items for ease-of-use can be found in Table 6. The specific items for each vehicle type can be found in the annexes.

Table 5. User-acceptance items (smartCEM services) / usefulness

Items	For which service	Response scale
Using the service increased my awareness of ecological driving.	EV-efficient driving	fully-disagree to fully-agree
Using the service restricts my freedom while driving.		
Using the service helped me to drive in a more energy efficient way.		

Using the service helped me finding an available charging station.	EV-navigation	
Using the service made it easier for me to use an electric vehicle/a scooter/the bus	EV-trip management	
Using the service helped me plan my trip.		
Using the service made public transport as a mode of transport more attractive.		
Using the service increased my willingness to use an electric vehicle/ a scooter more frequently.	EV-sharing	
Using the service helped me to reach my destination		
Using the service supported me during the charging process.	EV-charging station management	
Using the service helped me organize the vehicle charging process.		
The service provided me with all the information which I needed to complete my trip.	EV-navigation, EV-efficient driving, EV-trip management	
Overall, I find the system useful.	For all services	

Table 6. User-acceptance items (smartCEM services) / ease-of-use

Items (for all services)	Response scale
It is easy for me to remember how to perform tasks using the service.	fully-disagree to fully-agree
Interacting with the service requires a lot of my mental effort.	
My interaction with the service is clear and understandable.	
I find it takes a lot of effort to become skilful at using the service.	
The service is too rigid and inflexible to interact with.	
It was easy for me to follow the information provided by the system.	
The system was adaptable according to my personal needs.	
Overall, I find the service easy to use.	

The third component of the TAM-model, the intention to use, was operationalized through the commonly used Van der Laan scale of user acceptance of advanced transport telematics (Van Der Laan, Heino, & De Waard, 1997). The items of this semantic differential can be seen in Figure 35.

	-2	-1	0	+1	+2	
Useful	☐	☐	☐	☐	☐	*Useless*
Pleasant	☐	☐	☐	☐	☐	*Unpleasant*
Bad	☐	☐	☐	☐	☐	*Good*
Satisfying	☐	☐	☐	☐	☐	*Disappointing*
Effective	☐	☐	☐	☐	☐	*Ineffective*
Irritating	☐	☐	☐	☐	☐	*Likeable*
Assisting	☐	☐	☐	☐	☐	*Obstructing*
Undesirable	☐	☐	☐	☐	☐	*Desirable*
Raising alertness	☐	☐	☐	☐	☐	*Sleep-inducing*

Figure 35.- Semantic differential of the Van der Laan scale (from Van Der Laan, Heino, & De Waard, 1997)

3.1.3. General range-anxiety / trust

Range Anxiety is the fear of being stranded by an electric vehicle because of insufficient battery performance or level of charge. This fear is thought to be one of the most influential factors challenging the rise of EV in daily usage.

Most relevant aspects of range anxiety from a literature State-of-Art review are here presented in order to investigate anticipated findings.

- In some cases users ask for a range higher than 'regular' gasoline vehicles or ICE (Deloitte, 2011).
- Range anxiety significantly drops with increased familiarity with EV.
- One of the main reasons for range anxiety is the low number of power charging stations compared to the number of gas stations (Bakker, 2011).
- The very presence of power charging stations contributes in lowering the general sense of range anxiety (Bakker, 2011).
- Owning a second car to be used for longer journeys contributes to the decrease of range anxiety (Davis, 2011).
- 120-miles range would suffice to cover about 95% of trips undertaken (US figures) (Pearre *et al.*, 2010).

Three questions are asked to the users (see Table 8) in order to understand what performances they expect from electric vehicles, particularly from the battery range, and their feelings towards them: a short battery lifetime is, in fact, one of the most widespread issues of the EV. In this regard, smartCEM services aim at increasing the users' confidence by providing relevant information on the remaining battery lifetime and on the targets within reach.

Table 7. General range-anxiety items (electric vehicles)

Construct	Item	Response scale
Range Anxiety	I feel comfortable concerning the range of the electric vehicle/scooter.	Fully-disagree to fully-agree
	What range would you consider optimal for an electric vehicle/scooter?	Less than 50 km / 50-100 km / 100-150 km/ 150-200 km / 200-250 km / 250-300 km/ More than 300 km
	What is your accepted minimal battery range for daily usage?	(open question)

3.1.4. Range-anxiety / trust related to smartCEM services

Navigation and Efficient Driving are the main services which are assessed by the range-anxiety user questionnaires (see Table 9). Indeed, it is important that the smartCEM services improve the driving efficiency of electric vehicles, but also that the drivers are aware of the new features introduced by the project and thus more keen to use them. A Navigation service could as well provide a useful support to the driver, who may feel more confident to reach his/ her destination if he/ she knew that an optimized path for the vehicle was calculated, based on the state of charge (SoC) of the battery, driving style, typography and available charging stations.

Table 8. Range-anxiety items (smartCEM services)

Items	For which service	Response scale
Using the service made me more secure about the range of my battery.	EV-navigation, EV-efficient driving	Fully-disagree to Fully-agree
Using the service made me more confident to reach my target within the range of my battery.	EV-navigation, EV-efficient driving	
I trusted the service to provide me with accurate information.	For all services	
The service made me worry less about the range of my battery.	EV-navigation, EV-efficient driving	
The service improved my confidence to take longer trips.	EV-navigation, EV-efficient driving	
How often do you believe the information provided by the service was not trustworthy?	EV-navigation, EV-efficient driving	1=Never to 5=Always

3.1.5. General willingness-to-pay

Willingness-to-pay is a key factor to consider when evaluating the potential uptake of EVs. The actual acquisition cost of EVs is significantly higher than combustion vehicles and therefore it is important to understand which benefits are perceived by users in order to pay an additional cost.

Table 9. General willingness-to-pay items (electric vehicles)

Construct	Item	Response scale
Willingness to pay	Which of the following factors would discourage you from buying an EV/scooter?	1 = price, 2 = lack of charging infrastructure at home / at work / at …, 3 = short range, 4 = long range, 5 = immature technology
	Which of the above factors would be your biggest discouragement factor when considering a vehicle purchase?	Open question
	Which of the following factors would influence your intention to buy an electric vehicle? (multiple answers possible)	buying price, reliability, low running cost (€ per Km), monthly payment , the look of the car, size of the car, insurance, no carbon emissions, no noise, engine power, makes statement about my commitments green issues, love of new technology
	Which of the above factors would be your biggest influencing factor when considering a vehicle purchase?	Open question
	How much of an increase in percentage of running costs would you pay for an electric vehicle?	(open question)
	I would consider buying an electric vehicle/scooter?	certainly-not to for-sure
	I would consider paying to rent an electric vehicle/scooter frequently?	certainly-not to for-sure
	I would accept personalised advertising in return for a cheaper rental or public charging.	certainly-not to for-sure
	Which of the following incentives would influence your intention to buy an electric vehicle/scooter the most?	1 = tax allowance, 2 = price allowance, 3 = exemption from city toll, 4 = free parking, 5 = free bus lane usage
	Please select which of the following statements concerning government	Fundamental: only through government incentives will

	incentives to buy electric cars are is most relevant to you:	it be possible to buy an electric car Important: they can speed up the introduction of electric cars into the market Useful, they could be a great help when buying an electric car Unnecessary: when buying an electric car technical features are more important than price Bad for the market: in that way the market will become totally dependent on government incentives without being able to develop its own policies.
	If you were going to buy a car, which of these sources of information would you use?	Dealerships, internet, taking to the other people, family, friends, etc., past experience, newspaper/magazine, consumer reports, TV, other

3.1.6. Willingness-to-pay for smartCEM services

The smartCEM services enhance the user experience of driving EVs. This questionnaire elicits understanding of how important those benefits are to users, that is, if they are willing to pay for them and how much.

Table 10. Willingness-to-pay items (smartCEM services)

Items	For which service	Response scale
Based on your present impression of the service do you think that the service is worth paying for?	For all services	certainly-not to for-sure
Why or why not do you think that the service is worth paying for?	For all services	Open
I would like to pay for the service…. (multiple response are possible)	EV-sharing	Depending on the kilometres I have driven/depending on the time I have driven/ via flat fee (fixed price including all costs of usage)
How much more would you be willing to pay for a multimodal transport card including EV-	EV-sharing	Open

sharing service?		
I would agree to dynamic pricing schemes i.e. fare discounts if one accepts modifying his/her trip preferences, for example, end the trip at a charging point instead of the initially desired destination	EV-sharing	fully-disagree to fully-agree
I would agree to pay a penalty if I do not use/pick up the EV although I have booked it before.		
I would agree to pay a penalty if I do not give back the EV at the agreed location or time.		
I would be willing to pay the following flat fee price to use the system per year … Euro		
I would pay via…(multiple response are possible)	EV-sharing	Credit card/bank debit/cash
Would you prefer personalised advertising in return for a cheaper rental or reduced public charging costs?	EV-sharing, EV-charging station management	certainly-not to for-sure
Would you consider a reduced charge in exchange for direct advertising to your mobile phone?	EV-sharing, EV-charging station management	certainly-not to for-sure
Would you like to receive offers from nearby shops, restaurants etc. when you complete your journey?	EV-navigation	certainly-not to for-sure

3.1.7. Additional items

Besides the questionnaire items concerning acceptance, range-anxiety and willingness-to-pay there are additionally some questions concerning the overall usage of the vehicles, the services and charging aspects (see Table 11).

Table 11. Additional items concerning charging, the services and vehicle usage

Construct	Item	Response scale
Charging	What is your accepted maximum charging duration? Please indicate for a) during the day, b) during weekends and c) at night.	(open question)
Services	Did the service improve your perception of EVs?	1=No, definitely not, 2=No, probably not, 3=Perhaps, cannot decide 4=Yes, probably, 5=Yes, definitely
	What benefits do you see in using an EV with the functions you experienced? (multiple responses possible)	Time saving, money saving, CO2 reduction, Others: (please state)
	What future system uses do you see	(open question)

	in using an EV with the functions you experienced?	
	What problems have you experienced or could you think of when using the service/the EV?	(open question)
EV usage	How many times have you driven an electric vehicle/electric scooter?	1= first time, 2= less than 5 times, 3= more than 20 times
	Would you replace your conventional vehicle with an electric vehicle? Please specify why or why not.	(open question)

3.1.8. Other items specifically for EV-sharing service

The EV-sharing service is the main function in smartCEM, with many other services being integrated or scaled based on this service. Due to its importance, there are additional questions which are only relevant to this service – they are mainly based on the provider feedback in smartCEM (see Table 12).

Table 12. Relevant items specifically for EV-sharing service

Item	Response scale
How important are the following criteria for you: (or 'please specify the main reasons for using the service') – multiple answers are possible:	…open sharing scheme where I can leave my vehicle/scooter wherever I wish
	…that the vehicle/scooter is clean
	… that a help-hotline is available in case of problems
	… that the pricing-scheme is transparent
	… that the type of vehicle/scooter matches my preferences
	… that the reservation can be done using a smartphone
What motivates you to use this sharing service	Vehicle is electric…, I like the concept of sharing a scooter, other…
Would you use conventional scooter-sharing?' Please specify why or why not?	certainly-not to for-sure and open question

4. Modelling influencing factors for the usage of EVs

Analysing the use of vehicles in urban environments is so complex that modern software tools are often very advantageous in capturing the complex relationship between different actors and elements in the system. If each involved variable in a complex relationship is modelled as an element, then it is not uncommon to have interaction models with 50 to 100 elements that are linked depending on how these elements (or variables) influence and interact with each other.

The modelling work with the network analysis is intended to support both policy makers as well as companies that intend to provide mobility services with EVs in urban areas (in a sense, policy makers are already responsible for mobility services such as traffic lights, bus lanes and regulations). Many factors influence the uptake of various vehicle concepts for individual urban mobility. The goal here is to analyse and identify the strongest ones. The model is set up and used here to analyse interactions between different elements (actors) in a system and determine which elements (variables) have the strongest influence on target parameters (variables) of interest.

The evaluation of the model should help organizations to better understand the complex interactions of variables in an urban area that lead to more (or less) usage of EVs compared to classic conventional vehicles with internal combustion engines. In this initial stage the model only considers pure EVs (since a plug-in hybrid or range extender could be programmed to only act as an electric vehicle within specific bounds in the urban area).

In the current model the willingness to use different vehicles in the city (system) will be analysed. It is assumed that an increase in the willingness to use a vehicle gives an indication about user acceptance or at least the elements that may have an influence on user acceptance. One of the primary (measureable) goals of smartCEM is increasing user acceptance for electro-mobility. Once the model has been sufficiently developed such that all evaluation results are plausible, then adjustments in the weighting of particular connections (interactions) can be used to determine first the stability of the model, then the effects on the system. A model can be considered ‘stable’ when only minimal changes occur from changes in the weighting.

4.1. The basics of modelling

The basis for modelling in the smartCEM project is network analysis using a visio graphical editor and an evaluation tool (Beta-Version) programmed by Bosch several years ago. In the network analysis elements (blocks), also known as variables, are connected together by interactions (weighted arrows) between the elements based on the cause-effect principle, as Figure 36 shows:

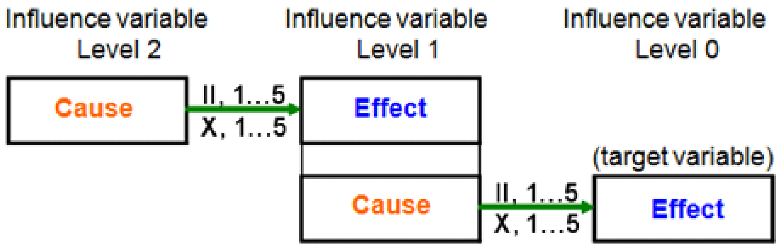

Figure 36.- Basic network model with effect relationships of the influence variables

An interaction (green) describes what happens to the connected element (where the arrow-head enters) when the value of the origin element (block) increases. An increase in the origin element can either lead to an increase (parallel) or decrease (counteracting) of the connected element. Elements (variables) are only defined verbally and have no intrinsic mathematical grounding. Definitions and connections are all built around the so-called target variables, which are those elements that will be investigated in the analysis, e. g. 'willingness to use an electric car share vehicle'. The network is developed using expert knowledge within and outside the project (e. g. knowledge gained in an E-CarShare project in Berlin). Comments and observations made by experts are worked into the model as well as the results of expert discussions and exchanges of ideas. In this sense smartCEM is the ideal platform for developing such a model since smartCEM brings together both experts from the technology side and service providers that otherwise would not come together in such a setting.

The evaluation tool (Beta-version) programmed by Bosch (developed outside the scope of the smartCEM project) analyzes both the hierarchy of connected elements, as well as the weighting of the elements in order to establish a ranking of the variables that have the strongest influence on the selected target variable(s) (see Figure 37). The results are listed in graphical form and also include the degree of influence that the various elements have on the target variables as well as the hierarchical distance between elements (see levels in Figure 36). That is how many hierarchy levels separate an influencing variable from the target variable. Finally an influencing portfolio is generated that shows how much the different variables are influenced by the system or vice-versa, see Figure 38. In this form it is also visible which elements act as buffers in the system and which are most active in the system.

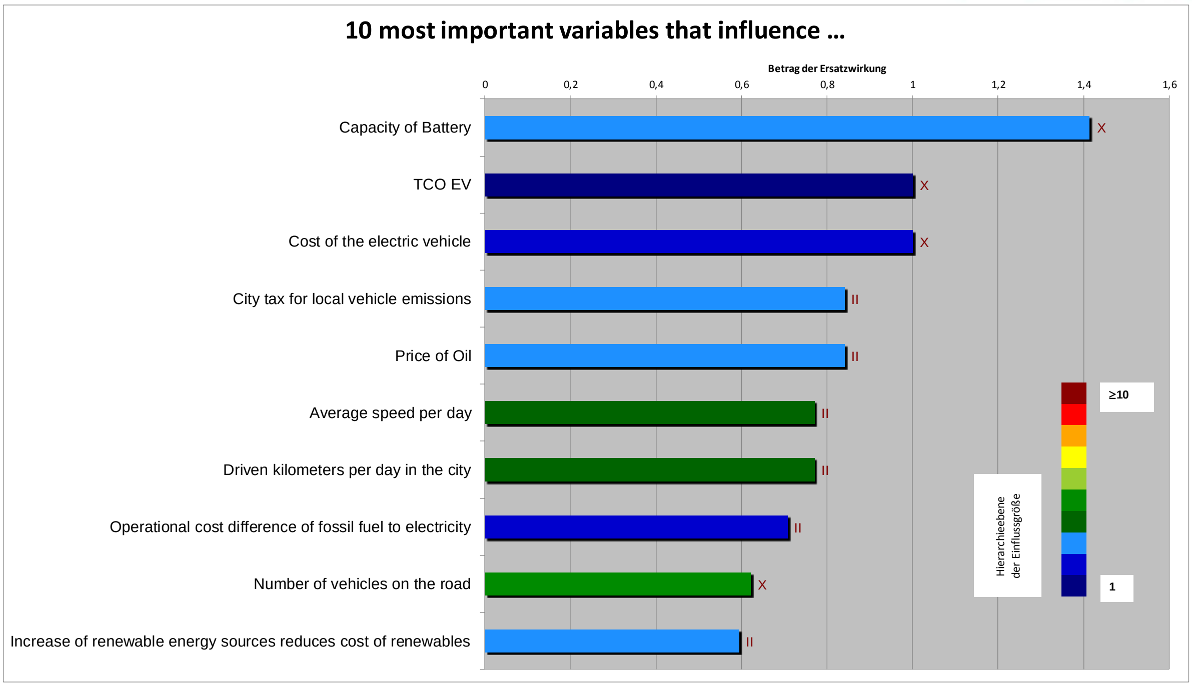

Figure 37.- Example of ranking list of variables influencing the willingness to purchase an EV

Figure 40 shows the strongest variables (elements) at the top of the diagram and weakest at the bottom. Each target variable can be evaluated in this manner.

The model can also be considered 'stable' if evaluation results in a high number of plausible rankings. In the case of the 10 most important influencing factors to purchase an electric vehicle the cost of the battery is at the top of the list. As the cost of the battery increases, willingness to purchase decreases (indicated by the X at the end of the bar). The next strongest variable is the total cost of ownership (TCO) of the vehicle. It is logical that as the cost of owning and operating the electric vehicle increases the willingness to purchase decreases. This assessment has been confirmed in numerous surveys in the past.

It appears as though a number of variables that have a strong influence on the willingness to purchase an electric vehicle depend on the cost of the vehicle as well as the cost to operate the vehicle. Even the 'driven kilometres per day in the city' show plausible results. Increases in the driven kilometres lead to increased willingness to purchase an electric vehicle, especially in an urban area. It is assumed that in an urban area short trips are typically made and the possibility to charge vehicles at a number of locations reduces range anxiety. The more kilometres that are driven, the better the economics due to the efficiency and comparatively low cost of energy.

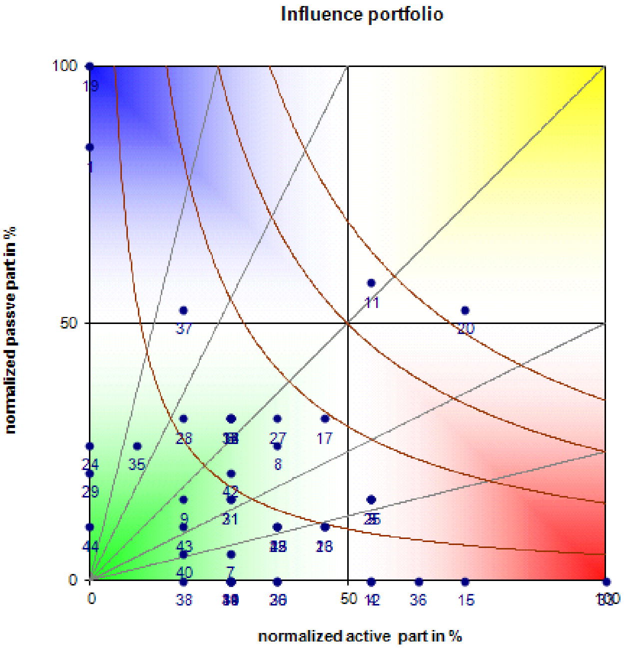

Figure 38.- Influencing portfolio showing active and passive roles in the system

The portfolio of variables has four quadrants that indicate how strong these variables influence the system or vice-versa (Figure 41). Variables that end up in the lower left corner are classified as so-called buffering variables that have few input and output effects on the system and thus buffer it. Variable in the upper left quarter are passive variables that have little effect on the system, but are influenced by the system. On the other side, variables in the lower right quadrant are known as active since they have a strong effect of the system, but are not influenced by the system. Finally those variables in the upper right corner (practically none in Figure 41) are classified as critical since they are both influenced by, and effect, the system and thus need to be analysed closely to understand their role in the system. Overall the current modelled system could be summarized as buffered and thus ‘slow’ to change. This indeed reflects how changes penetrate the area of individual mobility.

4.1.1. How such modelling can be used in smartCEM

As described previously, the most common analysis of the model is to look directly at which variables have the strongest influence on user uptake and then to decide which means would be most suitable for tracking and evaluating these variables and especially useful in setting priorities for data collection and evaluation. If that is not directly possible, then the ranking of the variables should be used in a systematic way to derive evaluation criteria or confirm postulated criteria. The model will be refined and developed further in the project exactly for this intent. The second option for using the model is the testing variations of interconnection weightings to see what influence they have on the ranking and portfolio. These weighting represent a combination of variables and can also be used to derive or confirm evaluation criteria. These options will be followed with progress in the project. The actual final value of the model, however, may be found in work done in the area of evaluating and supporting future business cases developed within WP6.

It goes without saying that the model is only as good as the assumptions that go into setting the model up and the ability to define interactions between the blocks that are unique and independent of each other. This is seldom the case, but always the goal in improving the model. The model lives from good discussion and feedback, as well as careful thoughts about the relations between the different elements.

4.2. *The model*

4.2.1. First steps setting up the model

One of the first steps in setting up the model is to agree on the input and boundary conditions as well as the key assumptions.

Inputs and boundary conditions

The policy maker (or service provider) will certainly be looking at the model and results at this current point in time. However, the policy maker needs to assess the impact of changes in the urban area that will be favourable (or less favourable) for EV uptake in the area. Some possible changes that will be considered as inputs to the model:

- Increases/decreases in Settlement Density (urbanization is a continuing trend and challenge for city planners)
- Increase/decreases in the price of oil
- Increase/decrease in the number of vehicles on the road
- Future developments in battery capacity
- Driven kilometres per day
- Others?

Key assumptions

- Analysis looks primarily at vehicle usage within the urban area or surrounding satellites of the urban area (urban region)
- The model may also include (indirect) benefits for EVs in the urban areas, such as reduced cost for parking or access to attractive parking spots
- Deciding on the choice of vehicle for longer trips such as a vacation is not included
- Deciding to use (or not use) public transport in the mobility chain is not (yet) included
- When considering mechanisms to restrict travel in urban areas, we have London in the back of minds as the best example of implementing a congestion zone tax for travel into the centre of London during peak hours

- It is suggested to consider the percentage of use (mixture of number of trips and kilometres) as the target variables (and not 'willingness' …)

The next step is then to agree on target variables.

Target variables

Initial target variables for the analysis chosen for the model should reflect user acceptance (links to the relevant smartCEM sites are also included):

- Willing to use own private conventional vehicle
- Willing to use integrated public conventional vehicle – car-share with current vehicles,
- Willing to use own private electric vehicle → Newcastle
- Willing to use integrated public electric vehicle – car share with EVs → Donosti - San Sebastian and Barcelona.
- Willingness to purchase an electric vehicle.

Variables that consider the cost factors have been included. Variables that reflect trip time, travel speed and the parking situation availability have also been included as well as the aspects of settlement density and vehicles on the road. The topic of environmental issues facing urban areas has been started but can be further developed and linked with factors that influence the willingness of a municipality to set up charging stations in the urban setting. Elements that should reflect car sharing have also been included. The most important variables included are potential emission taxes and restricted areas in the city. The model currently includes 45 variables and could grow within the project up to 100 variables, depending on the ability to capture expert knowledge in the right level of detail and fidelity for the model. For an overview of the Model see Figure 39.

The model

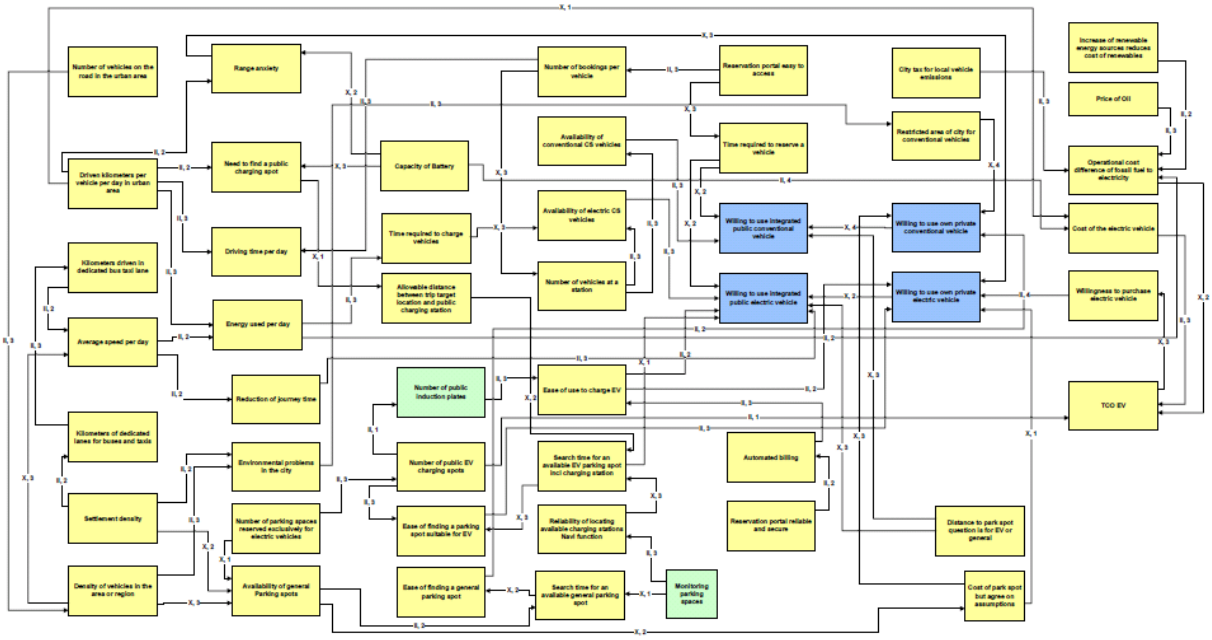

Figure 39.- Current interaction model with 45 variables (elements) & four target variables (blue)

4.3. How to analyse the model

The results are shown for two target variables that reflect the acceptance of electric vehicles in terms of willingness to use an electric vehicle that is owned by the user or car share an (public) electric vehicle.

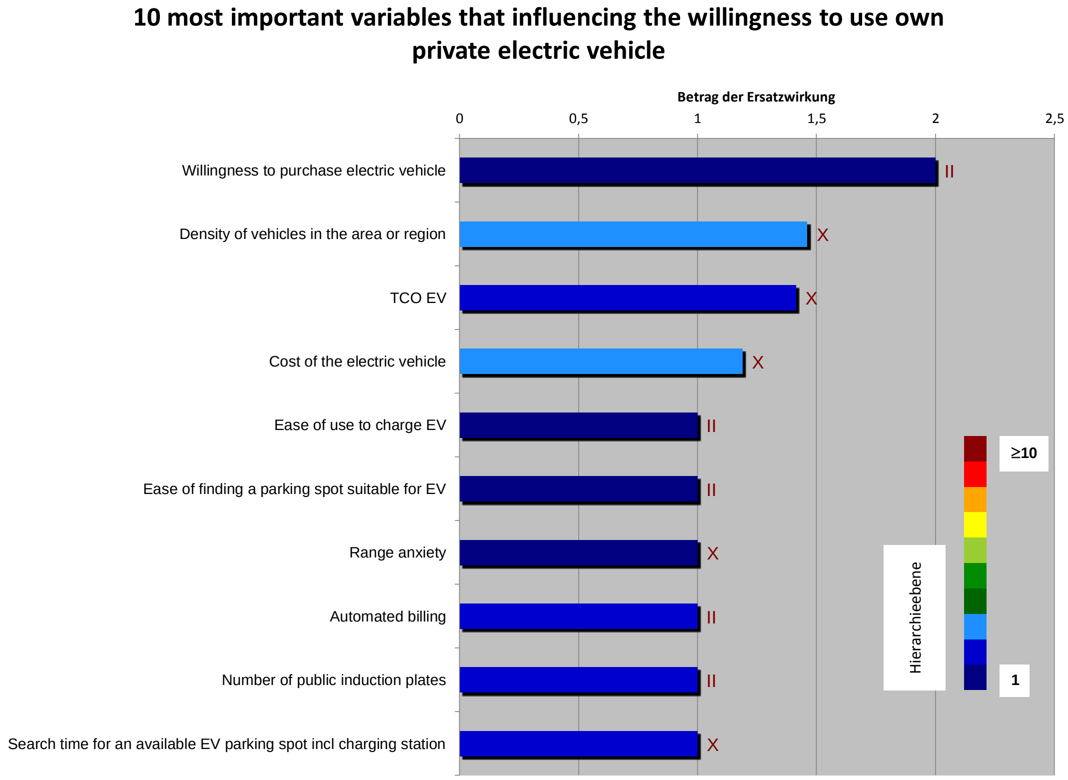

Figure 40.- 10 most important variables influencing the Willingness to use own electric vehicle

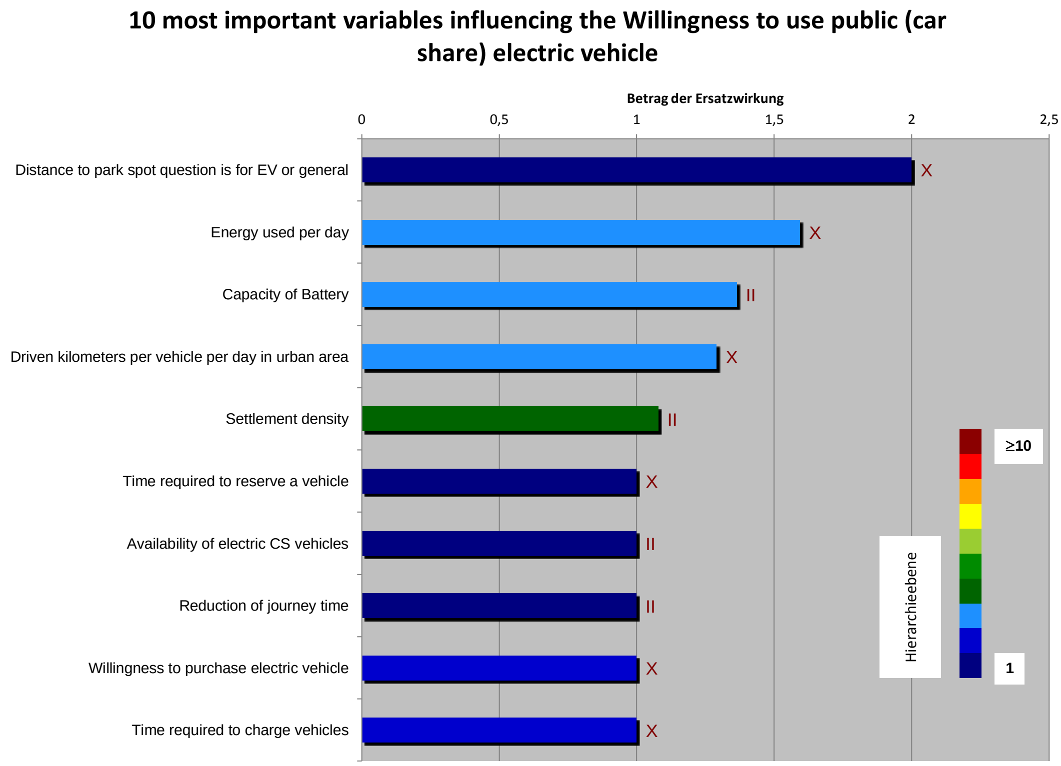

Figure 41.- 10 most important variables influencing the Willingness to use public (car share) electric vehicle

4.3.1. Initial results

Table 13 and Table 14 below show one means of using the analysis to support the evaluation of user acceptance. With this approach it is possible to trace an evaluation strategy from the (proposed) potential measurement to the target variable representing user acceptance. The ranking of the 10 most important factors (variables) influencing the target variable are listed according to their ranking. Some factors are given (boundary conditions) and cannot be influenced (or only indirectly) by smartCEM services. With other factors it is possible to develop a service that supports the influencing factor (based on the knowledge of the model itself) and thus has potential to improve user acceptance. The analysis, of course, goes one step further and proposes a potential measurement that could be used to track specifically how the service is supporting the factor that has the strongest influence on the acceptance of using an own electric vehicle in the urban area; either using a subjective questionnaire or acquisition data. However, these tables present two good examples, where the effect of the smartCEM services has been considered or not. During the task 4.5 Data analysis, the model will be update, in order to know as much as possible information and effects between the selected items and smartCEM services.

Table 13. 10 most important variables influencing the Willingness to use own electric vehicle including related smartCEM service and potential measurement

Item	Relies on smartCEM-Service	Potential measurement
Willingness to purchase electric vehicle	N/A	
Density of vehicles in the area or region	N/A	
TCO EV	Efficient driving (but weak)	
Cost of the EV	N/A	
Ease of use to charge the EV	EV-charging station management	User acceptance QT
Ease of finding a parking spot suitable for EV	EV-Navigation	Search time at destination
Range anxiety	EV-Navigation	Start of charge at trip end
Automated billing	EV-charging station management	User acceptance QT
Number of public induction plates	N/A	
Searching time for an available V parking spot including charging station	EV-Navigation and EV-charging station management	Search time at destination and distance between park spot and target destination

Table 14. 10 most important variables influencing the Willingness to use public (car share) electric vehicle including related smartCEM service and potential measurement

Item	Relies on smartCEM-Service	Potential measurement
Willingness to purchase electric vehicle	N/A	
Density of vehicles in the area or region	N/A	
TCO EV	N/A	
Cost of the EV	N/A	
Ease of use to charge the EV	EV-charging station management	User acceptance QT
Ease of finding a parking spot suitable for EV	EV-Navigation	Search time at destination
Range anxiety	EV-Navigation	Start of charge at trip end
Automated billing	EV-charging station management	User acceptance QT
Number of public induction plates	N/A	
Searching time for an available V parking spot including charging station	EV-Navigation and EV-charging station management	Search time at destination and distance between park spot and target destination

The ranking can be extremely important when setting priorities for analysing collected data and especially when discussing potential business cases in WP6. Experience with data handling has shown that large amounts of data are usually collected and later have to be prioritized in order to ensure a realistic amount of data analysis. The ranking of variables provides valuable recommendations for prioritizing this work. This has been the intention of the model throughout the discussions in WP4, but not yet fully utilized in this support function.

5. CONCLUSIONS

This deliverable describes the assessment tools developed in smartCEM Task 4.4. These tools should be used by Task 4.5 to collect and analyse the acquired data in each pilot site.

The smartCEM CO_2 emissions evaluation tool described in Chapter 2, requires quality input data in order to obtain useful results, and it is required that the files created by WP3 are Excel files (or csv), in order to be compatible with the developed tool.

The questionnaires presented in Chapter 3, are designed to investigate if and how the user acceptance of EVs is affected by the adoption of smartCEM services. For both the uptake of EVs and the uptake of the implemented services in the pilot sites, three concepts were identified as the most relevant: acceptance, range-anxiety and willingness-to-pay. After having collected all the feedbacks, a comparison between the baseline condition and the operational phase will be carried out in order to assess the improvement of EV user-uptake fostered by smartCEM services.

Previous research studies, such as EC-co-funded FP7 projects euroFOT (http://www.eurofot-ip.eu) and TeleFOT (http://www.telefot.eu) assessed impact of technology concerning users-related aspects. A huge campaign of questionnaires was carried out and a huge set of subjective data was collected. Relevant information about users' acceptance of systems, usability, workload and trust were gathered and they allowed researchers to test hypotheses about the impact of systems on safety, environment, efficiency and mobility. Several lessons learnt were collected about usage of questionnaires as tools for collecting subjective data. The most relevant are about length of questionnaires which should be limited, and the usage of open-ended questions. Others concern the redundancy of complexion methods, reminders and incentives to be provided to users in order to improve response rates.

These lessons learnt and best practice should be taken into account in smartCEM in order to save resources and improve quality of collected data. As a consequence, in smartCEM, the use of the questionnaires is proposed as follows: use the long versions for focus group sessions or interviews whereas the short versions can be used directly after vehicle usage. As mentioned above, results from and interaction with the model can be used to help focus and prioritize questions in the questionnaires. On the other hand replies from the questionnaires and focus groups have been confirmed by the model as means of assessing increased acceptance of EVs due to the services.

The general questionnaires include items on demographics, travel & mobility, attitudes and general questions concerning EVs (user-acceptance, range-anxiety and willingness-to-pay). The service questionnaires focus on the evaluation of the smartCEM services only. For each type of vehicle (electric vehicle, electric scooter, and hybrid bus) use the relevant questionnaire. All questionnaire types can be found in the annexes.

Finally, related to the model, it can be stated that this model is very useful since the ranking can be extremely important when setting priorities for analysing collected data and especially when discussing potential business cases in WP6. Experience with data handling has shown that large amounts of data are usually collected and later have to be prioritized in order to ensure a realistic amount of data analysis. The ranking of variables provides valuable recommendations for prioritizing this work. As well, it can be highlighted as first conclusions, also related with the surveys' results, that on the acceptance side, the results of nearly every survey show that costs (and total cost of ownership) are always at the top.

6. REFERENCES

- ARTEMIS project (Assessment and Reliability of Transport Emission Models and Inventory Systems), a European Commission project (2000-2007). (http://www.trl.co.uk/artemis/)
- Ajzen, I., & Fishbein, M. (1980). Understanding Attitudes and Predicting Social Behaviour. Prentice-Hall, Englewood Cliffs, NJ.
- Bakker J. J., (2011). Contesting range anxiety: The role of electric vehicle charging infrastructure in the transportation transition, TU/e, Eindhoven.
- Bertrand, M., & Bouchard, S. (2008). Applying the technology acceptance model to VR with people who are favourable to its use. Journal of Cyber Therapy and Rehabilitation, 1(2).
- Brooke, J. (1986). SUS - A quick and dirty usability scale. Earley.
- COPERT 4 software (http://www.emisia.com/copert/General.html)
- COST 319 action on the Estimation of Emissions from Transport (1993-1998). (http://www.cost.eu)
- Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. International Journal of Man-Machine Studies, 38, 475–487.
- Davis, F. D., Bargozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. Management Science, 35, 982–1003.
- Everett A., Burgess M., Walsh C., (2011). Initial Findings from the Ultra Low Carbon Vehicle Demonstrator Programme, Technology Strategic Board, Swindon.
- Ferreira J. C., Monteiro V., Afonso J. L., (2012).Electric vehicle route recommender system, International conference on smart grids and Green IT systems, Porto.
- Höltl, A., Trommer, S., Schießl, C., Fricke, N., Staubach, M., Hoek, R., Bernatallada, G. (2012). Requirements and motivators for private and commercial drivers. D6.1. Retrieved from http://ecomove-project.eu/assets/Documents/Deliverables/New/To-be-updated/120622-DEL-SP6-D6.1-updated.pdf
- JEC WTW study Version 4 'Well-to-Wheels analysis of future automotive fuels and powertrains in the European context WELL-TO-TANK (WTT)' Report, Version 4, July 2013. (http://iet.jrc.ec.europa.eu/)
- LBST (L-B-System Technic). (http://www.lbst.de)
- MEET project (Methodologies to Estimate Emissions from Transport), a European Commission sponsored project (1996-1998) (http://ec.europa.eu/index_en.htm)

- Nilsson M., (2011).Electric vehicles: An interview study investigating the phenomenon of range anxiety, Elvire project, Gothenburg.
- PARTICULATES project (Characterization of Exhaust Particulate Emissions from Road Vehicles), a European Commission project (2000-2003). (http://ec.europa.eu/transport/road_safety/pdf/projects/particulates.pdf)
- Pearre N. S. et al., (2011). Electric vehicles: How much range is required for a day's driving?, Transportation Research Part C 19, pp. 1171-1184, Elsevier.
- Ramírez A. L., Jiménez A. L., (2012). Simulation of an extended range electric vehicle usage in a real environment, Hogskolan.
- Rohrmann, B. (2007). Verbal qualifiers for rating scales: Sociolinguistic considerations and psychometric data. Project Report. University of Melbourne/Australia.
- Robinson A.P., Blythe P.T., Bell, M.C., Huebner, Y., Hill, G.A. (2013). Analysis of electric vehicle driver recharging demand profiles and subsequent impacts on the carbon content of electric vehicle trips by in Energy Policy 61, 2013, PP337-348
- Van Der Laan, J. D., Heino, A., & De Waard, D. (1997). A simple procedure for the assessment of acceptance of advanced transport telematics. Transportation Research Part C: …, 5(1), 1–10. Retrieved from http://www.sciencedirect.com/science/article/pii/S0968090X96000253.

7. ANNEXES

User-questionnaire general user-uptake long version for electric vehicles

User-questionnaire general user-uptake long version for electric scooters

User-questionnaire service user-uptake long version for electric vehicles

User-questionnaire service user-uptake long version for electric scooters

User-questionnaire general and service user-uptake for hybrid bus

User-questionnaire general user-uptake short version for electric vehicles

User-questionnaire general user-uptake short version for electric scooters

7.1. User-questionnaire: general user-uptake long version for electric vehicles

What is your age?

__________ ❑ no answer

What is your gender?

❑ female ❑ male ❑ no answer

What is your current employment status?

❑ full-time
❑ part-time
❑ retired
❑ full-time homemaker
❑ unemployed seeking employment
❑ unemployed not seeking employment
❑ full-time student
❑ volunteer work (unpaid)
❑ no answer

How can your job status be classified?

❑ employee
❑ self-employed
❑ student
❑ unemployed
❑ retired
❑ not employed
❑ no answer

What is your latest school leaving qualification?

❑ no school completed
❑ elementary school
❑ high school
❑ college/university
❑ post graduate studies
❑ no answer

Do you hold a valid car driving license?

❑ yes ❑ no ❑ no answer

Do you hold a monthly public transport ticket?

❑ yes ❑ no ❑ no answer

What is your monthly net income?

❑ less than € 1.000,-
❑ € 1.000,- to € 2.000,-
❑ €2.000,- to € 3.000,-
❑ more than € 5.000,-
❑ no answer

Including yourself, how many people live in your household?

❑ single
❑ two
❑ three
❑ four
❑ more than four
❑ no answer

How many children younger than 16 years live in your household?

❑ none
❑ one
❑ two
❑ three
❑ more than three
❑ no answer

Mobility

How many vehicles are owned, leased, or available for regular use by the people who currently live at your household?

❑ none
❑ one
❑ two
❑ three
❑ more than three
❑ no answer

What is the body type of the aforementioned vehicles?

❑ car
❑ van
❑ RV
❑ SUV
❑ other
❑ no answer

What is the engine type/make of the aforementioned vehicles?

❑ gasoline
❑ diesel
❑ LPG/LNG
❑ dual fuel
❑ HEV
❑ PHEV
❑ BEV
❑ ER-EV
❑ FCHEV
❑ other
❑ no answer

What is the year of production of the aforementioned vehicles?

____

How can ownership of the aforementioned vehicles be specified?

❑ household/person
❑ lease
❑ institution
❑ other
❑ no answer

Where do you usually park your car?

❑ private parking at own property close to home
❑ private parking lot (other than own property)
❑ public car park
❑ public street
❑ no answer

How many bicycles are in practical use by the people who currently live at your household?

❑ none
❑ one
❑ two
❑ three
❑ more than three
❑ no answer

Driving experience

How many km do you usually drive per year by car (private and shared vehicles)?

❑ less than 5000
❑ less than 10.000
❑ less than 15.000
❑ more than 15.000
❑ no answer

What is your main trip purpose (with private and shared vehicles)?

❑ home
❑ work and work-related
❑ education/childcare
❑ shopping
❑ social/recreation
❑ personal business/medical
❑ other
❑ no answer

Which is the most prevailing road category for your daily trips?

❑ city
❑ rural
❑ highways
❑ other
❑ no answer

How often do you drive?

less than once per week	at least one time per week	more than one time per week	everyday from Monday to Friday	everyday
❑	❑	❑	❑	❑

In a working day: How many trips do you take?

0	1-2	3-5	more than 5
❑	❑	❑	❑

Availability, reachability and usage of alternative modes

What is the distance to your nearest public transport station (Bus, Tram, Metro, Train)?

less than 100m	more than 100 but less than 500m	less than 1000m	more than 1000m	no answer
❑	❑	❑	❑	❑

Please rate the following statements:

	never	*daily*	*weekly*	*monthly*	*no answer*
How often do you use the car - during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the car - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use public transport- during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use public transport - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the bike - during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the bike - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you walk - during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you walk - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑

What type of transport do you use most frequently?

my own car	rental car/ Car-sharing	public transport	other: ______
❑	❑	❑	❑

Do you know whether there is an annual ticket (or for a half year) for public transport available in your city/region?

yes	no	no answer
❑	❑	❑

Do you know whether there is a multimodal transport card available in your city/region? (this is a card, where you can use bus, tram, metro, carsharing, rent-a-bike altogether)

yes	no	no answer
❑	❑	❑

Attitudes and Technology Usage

To what extent do you participate in or use the following:

	never	*once per week*	*between 2-4 days per week*	*more than 5*
social networks	❑	❑	❑	❑
share/pooling networks	❑	❑	❑	❑
ICT services	❑	❑	❑	❑

Which kind of networks do you use?

facebook	linkedin	twitter	other: ________
❑	❑	❑	❑

Do you have internet access on your mobile phone?

❑ yes
❑ yes, but just recently (less than one month)
❑ no

What kind of ICT devices do you normally use?

❑ smartphone
❑ PDA
❑ tablet
❑ ebook
❑ navigation tools
❑ other: _____

What kind of ICT devices do you normally use in your vehicle?

❑ navigation tools
❑ telephone
❑ internet
❑ other: _____

Do you have internet at home?

❑ yes ❑ no

Are you interested in the adoption of new ICT devices?

❑ yes ❑ no

If you use the Internet, which of the following services do you use?

❑ email
❑ on-line shopping
❑ social networking
❑ music/video
❑ skype
❑ games
❑ maps
❑ don’t use internet

Approximately, how much on average do you think it currently costs to fully charge an electric Vehicle?

❑ 1-3 €
❑ 4-8 €
❑ more than 10 €
❑ don't know

How much do you agree with the following statements about cars?

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
Road transport is a major source of emissions, which harm the environment.	❑	❑	❑	❑	❑
Driving an electric car is like driving a conventional car with automatic gears. So, in many respects electric cars are just like conventional cars.	❑	❑	❑	❑	❑
	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*

Electric cars are currently quite expensive.	❑	❑	❑	❑	❑
Electric cars can run for a maximum of 150 km between two charges.	❑	❑	❑	❑	❑
The charging time is never less than 30 minutes.	❑	❑	❑	❑	❑
100 km cost less than 2 Euros.	❑	❑	❑	❑	❑
Electric cars have no tailpipe emissions.	❑	❑	❑	❑	❑
Electric cars are safe.	❑	❑	❑	❑	❑
Electric cars have high maintenance costs.	❑	❑	❑	❑	❑
Electric cars increase the pleasure of driving.	❑	❑	❑	❑	❑
Electric cars are noisy.	❑	❑	❑	❑	❑

From your own point of view, which is the most important aspect to be considered while driving?
Write a number from 1 to 7: 1 the most important, 7 the least important

_____ safety

_____ time spent on the trip

_____ efficiency

_____ fuel

_____ mobility

_____ emissions

_____ other:__________

User acceptance

What is your immediate impression after completing your journey in an electric vehicle?

bad impression	inadequate impression	fair impression	good impression	excellent impression
❑	❑	❑	❑	❑

Based on your present impression, would you consider driving electric vehicles more often in the future?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Willingness-to-pay

Which of the following factors would discourage you from buying an electric vehicle? (multiple answers are possible)

❑ price
❑ lack of charging infrastructure at home
❑ lack of charging infrastructure at work
❑ lack of public charging infrastructure
❑ short range
❑ immature technology

Which of the above factors would be your biggest discouragement factor when considering a vehicle purchase?

____

Which of the following factors would influence your intention to buy an electric vehicle? (multiple answers possible)

❑ buying price
❑ reliability
❑ low running cost (€ per Km)
❑ monthly payment
❑ the look of the car
❑ size of the car
❑ insurance
❑ no carbon emissions
❑ no noise
❑ engine power
❑ makes statement about my commitments green issues
❑ love of new technology

Which of the above factors would be your biggest influencing factor when considering a vehicle purchase?

____

Which of the following incentives would influence your intention to buy an electric vehicle the most?

❑ tax allowance
❑ price allowance
❑ exemption from city toll
❑ free parking
❑ free bus lane usage

How much of an increase in percentage of running costs would you pay for an electric vehicle?

____

Please select which of the following statements concerning government incentives to buy electric cars are is most relevant to you (please select one answer only):

❑ Fundamental: only through government incentives will it be possible to buy an electric car.

❑ Important: they can speed up the introduction of electric cars into the market.

❑ Useful, they could be a great help when buying an electric car.

❑ Unnecessary: when buying an electric car technical features are more important than price.

❑ Bad for the market: in that way the market will become totally dependent on government incentives without being able to develop its own policies.

	certainly-not	*unlikely*	*about-50:50*	*likely*	*for-sure*
I would consider buying an electric vehicle.	❑	❑	❑	❑	❑
I would consider paying to rent an electric vehicle frequently.	❑	❑	❑	❑	❑
I would accept personalised advertising in return for a cheaper rental or public charging.	❑	❑	❑	❑	❑

If you were going to buy a car, which of these sources of information would you use? (multiple answers are possible)

- ❑ dealerships
- ❑ internet
- ❑ taking to the other people, family, friends, etc.
- ❑ past experience
- ❑ newspaper/magazine
- ❑ consumer reports
- ❑ TV
- ❑ other:_________

Range anxiety

Please rate the following statement: I feel comfortable concerning the range of the electric vehicle.

fully-disagree	disagree	neutral	agree	fully-agree
❑	❑	❑	❑	❑

What range would you consider optimal for an electric vehicle?

less than 50 km	50-100 km	100-150 km	150-200 km	200-250 km	250-300 km	more than 300 km
❑	❑	❑	❑	❑	❑	❑

What is your accepted minimal battery range for daily usage?

____

Additional questions

What is your accepted maximal charging duration? Please indicate for:

during the day	at night	during weekends
_________	_________	_________

Did the service improve your perception of electric vehicles?

certainly-not	unlikely	about-50:50	likely	for-sure

❑	❑	❑	❑	❑

What benefits do you see in using an electric vehicle with the functions you experienced? (multiple responses possible)

time saving	money saving	CO2 reduction	other: _______
❑	❑	❑	❑

What future system uses do you see in using an electric vehicle with the functions you experienced?

What problems have you experienced or could you think of when using the electric vehicle?

How many times have you driven an electric vehicle?

first time	less than 5 times	more than 20 times
❑	❑	❑

Would you replace your conventional vehicle with an electric vehicle?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Please specify why or why not:

7.2. User-questionnaire general user-uptake long version for electric scooters

What is your age?

__________ ❑ no answer

What is your gender?

❑ female ❑ male ❑ no answer

What is your current employment status?

❑ full-time
❑ part-time
❑ retired
❑ full-time homemaker
❑ unemployed seeking employment
❑ unemployed not seeking employment
❑ full-time student
❑ volunteer work (unpaid)
❑ no answer

How can your job status be classified?

❑ employee
❑ self-employed
❑ student
❑ unemployed
❑ retired
❑ not employed
❑ no answer

What is your latest school leaving qualification?

❑ no school completed
❑ elementary school
❑ high school
❑ college/university
❑ post graduate studies
❑ no answer

Do you hold a valid car driving license?

❑ yes ❑ no ❑ no answer

Do you hold a monthly public transport ticket?

❑ yes ❑ no ❑ no answer

What is your monthly net income?

- ❑ less than € 1.000,-
- ❑ € 1.000,- to € 2.000,-
- ❑ €2.000,- to € 3.000,-
- ❑ more than € 5.000,-
- ❑ no answer

Including yourself, how many people live in your household?

- ❑ single
- ❑ two
- ❑ three
- ❑ four
- ❑ more than four
- ❑ no answer

How many children younger than 16 years live in your household?

- ❑ none
- ❑ one
- ❑ two
- ❑ three
- ❑ more than three
- ❑ no answer

Mobility

How many vehicles are owned, leased, or available for regular use by the people who currently live in your household?

- ❑ none
- ❑ one
- ❑ two
- ❑ three
- ❑ more than three
- ❑ no answer

What is the body type of the aforementioned vehicles?

- ❑ car
- ❑ van
- ❑ RV
- ❑ SUV
- ❑ other
- ❑ no answer

What is the engine type/make of the aforementioned vehicles?

- ❑ gasoline
- ❑ diesel
- ❑ LPG/LNG
- ❑ dual fuel
- ❑ HEV
- ❑ PHEV
- ❑ BEV
- ❑ ER-EV
- ❑ FCHEV
- ❑ other
- ❑ no answer

What is the year of production of the aforementioned vehicles?

____

How can ownership of the aforementioned vehicles be specified?

❑ household/person
❑ lease
❑ institution
❑ other
❑ no answer

Where do you usually park your car?

❑ private parking at own property close to home
❑ private parking lot (other than own property)
❑ public car park
❑ public street
❑ no answer

How many bicycles are in practical use by the people who currently live at your household?

❑ none
❑ one
❑ two
❑ three
❑ more than three
❑ no answer

Driving experience

How many km do you usually drive per year by car (private and shared vehicles)?

❑ less than 5000
❑ less than 10.000
❑ less than 15.000
❑ more than 15.000
❑ no answer

What is your main trip purpose (with private and shared vehicles)?

❑ home
❑ work and work-related
❑ education/childcare
❑ shopping
❑ social/recreation
❑ personal business/medical
❑ other
❑ no answer

Which is the most prevailing road category for your daily trips?
❑ city
❑ rural
❑ highways
❑ other
❑ no answer

How often do you drive?

less than once   at least one   more than one   everyday from   everyday

per week	time per week	time per week	Monday to Friday	
❑	❑	❑	❑	❑

On a working day: How many trips do you take?

0	1-2	3-5	more than 5
❑	❑	❑	❑

Availability, reachability and usage of alternative modes

What is the distance to your nearest public transport station (Bus, Tram, Metro, Train)?

less than 100m	more than 100 but less than 500m	… less than 1000m	more than 1000m	no answer
❑	❑	❑	❑	❑

Please rate the following statements:

	never	*daily*	*weekly*	*monthly*	*no answer*
How often do you use the car - during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the car - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use public transport- during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use public transport - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the bike - during summertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you use the bike - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑
How often do you walk - during summertime (normal weather condition)?	❑	❑	❑	❑	❑

How often do you walk - during wintertime (normal weather condition)?	❑	❑	❑	❑	❑

What type of transport do you use most frequently?

my own car	rental car/ car-sharing	public transport	other: ______
❑	❑	❑	❑

Do you know whether there is an annual ticket (or for a half year) for public transport available in your city/region?

yes	no	no answer
❑	❑	❑

Do you know whether there is a multimodal transport card available in your city/region? (this is a card, where you can use bus, tram, metro, carsharing, rent-a-bike altogether)

yes	no	no answer
❑	❑	❑

Attitudes and Technology Usage

To what extent do you participate in or use the following:

	never	*once per week*	*between 2-4 days per week*	*more than 5*
social networks	❑	❑	❑	❑
share/pooling networks	❑	❑	❑	❑
ICT services	❑	❑	❑	❑

Which kind of networks do you use?

Facebook	Linkedin	Twitter	Other: ________
❑	❑	❑	❑

Do you have internet access on your mobile phone?

❑ yes
❑ yes, but just recently (less than one

month)
❑ no
What kind of ICT devices do you normally use?

❑ smartphone
❑ PDA
❑ tablet
❑ ebook
❑ navigation tools
❑ other: ______

What kind of ICT devices do you normally use in your vehicle?

❑ navigation tools
❑ telephone
❑ internet
❑ others: ______

Do you have internet at home?
❑ yes ❑ no

Are you interested in the adoption of new ICT devices?
❑ yes ❑ no

If you use the Internet, which of the following services do you use?

❑ email
❑ on-line shopping
❑ social networking
❑ music/video
❑ skype
❑ games
❑ maps
❑ don't use internet

Approximately, how much on average do you think it currently costs to fully charge an electric scooter?

❑ 1-3 €
❑ 4-8 €
❑ more than 10 €
❑ don't know

How much do you agree with the following statements about cars?

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
Road transport is a major source of emissions, which harm the environment.	❑	❑	❑	❑	❑
Driving an electric car is like driving a conventional car with automatic gears. So, in many respects electric cars are just like conventional	❑	❑	❑	❑	❑

cars.

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
Road transport is a major source of emissions, which harm the environment.	❑	❑	❑	❑	❑
Electric cars are currently quite expensive.	❑	❑	❑	❑	❑
Electric cars can run for a maximum of 150 km between two charges.	❑	❑	❑	❑	❑
The charging time is never less than 30 minutes.	❑	❑	❑	❑	❑
100 km cost less than 2 Euros.	❑	❑	❑	❑	❑
Electric cars have no tailpipe emissions.	❑	❑	❑	❑	❑
Electric cars are safe.	❑	❑	❑	❑	❑
Electric cars have high maintenance costs.	❑	❑	❑	❑	❑
Electric cars increase the pleasure of driving.	❑	❑	❑	❑	❑
Electric cars are noisy.	❑	❑	❑	❑	❑

From your own point of view, which is the most important aspect to be considered while driving.
Write a number from 1 to 7: 1 the most important, 7 the least important

_____ safety

_____ time spent on the trip

_____ efficiency

_____ fuel

_____ mobility

_____ emissions

_____

_____ other:_________

User acceptance

What is your immediate impression after completing your journey using an electric scooter?

bad impression	inadequate impression	fair impression	good impression	excellent impression
❑	❑	❑	❑	❑

Based on your present impression, would you consider driving electric scooters more often in the future?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Willingness-to-pay

Which of the following factors would discourage you from buying an electric scooter? (multiple answers are possible)

❑ price
❑ lack of charging infrastructure at home
❑ lack of charging infrastructure at work
❑ lack of public charging infrastructure
❑ short range
❑ immature technology

Which of the above factors would be your biggest discouragement factor when considering a scooter purchase?

____

Which of the following factors would influence your intention to buy an electric scooter? (multiple answers possible)

❑ buying price
❑ reliability
❑ low running cost (€ per Km)
❑ monthly payment
❑ the look of the car
❑ size of the car
❑ insurance
❑ no carbon emissions
❑ no noise
❑ engine power
❑ makes statement about my commitments green issues
❑ love of new technology

Which of the above factors would be your biggest influencing factor when considering a vehicle purchase?

____

Which of the following incentives would influence your intention to buy an electric scooter the most?

❑ tax allowance
❑ price allowance
❑ exemption from city toll
❑ free parking
❑ free bus lane usage

How much of an increase in percentage of running costs would you pay for an electric scooter?

____

Please select which of the following statements concerning government incentives to buy electric cars are is most relevant to you: (please select one answer only)

❑ Fundamental: only through government incentives will it be possible to buy an electric car

❑ Important: they can speed up the introduction of electric cars into the market

❑ Useful, they could be a great help when buying an electric car

❑ Unnecessary: when buying an electric car technical features are more important than price

❑ Bad for the market: in that way the market will become totally dependent on government incentives without being able to develop its own policies.

Please rate the following statements:

	certainly-not	*unlikely*	*about-50:50*	*likely*	*for-sure*
I would consider buying an electric scooter.	❑	❑	❑	❑	❑
I would consider paying to rent an electric scooter frequently.	❑	❑	❑	❑	❑
I would accept personalised advertising in return for a cheaper rental or public charging.	❑	❑	❑	❑	❑

If you were going to buy a car, which of these sources of information would you use? (multiple answers are possible)

- ❑ dealerships
- ❑ internet
- ❑ taking to the other people, family, friends, etc.
- ❑ past experience
- ❑ newspaper/magazine
- ❑ consumer reports
- ❑ TV
- ❑ other:_________

Range anxiety

Please rate the following statement: I feel comfortable concerning the range of the electric scooter.

fully-disagree	disagree	neutral	agree	Fully-agree
❑	❑	❑	❑	❑

What range would you consider optimal for an electric scooter?

less than 50 km	50-100 km	100-150 km	150-200 km	200-250 km	250-300 km	more than 300 km
❑	❑	❑	❑	❑	❑	❑

What is your accepted minimal battery range for daily usage?

____

Additional questions

What is your accepted maximal charging duration? Please indicate for:

during the day	at night	during weekends
________	________	________

Did the service improve your perception of electric scooters?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

What benefits do you see in using an electric scooter with the functions you experienced? (multiple responses possible)

time saving	money saving	CO2 reduction	Oothers: ________
❑	❑	❑	❑

What future system uses do you see in using an electric scooter with the functions you experienced?

____

What problems have you experienced or could you think of when using the electric scooter?

____

How many times have you driven an electric scooter?

first time	less than 5 times	more than 20 times
❑	❑	❑

Would you replace your conventional scooter with an electric scooter?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Please specify why or why not:

____

7.3. User-questionnaire service user-uptake long version for electric vehicles

Please rate the following statements:

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
It is easy for me to remember how to perform tasks using the service.	❑	❑	❑	❑	❑
Interacting with the service requires a lot of my mental effort.	❑	❑	❑	❑	❑
My interaction with the service is clear and understandable.	❑	❑	❑	❑	❑
I find it takes a lot of effort to become skilful at using the service.	❑	❑	❑	❑	❑
The service is too rigid and inflexible to interact with.	❑	❑	❑	❑	❑
It was easy for me to follow the information provided by the system.	❑	❑	❑	❑	❑
The system was adaptable according to my personal needs.	❑	❑	❑	❑	❑
Overall, I find the service easy to use.	❑	❑	❑	❑	❑

User-acceptance – usefulness

Please rate the following statements:

	fully-disagree	*disagree*	*neutral*	*agree*	*fully-agree*
Using the EV-efficient driving service increased my awareness of ecological driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service restricts my freedom while driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service helped me to drive in a more energy efficient way.	❑	❑	❑	❑	❑
Using the EV-navigation service helped me finding an available charging station.	❑	❑	❑	❑	❑
Using the EV-trip management service made it easier for me to use an electric vehicle.	❑	❑	❑	❑	❑
Using the EV-trip management service helped me plan my trip.	❑	❑	❑	❑	❑
Using the EV-trip management service made public transport as a mode of transport more attractive.	❑	❑	❑	❑	❑
Using the EV-sharing service increased my willingness to use an electric vehicle more frequently.	❑	❑	❑	❑	❑
Using the EV-sharing service helped me to reach my destination.	❑	❑	❑	❑	❑
Using the EV-charging station management service supported me during the charging process.	❑	❑	❑	❑	❑
Using the EV-charging station management helped me organize the vehicle charging process.	❑	❑	❑	❑	❑

	fully-disagree	disagree	neutral	agree	fully-agree
The service provided me with all the information which I needed to complete my trip.	❑	❑	❑	❑	❑
Overall, I find the system useful.	❑	❑	❑	❑	❑

Attitude towards using: Van der Laan acceptance scale

I find the system (please tick a box on every line):

1	useful	|__|__|__|__|__|	useless
2	pleasant	|__|__|__|__|__|	unpleasent
3	bad	|__|__|__|__|__|	good
4	nice	|__|__|__|__|__|	annoying
5	effective	|__|__|__|__|__|	superfluous
6	irritating	|__|__|__|__|__|	likeable
7	assisting	|__|__|__|__|__|	worthless
8	undesirable	|__|__|__|__|__|	desirable
9	raising Alertness	|__|__|__|__|__|	sleep-inducing

Willingness-to-pay

Based on your present impression of the service do you think that the service is worth paying for?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Why or why not do you think that the service is worth paying for?

____

I would like to pay for the service…. (multiple response are possible):

depending on the kilometers I have driven	depending on the time I have driven	via flat fee (fixed price including all costs of usage)	Other: ________
❑	❑	❑	❑

How much more would you be willing to pay for a multimodal transport card including EV-sharing service?

____

Please rate the following statements:

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
I would agree to dynamic pricing schemes i.e. fare discounts if one accepts modifying his/her trip preferences, for example, end the trip at a charging point instead of the initially desired destination.	❑	❑	❑	❑	❑
I would agree to pay a penalty if I do not use/pick up the electric vehicle although I have booked it before.	❑	❑	❑	❑	❑
I would agree to pay a penalty if I do not give back the electric vehicle at the agreed location or time.	❑	❑	❑	❑	❑

I would be willing to pay the following flat fee price to use the system per year … (in Euro):

____

I would pay via…(multiple response are possible)

credit card	bank debit	cash
❑	❑	❑

Please rate the following statements:

	certainly-not	*unlikely*	*about-50:50*	*likely*	*for-sure*
Would you prefer personalised advertising in return for a cheaper rental or reduced public charging costs?	❑	❑	❑	❑	❑
Would you consider a reduced charge in exchange for direct advertising to your mobile phone?	❑	❑	❑	❑	❑
Would you like to receive offers from nearby shops, restaurants etc. when you complete your journey?	❑	❑	❑	❑	❑

Range anxiety

Please rate the following statements:

	fully-disagree	*disagree*	*neutral*	*agree*	*fully-agree*
Using the service made me more secure about the range of my battery.	❑	❑	❑	❑	❑
Using the service made me more confident to reach my target within the range of my battery.	❑	❑	❑	❑	❑
I trusted the service to	❑	❑	❑	❑	❑

provide me with accurate information.					
The service made me worry less about the range of my battery.	❑	❑	❑	❑	❑
The service improved my confidence to take longer trips.	❑	❑	❑	❑	❑

How often do you believe the information provided by the service was not trustworthy?

never	seldom	sometimes	often	always
❑	❑	❑	❑	❑

Questions for EV-sharing service:

How important are the following criteria for you – multiple answers are possible:

	not important	*a-little important*	*moderately important*	*quite-a-bit important*	*Very important*
…open sharing scheme where I can leave my vehicle wherever I wish.	❑	❑	❑	❑	❑
…that the vehicle is clean.	❑	❑	❑	❑	❑
… that a help-hotline is available in case of problems.	❑	❑	❑	❑	❑
… that the pricing-scheme is transparent.	❑	❑	❑	❑	❑
… that the type of vehicle matches my preferences.	❑	❑	❑	❑	❑
… that the reservation can be done using a smartphone.	❑	❑	❑	❑	❑

What motivates you to use this sharing service?

❑ vehicle is electric…
❑ I like the concept of sharing a scooter…
❑ others: ______

Would you use conventional scooter-sharing?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Please specify why or why not?

____

7.4. User-questionnaire service user-uptake long version for electric scooters

User-acceptance – usefulness

Please rate the following statements:

	fully-disagree	*disagree*	*neutral*	*agree*	*fully agree*
Using the EV-efficient driving service increased my awareness of ecological driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service restricts my freedom while driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service helped me to drive in a more energy efficient way.	❑	❑	❑	❑	❑
Using the EV-navigation service helped me finding an available charging station.	❑	❑	❑	❑	❑
Using the EV-trip management service made it easier for me to use an electric scooter.	❑	❑	❑	❑	❑
Using the EV-trip management service helped me plan my trip.	❑	❑	❑	❑	❑
Using the EV-trip management service made public transport as a mode of transport more attractive.	❑	❑	❑	❑	❑
Using the EV-sharing service increased my willingness to use an electric scooter more frequently.	❑	❑	❑	❑	❑
Using the EV-sharing service helped me to reach my destination.	❑	❑	❑	❑	❑
Using the EV-charging station management service supported me during the charging process.	❑	❑	❑	❑	❑
Using the EV-charging station management helped me organize the scooter charging process.	❑	❑	❑	❑	❑
	fully-disagree	*disagree*	*neutral*	*agree*	*fully agree*

The service provided me with all the information which I needed to complete my trip.	❑	❑	❑	❑	❑
Overall, I find the system useful.	❑	❑	❑	❑	❑

Attitude towards using: Van der Laan acceptance scale

I find the system (please tick a box on every line):

1	useful	|__|__|__|__|__|	useless
2	pleasant	|__|__|__|__|__|	unpleasent
3	bad	|__|__|__|__|__|	good
4	nice	|__|__|__|__|__|	annoying
5	effective	|__|__|__|__|__|	superfluous
6	irritating	|__|__|__|__|__|	likeable
7	assisting	|__|__|__|__|__|	worthless
8	undesirable	|__|__|__|__|__|	desirable
9	raising alertness	|__|__|__|__|__|	sleep-inducing

Willingness-to-pay

Based on your present impression of the service do you think that the service is worth paying for?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Why or why not do you think that the service is worth paying for?

____

I would like to pay for the service…. (multiple response are possible):

depending on the kilometers I have driven	depending on the time I have driven	via flat fee (fixed price including all costs of usage)	Other: _______
❑	❑	❑	❑

How much more would you be willing to pay for a multimodal transport card including EV-sharing service?

____

Please rate the following statements:

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
I would agree to dynamic pricing schemes i.e. fare discounts if one accepts modifying his/her trip preferences, for example, end the trip at a charging point instead of the initially desired destination.	❑	❑	❑	❑	❑
I would agree to pay a penalty if I do not use/pick up the scooter although I have booked it before.	❑	❑	❑	❑	❑
I would agree to pay a penalty if I do not give back the scooter at the agreed location or time.	❑	❑	❑	❑	❑

I would be willing to pay the following flat fee price to use the system per year … (in Euro):

____

I would pay via…(multiple response are possible)

credit card	bank debit	cash
❑	❑	❑

Please rate the following statements:

	certainly-not	*unlikely*	*about-50:50*	*likely*	*for-sure*
Would you prefer personalised advertising in return for a cheaper rental or reduced public charging costs?	❑	❑	❑	❑	❑
Would you consider a reduced charge in exchange for direct advertising to your mobile phone?	❑	❑	❑	❑	❑
Would you like to receive offers from nearby shops, restaurants etc. when you complete your journey?	❑	❑	❑	❑	❑

Range anxiety

Please rate the following statements:

	fully-disagree	*disagree*	*neutral*	*agree*	*fully-agree*
Using the service made me more secure about the range of my battery.	❑	❑	❑	❑	❑
Using the service made me more confident to reach my target within the range of my battery.	❑	❑	❑	❑	❑

	fully-disagree	*disagree*	*neutral*	*agree*	*fully-agree*
I trusted the service to provide me with accurate information.	❑	❑	❑	❑	❑
The service made me worry less about the range of my battery.	❑	❑	❑	❑	❑
The service improved my confidence to take longer trips.	❑	❑	❑	❑	❑

How often do you believe the information provided by the service was not trustworthy?

never	seldom	sometimes	often	always
❑	❑	❑	❑	❑

Questions for EV-sharing service:

How important are the following criteria for you – multiple answers are possible:

	not important	*a-little important*	*moderately important*	*quite-a-bit important*	*Very important*
…open sharing scheme where I can leave my scooter wherever I wish	❑	❑	❑	❑	❑
…that the scooter is clean	❑	❑	❑	❑	❑
… that a help-hotline is available in case of problems	❑	❑	❑	❑	❑
… that the pricing-scheme is transparent	❑	❑	❑	❑	❑
… that the type of scooter matches my preferences	❑	❑	❑	❑	❑
… that the reservation can be done using a smartphone	❑	❑	❑	❑	❑

What motivates you to use this sharing service?

❑ scooter is electric…
❑ I like the concept of sharing a scooter…
❑ other: _____

Would you use conventional scooter-sharing?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Please specify why or why not?

7.5. *User-questionnaire general and service user-uptake for hybrid bus*

Demographics

What is your age?

__________ ❑ no answer

What is your gender?

❑ female ❑ male ❑ no answer

What is your immediate impression after completing your journey in a hybrid bus?

bad impression	inadequate impression	fair impression	good impression	excellent impression
❑	❑	❑	❑	❑

User-acceptance - perceived-ease-of-use

Please rate the following statements:

Statement	Response				
	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
Interacting with the service requires a lot of my mental effort.	❑	❑	❑	❑	❑
My interaction with the service is clear and understandable.	❑	❑	❑	❑	❑
I find it takes a lot of effort to become skilful at using the service.	❑	❑	❑	❑	❑

	fully-disagree	*mainly-disagree*	*neutral*	*mainly-agree*	*fully-agree*
It was easy for me to follow the information provided by the system.	❑	❑	❑	❑	❑
Overall, I find the service easy to use.	❑	❑	❑	❑	❑

User-acceptance - usefulness

Please rate the following statements:

Statement	**Response**				
	fully-disagree	*disagree*	*neutral*	*agree*	*fully-agree*
Using the EV-efficient driving service increased my awareness of ecological driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service restricts my freedom while driving.	❑	❑	❑	❑	❑
Using the EV-efficient driving service helped me to drive in a more energy efficient way.	❑	❑	❑	❑	❑
Overall, I find the system useful.	❑	❑	❑	❑	❑

Attitude towards using: Van der Laan acceptance scale

I find the system (please tick a box on every line):

1	useful	|__|__|__|__|__|	useless
2	pleasant	|__|__|__|__|__|	unpleasent
3	bad	|__|__|__|__|__|	good
4	nice	|__|__|__|__|__|	annoying
5	effective	|__|__|__|__|__|	superfluous
6	irritating	|__|__|__|__|__|	likeable
7	assisting	|__|__|__|__|__|	worthless
8	undesirable	|__|__|__|__|__|	desirable
9	raising alertness	|__|__|__|__|__|	sleep-inducing

7.6. User-questionnaire general user-uptake short version for electric vehicles

What is your age?

__________ ❑ no answer

What is your gender?

❑ female ❑ male ❑ no answer

What is your immediate impression after completing your journey in an electric vehicle?

bad impression	inadequate impression	fair impression	good impression	excellent impression
❑	❑	❑	❑	❑

Based on your present impression, would you consider driving electric vehicles more often in the future?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Did the service improve your perception of electric vehicles?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

How many times have you driven an electric vehicle?

first time	less than 5 times	more than 20 times
❑	❑	❑

7.7. User-questionnaire general user-uptake short version for electric scooters

Demographics

What is your age?

__________ ❑ no answer

What is your gender?

❑ female ❑ male ❑ no answer

What is your immediate impression after completing your journey using an electric scooter?

bad impression	inadequate impression	fair impression	good impression	excellent impression
❑	❑	❑	❑	❑

Based on your present impression, would you consider driving electric scooters more often in the future?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

Did the service improve your perception of electric scooters?

certainly-not	unlikely	about-50:50	likely	for-sure
❑	❑	❑	❑	❑

How many times have you driven an electric scooter?

first time	less than 5 times	more than 20 times
❑	❑	❑