ICT cloud-based platform and mobility services available, universal and safe for all users

D4.2 MoveUs energy efficiency assessment plan

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Abstract:

- Automatic translation of mobility options for users from energy consumption parameters to more meaningful user parameters.
    - Energy efficiency calculator
    - Transformation from energy efficiency values to user relevant parameters
- Assessment plan for MoveUs
    - Energy efficiency KPI and parameters calculator
    - Tailored assessment plan for MoveUs pilots for energy efficiency evaluation.
- Definition of Assessment plan report

HISTORY

Version	Date	Modification reason	Modified by
0.0	14.01.2015	Initial layout of the deliverable	TUT – Angelica Nieto, Fernanda Mantilla
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Contents

List of Figures

List of Tables

List of Abbreviations

<Abbreviation>	<Explanation>
ALM	Alternative Modes
App	Application
CCF	Carbon Conversion Factor
CCF_{car}	Carbon Conversion Factor for private car
CCF_{mb}	Carbon Conversion Factor for motorbike
CCF_{PT}	Carbon Conversion Factor for Public Transport
CDG	Municipality of Genoa
CEC	Consumption Estimation Calculator
CFP	Carbon Footprint
CO_2	Carbon Dioxide
EC	Energy Consumption
EDV	Electrically Driven Vehicle
EE	Energy Efficiency
EMT	Empresa Municipal de Transportes de Madrid
EPA	United States Environmental Protection Agency
EU	European Union
EU ETS	European Union Emission Trading System
GPS	Global Positioning System
GSM	Global System for Mobile Communication
ICT	Information Communications Technology
ID	Identification
ISO	International Organization for Standardization
ITS	Information and Technology services
KPI	Key Performance Indicator
Kcal	Kilocalories
Kwh	Kilowatts/hour
MJP	Multimodal Journey Planner
mmbtu	One million British Thermal Unit

OECD	Organization for Economic Co-operation and Development
OR	On-road Route
pkm	passengers per kilometer
PT	Public Transport
PV	Private Vehicles
PVT	Private Vehicles Transport
QRY	Quaeryon
RBFN	Radial Basis Function Network
SICE	Sociedad Ibérica de Construcciones Eléctricas S.A.
SUMO	System for Evaluation of Mobility Projects
SUV	Sports Utility Vehicle
SWB	Subjective well-being
TECNALIA	Tecnalia Research and Innovation
TF	Traffic Free road
TRE	Tampereen Kaupunki
TUT	Tampere University of Technology
UK	United Kingdom
US	United States
W	Watts
WP	Work Package

Executive Summary

The **calculation algorithms** for the energy efficiency related with each one of the journey options that are proposed to users are presented in this deliverable, as well as the definition of the **transformations from energy efficiency values to user representative values**.

The **assessment plan** for the different cities that are part of MoveUs project is described in this deliverable being used to evaluate the energy performance of the transport domain. **Tailored assessment plan** for each one of the cities is presented based on the their characteristics and needs, the infrastructure and energy goals. This plan is the next step of the energy efficiency methodology that was defined and described in D4.1 where each city identified their goals, target groups, KPIs, affecting parameters and base lines for future evaluation.

Finally, the template of the **assessment plan report** will be presented in this deliverable to be used during the deployment of MoveUs platform in the different Living Labs. It will include the reporting of the initial state of the systems and the results at the end of the project to compare the benefits of the use of MoveUs in each city and identify how the system can be improved.

1 Introduction

The aim of this deliverable is to present the measurement, evaluation and representation of the energy consumption for different mobility options for smart cities. In addition the algorithm for calculation of energy and its conversion into meaningful values is described in this document. The KPIs that were defined for each pilot city following the methodology developed in T4.1 and presented in deliverable (D4.1?) serves as a base for the assessment plan to be generated. The main work is divided in three sections, which describe the developments for T4.2 and the Energy Efficiency Calculator, are the following:

- **Calculation of energy consumption for PT, PVT, ALM:** This section deals with the measurement of energy consumption for each of the trip option in the cities that are part of MoveUs project. Energy consumed is usually expressed as joule or kWh of energy. But to consider the environmental concern, it is considered the amount of CO_2 generated by burning the natural gas for vehicles to run. Therefore, it is proposed to show the measurement in the form of emissions for PT and PVT, and as food equivalent for ALM. All the factors that affect the selection between different mobility modes and the energy consumption (e.g. like weather, age, infrastructure, trip characteristics, and lifestyle) that were defined in D4.1 are considered in the calculation of the energy consumption for obtaining CO_2 values for PT or PVT and kCal values for ALM.

- **Energy transformation to meaningful values and its user interface**: The emissions and kcal values for every trip option are to be transformed in a value, which is clearly understood by the MoveUs user to bring about behavioural changes. Various factors regarding the pilots are considered along with the state of art on what can be effective to bring habitual changes in people's choice. Then, the equivalence to CO_2 and Kcal is defined along with the algorithm to transform from CO_2 and Kcal to that equivalent decided translation parameter known as energy label.
  The most important part for the interaction with MoveUs users is the mobile app's user interface. It is important to decide what information and how much data should be provided to the user. Moreover, the way of showing the important selected information so that it has an impact on people is crucial. Therefore, a study of all this aspects have been done in the different approaches that exist in this area and based on the results, an interface is defined for the mobile app.

- **Assessment of pilot cities:** The information related to all of the data sources required for the KPI's that were defined for every MoveUs pilot is summarized in this section. This information, as well as the affecting parameters, is integrated in the Energy Consumption module in MoveUs platform. The KPI's are continuously measured and used for assessment of the energy efficiency of the transportation domain of each city over time. From the graphs obtained for various KPI's, a comparison can be made and the changes can be observed. The effect of different services applied to the cities can be used to compare how the users have or haven't changed the mode of transportation choices towards greener modes. Hence depending on all of the above factors an assessment plan is defined and the evaluation and report is performed and will be reported in D4.3.

With the definition of the assessment plan and report, in addition to the implementation of the energy efficiency module in MoveUs platform, it will be possible to compare the status of the cities at the starting point and after one year of using MoveUs system.

2 Background

2.1 State of art for representation of Energy information

To take initiatives for saving the environment people should first know how they are contributing to energy problems and then they should be given knowledge on the appropriate ways to take actions. Moreover, they should stay intact with their own energy efficiency attitude.

One of the projects carried out in Cannes aimed at doing so by assessing 40 households domestic energy use. It was required to measure the energy consumption of the daily household and thereby give a chance to the user to interact and take actions for mitigating the energy issues. Incentives were provided to people in form of bus tickets, concert tickets for local events, energy saving light bulbs. Smart meters were installed in every residence to provide real time information as well as the data was sent to data centre after every 50W modulation. Now the representation of the measured data to the users is the main key. Power, energy and temperature were monitored. And hereby the energy was displayed on the web-based interface as kWh of electricity consumed per hourly basis with also the temperature scale. Now the user can compare between the amount of electricity that is being consumed at different times and understand at what time of the day lesser energy is consumed. Also the most important thing here is that energy was translated to money so that people would be able to understand the actual comparison between the energy they are consuming and equivalently the money they are spending. Moreover, to keep up people’s involvement in this, some sociological surveys were carried out giving the upper and lower bounds of energy levels which the user has to maintain through intervention. User is supposed to see the upper bound and try to reach the lower bound, which is the level to be achieved for energy savings. And these upper and lower bounds were converted to currencies. The efforts taken by the user to reduce energy consumption on the basis of levels and as explained in below diagram were noted and added to EcoTroks a reward giving scheme. The user depending on the points collected in EcoTroks based on the energy saved in the previous week would be provided with reward.[39]

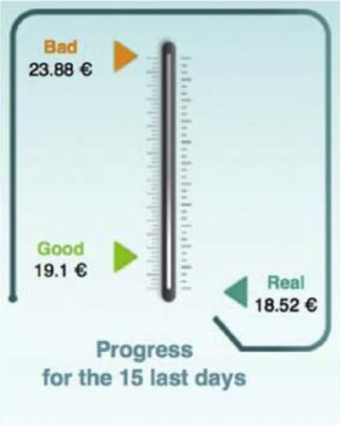


Figure 1: Energy Scale [39]

A study was carried out to check how the representation of eco-feedback energy information affects people’s behaviour. Eco-feedback systems provide the user with the historical data and the current data by which user is able to analyse how much he is consuming. It was seen that showing the energy in its own unit doesn’t make any huge impact on user’s decision for energy savings. But if this energy unit is represented in some other unit, the response of people was more effective towards reduction of energy consumption. Three groups were made wherein Group A was provided with direct energy unit as kWh, group B was provided with translated values as number of trees required to offset the CO_2 produced by electricity, and Group C wasn’t provided with any eco feedback. The result of this study concluded that eco feedback played an immense role in energy consumption reduction. In addition to it, it was found that people were unable to visualize and understand the direct energy unit kWh whereas a decrease in energy consumption was seen if the environmental units like number of trees required to offset to CO_2 emissions was used [40].

Another study on how the interface should be to achieve more effective results says that there are 4 important things, which should be considered for a successful interface. Those are historical comparison, normative comparison, incentives and disaggregation. Significance of historical comparison was described earlier. Normative comparison would give a chance to compare and compete with friends about the energy savings done by user. Incentives help the user to be kept involved in the energy savings mission. Moreover disaggregation helps user get idea about the consumption of each specific device [41].

EU 2020 has set some targets and one out of which is reduction of greenhouse gases to 20% by 2020, which comes under EU ETS (Emissions Trading System). Companies hereby can buy or sell the emissions allowances. It was seen that cars contribute to 12% of the total EU emissions and hence the limits put on the emissions for new cars is **130 grams** of CO_2 per kilometre (g CO_2/km) by 2015. Thus the fuel consumption should be nearly by 5.6 litres per 100 km (l/100 km) of petrol or 4.9l/100 km of diesel. The target for 2021 is **95 grams** of CO_2 per kilometre, which means 4.1 l/100 km of petrol or 3.6 l/100 km of diesel. To make this strategy effective penalties would be applied as follows:

- €5 for the first g/km of exceedance
- €15 for the second g/km
- €25 for the third g/km
- €95 for each subsequent g/km.

Also to encourage this approach, incentives would be granted to manufacturers saving emissions up to 7 g/km per year [42]. Keeping in mind these EU targets the indexes for the eco label could be decided.

2.2 Opportunities where MoveUs can help to reduce Energy consumption/carbon foot print

The interconnection between different components is the core for more sustainable transport systems. Achieving an efficient intermodal transport system needs more than a creation of new components (e.g. new bus lines, or new services) but also its interconnection. ICTs could connect those components through intelligent devices like mobile phones by bringing personalized information directly to the end users. In this section we review existing ICTs in order to determine how MoveUs can help cities to achieve more sustainable transport systems.

2.2.1 Influence travel choice

Application of new technologies such as electrical cars or more efficient vehicles is just one face of the solutions that can be implemented to reduce the EC. The maximum EE of the system can only be achieved if authorities put their effort in improving every aspect of the system. Individual behavior is a crucial component that allows more efficient use of the current cities infrastructures. Based on this premise, ICTs can help to achieve higher EE by influencing the citizens' choice of transport mode, actions well known as soft policy measures.

Multimodal journey planners can influence travel choice by comparing alternative routes with different combinations of modes for same destination, decisions can be done by the user. The access of decisive information (such price, time, contamination, etc.) through these platforms might be sufficient to change user's travel behavior, like it was explained in Brög (2002)[1]. There are a considerable number of journey planners available which target an specific mode (e.g. bus, train etc), however they don't provide further information. Multi-journals planners allow users to plan their journey by choosing between different modes and criteria (e.g. money, time, emissions etc.) [2].

Examples can be found locally, national, continental or global. Global journey planners are those that are specifically for air transport, but they offer additional information about PT or rent-car services for the last mile, as an example eNotions from Germany. Continental journey planners are a new concept in Europe; one example is the ITS EUROPE 2020 that aims to create a unique European multimodal journey planner for persons and goods. National journey planners like Journey.fi by Mediamobile Nordic gives national information on rail, bus, flight and walking routes in Finland. Another platform is DELFI from Germany, which integrates the multi journal planers from all the German regions. Local journey planners like Helsinki planner, offers alternatives in the city of Helsinki and surroundings.

For many people, simply by having access to those ICTs that try to change the individual behavior through information is not enough, for some individuals require more than that to make a change. In those cases other initiatives include motivational support. Those strategies usually include the information shown by the previously described initiatives, and additionally request that users make plans with a view to changing their travel behavior. Taniguchi study found that behavioral plan has an strong effect on the actual behavioral change process [3]. Motivation is crucial in order to implement soft policy measures, however it is unclear which kind of incentives will work, and most of the information about other projects do not explain how they work [4][5].

That's why authorities need to look further into what motivates people to change and also what motivates them to maintain those changes. Consequently it is necessary to create ICTs that identify and focus on individual users' reasons, so the implemented strategies will be more effectively designed. MoveUs keeps record of users choice, so every time user makes choice supporting PT, a rising trend could be seen by the user in his energy savings.

2.2.2 Change driver behavior

ICTs can influence users' driving behavior, but their potential is limited to the vehicle properties as the maximum energy efficiency than can be achieved is the vehicle efficiency. Enforcement technologies, like cameras to enforce the speed limits are the most commonly used ICT, however the scope of the cameras is limited to spots, and between those the driver behavior is unknown. Other ICTs for intelligent speed adaptation is a proposal from ISA, which aims to force the vehicle to be on the speed limit[6], other initiatives only show better practices in order to save fuel, but the speed is controlled by the driver and they focus in increasing the awareness of eco-driving benefits [7][8].The eco-driving is a type of driving style that aims to minimize fuel consumption. Some studies from Canada found that giving suggestion to drivers can lead to 5-20% reduction in fuel consumption, reductions depend highly on the driver style and willing to change [9]. The core of these technologies is on the education and feedback to drivers, motivational information is necessary (e.g. money save) so the drivers can see a direct benefit. MoveUs services guide the users for energy efficient journey planning. The energy calculator service provides carbon footprint value to the user. This feedback provided by the smart phone app makes the user aware of the utilization of energy by using particular transport option. Also the user would be able to see the translated meaningful value, so the importance of energy saving will then be understood.

2.2.3 Increase vehicles occupancy

Car ownership is one of the factors that highly increase the use of private vehicles, so there is potential energy efficiency saving by redefining the relation between driver and vehicle, from consumer of a product to consumer of a service or provider. Systems like carpooling increase the energy efficiency by increasing the level of occupancy per vehicle, so car owner offers a service. The other type of strategy is increase the utilization of the vehicle through car sharing programs, the driver uses a service offered by an operator, it is an intermediary point between the car manufacturer and the user.

Increasing the number of passengers in each vehicle has been done through carpooling services, called also as dynamic ride-sharing, these services involve travellers using advanced ICT technologies to arrange a short-notice, one-time, shared ride usually in their own cars. Services like [10] and [11] are some of the examples. These services not only have the potential to affect the vehicle's efficiency, but also offer a potential to reduce the number of vehicles that at the same time, reduce congestion in road.

Other service that is growing fast is the time-sharing car. Programs like zipcar provide the availability of a mobility service through personal vehicles, in which users no longer have to own them. Availability of deterrent parkings and guiding technologies to park cars in different places around the city, people reserve the car for the time and what they need, at the end the application of these services bring multiple benefits that are reflected in energy efficiency improvements such as: reduction of journeys= less energy consumption, the users don't have to deal with maintenance= adequate maintenance guaranty maximum vehicle fuel utilization, the price of drive is close to the real cost= price plays a considerable role in people's decisions to reduce the travel behavior; so putting the real value on the system prevents the over use of vehicles [12].

However these services are isolated, they are not part of current journey planners, the potential to integrate those is that users can have more options and integrate to groups in order to increase the possibilities.

MoveUs has one of the service for Madrid where priority is given to public transportation at intersections. This service aims to motivate people to use PT as they can reach early at their destinations. As a consequence, more people travel in PT and the vehicle occupancy rate increases. This helps in our cause of increasing energy efficiency due to consumption of lesser fuel per journey.

2.2.4 Improve system efficiency

Other way ICTs can help to increase the energy efficiency of cities' transport systems is by improving the use of the current infrastructure (e.g. highways, parking etc.) through information about the availability of alternatives. In roads, the usual information is traffic management where user can see alternative roads to avoid congestion. Additional information like accidents or reparations on the road are also commonly provided [13][14][15].

Parking availability has a great impact in whether the user takes or not a car. Projects like PUSH&PULL are inducing a change in mobility behavior (from car to more sustainable modes) by applying parking management to 8 European cities [16]. Similar results can be found in Sydney Australia and Canada, where users avoid taking car mainly to avoid parking problems, one of them is to pay parking [17][18]. In this sense, cities should not deploy more parking places, instead they can implement intelligent system to manage the current parking capacity.

In studies from France, it was found that annually 70 million hours are spent each year looking for parking spaces. Additionally, those cars represent 5 to 10% of the traffic in main roads and until 60% in small streets [19]. In cases where user is keen on using private car as a mode of transportation, ICTs can reduce the fuel consumption by providing services such as: localization of free places, pre-booking, and payment facilities. Solution like HERE ballon in South Korea and i2PARK app, aim to reduce the time spend in looking for free parking places [20][21].

MoveUs has one of its performance indicators, which calculates the presence of alternative fuels vehicles as well the scope of offering these facilities. Thus it would give information about the share of new vehicle units in cities. Moreover, the MoveUs platform tracks information on weather, precipitation and fog thus in a way suggesting to use of PT. As seen in D4.1 bad weather conditions severely increase the energy consumption.

3 Energy calculation for journey options

3.1 Energy efficiency calculator for transport sector

3.1.1 CO_2 vehicles

Carbon conversion factor (CCF) is a value that represents a mode of transport that considers the vehicle size, age and fuel type. Public transport conversion factors also represent vehicle occupancy. These emissions are calculated per passenger and depend directly on the journey specifications: start point, final point, route, and transport mode choose by the users. The formulas for calculating carbon emissions are:

$$car\ emissions = \frac{Distance * CCF_{car}}{vehicle\ occupants}$$

$$Motobike\ emissions = \frac{Distance * CCF_{mb}}{vehicle\ occupants}$$

$$public\ transport\ emissions = Distance * CCF_{PT}$$

Carbon Conversion Factor for private car (CCF_{car}) depends on technical information about the vehicle. This factor unit is in $\frac{gCO_2}{km}$ grams of carbon dioxide equivalent per kilometer. There are several ways in how to manage this factor from a very specific to a simpler way. An example of a specific way is the Fuel Consumption Ratings from Natural Resources Canada; in this online tool, the user can select Model Year, class, maker, model (see Figure 2) and in the advance search the transmission, fuel and cylinders are available [22].

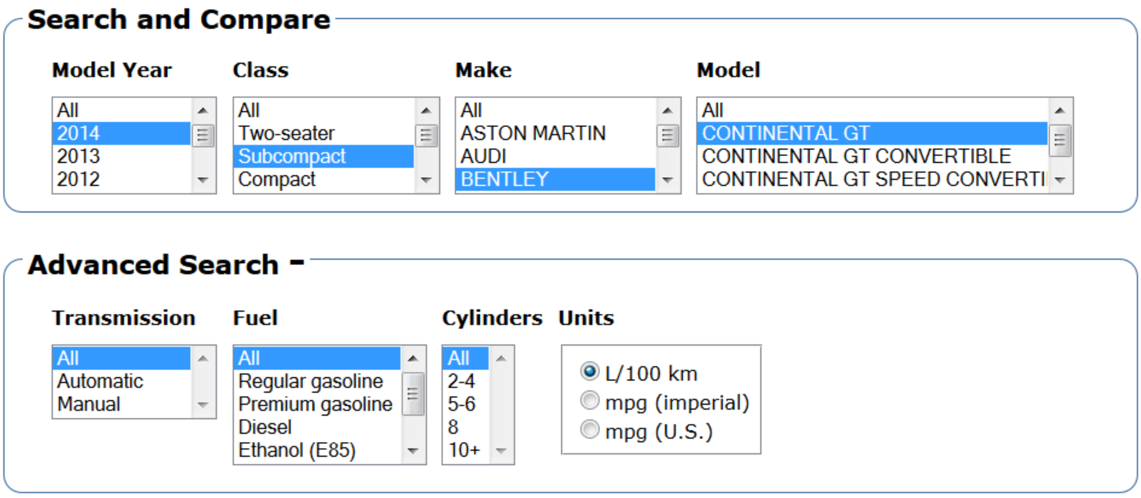
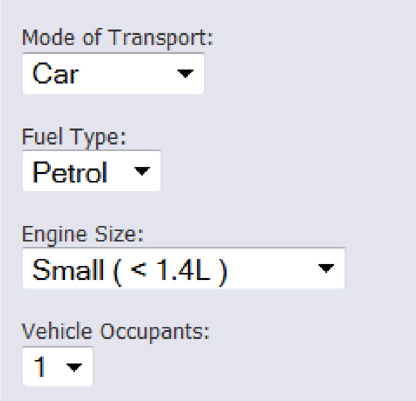


Figure 2: Fuel consumption rating from natural Resources Canada[22]

A simple way is the emission calculator from Traffic Scotland, the options available are fuel type, engine size and vehicle occupants (Figure 3). The classification of large, medium and small vehicle is defined based on engine sizes as can be seen in Table 1 [23].



Mode of Transport: Car

Fuel Type: Petrol

Engine Size: Small (< 1.4L)

Vehicle Occupants: 1

Figure 3 : CO_2 emissions in car transport mode from Traffic Scotland

Engine size (Litres)	Size label	CCF_{car}
	Gasoline	
<1,4	Small	147,8
1,4-2,0	Medium	185,0
>2,0	Large	259,7
	Diesel	
<1,7	Small	123,7
1,7-2,0	Medium	155,5
>2,0	Large	208,6

Table 1: Average CO_2 emissions factors based on data sourced by traffic Scotland [23].

In the case of Finland, the classification is done by the age of the car according to data from LIPASTO which is a calculation system for traffic exhaust emissions and energy consumption in Finland [24]. The values include the reduction of emission from Bio-share in gasoline that was 6% of the caloric value in 2011. CO_2 emissions from bio components of fuel are defined as zero. In 2020 this percentage has to be 10% for EU; however Finland has committed to a 20%. Unreduced factors are: gasoline 2350 g/litre and diesel 2660 g/litre.

In Finland, passenger cars are mainly gasoline driven or diesel driven, the emission produced by both vehicles are considered separately. This information will be obtained in the user registration, so they can specify the fuel and age of his/her car as well as the number of occupants. In the case of unregister user, it is assumed that the car is gasoline drive, the number of occupants is only the driver, and its CCF_{car} is the average (Table 2).

Vehicle type	Model	Size label	CCF_{car}
Gasoline	2001-2005	Old +10	224
	2006-2009	Teen 8-5	205
	After 2010	Young 0-5	183
Average Gasoline			217
Diesel	2001-2005	Old +10	211
	2006-2009	Teen 8-5	212
	After 2010	Young 0-5	190
Average Diesel			208

Table 2: Private car CCF_{car} and averages in Finland [24].

For electrical cars, the emissions are zero in Tampere because the electrical net uses hydroelectric power. However, this information can vary from city to city, so these emissions can be established for each city according to their power production. For hybrid cars CCF, it is useful to check the manufacturer specifications and have into account the Carbon emission from conventional fuel as well as the percentage on the total distance.

Carbon Conversion Factor for motorbikes (CCF_{mb}) as well as CCF_{car} depends on technical information. This factor unity is in $\frac{gCO_2}{km}$ grams of carbon dioxide equivalent per kilometer, including these values depends on the specific fleet compositions of each city.

Carbon Conversion Factor for public transport (CCF_{PT}) is calculated by dividing the amount of emissions per kilometer by the average number of passengers ($\frac{gCO_2}{pkm}$). For this reason, emissions can be lower for each passenger if the average level of occupancy increases. The average number of passengers travelling in city buses in Finland is 18 over an average of 80 available seats. As a result, in cases when users decide to make their journeys in rush hours, the emission is lower than if they perform the same trip in another time. However it is assumed that the transport system works in an ideal situation, where the number of passengers is constant during the whole day. Finally, as well as the car fleet, the public transport is composed by different age vehicles but the average is considered for the calculations. Buses are diesel driven and natural gas driven (Table 3: Public transport CCFPT averages in Finland for average occupancy (18) and full loaded (80) [24].).

Vehicle type	$CCF_{PT\ (18)}$	$CCF_{PT\ (full\ 80)}$
Diesel	58	16
Compress natural gas	68	16
Average	63	16

Table 3: Public transport CCF_{PT} averages in Finland for average occupancy (18) and full loaded (80) [24].

The following values can be used to calculate the emissions if the data is in other unit:

- *Gasoline:*

  Specific weight 0,75 kg/l , density 750 kg/m^3

  Carbon dioxide 2350 gCO_2/dm^3 fuel or 3133 gCO_2/kg fuel
- *Diesel:*

  Specific weight 0,845 kg/l, density 845 kg/m^3

  Carbon dioxide 2660 gCO_2/dm^3 fuel or 3148 gCO_2/kg fuel
- *Compressed natural gas:*

  Specific weight 0,723 kg/l, density 723 kg/m^3

  Carbon dioxide 2750 gCO_2/kg fuel

3.1.2 "Calorie calculator" in the journey planner alternative modes

Alternative Modes (ALM) (e.g. walking and cycling) are considered emission free because they use minimal fossil fuels for manufacturing the bicycle and these modes are pollution-free. The use of bicycle not only represents reductions in users' emissions but also bright health, economic, social and transport benefits.

The majority of car trips are in short-distances, for example, to go to school or shops. Cycling or walking these trips significantly reduces congestion and improves safety. Bicycles offer door-to-door service because they can be parked closer to destinations than cars and they are often quicker than cars over short distances of up to 5 km [25].

For ALM the system will calculate the energy expenditure in Kilocalories and its equivalent in food. The energy expenditure for cycling and walking are obtained with the following equations.

$$Cycling\ expenditure\ [Kcal] = 0{,}4 \left[\frac{Kcal}{km * kg}\right] * user's\ weigh\ [kg] * Distance[km]$$

$$Walking\ expenditure\ [Kcal] = \left(0{,}8 \left[\frac{Kcal}{km * kg}\right] * user's\ weigh\ [kg] + 1.5\right) * Distance[km]$$

These equations were obtained from McArdle William et al. (2006), assuming a cycling speed of 15km/h and walking speed of 5.63 km/h [26]. These equations apply when the user is registered, otherwise the system will calculate energy expenditure assuming a person weight of 70Kg, that for cycling 28 kcal/km and walking 57.5 kcal/km

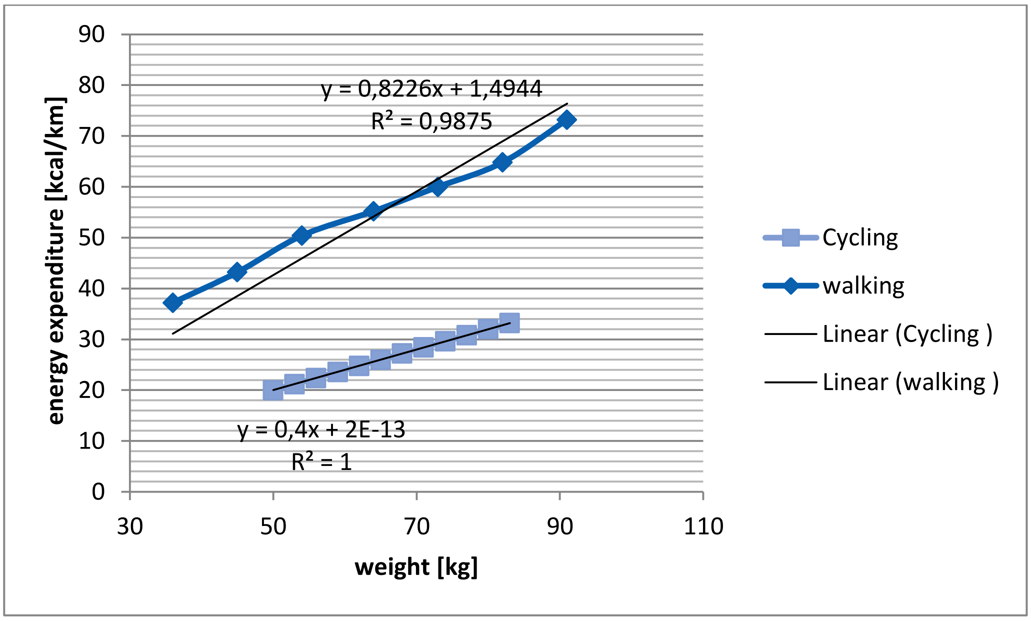


Figure 4: Energy expenditure for alternative modes values source from[26].

The food equivalent pretends to show to users in a more tangible or understandable way how many kcal represent in something that is part of their daily lives or at least part of their culture. In the case of Tampere city, two items stand out, ice cream during summer time and chocolate in winter. Ice cream in a serving size of 1/2 cup (72 g) is assumed as 145kcal and a milk chocolate bar (50g) is assumed as 183kcal. The equation for the equivalence is:

$$food\ equivalent = \frac{total\ kcal\ in\ alternative\ modejourney}{food\ kcal}$$

For Tampere, the result will be given in numbers of ice-cream or chocolate bars. It is important that each city chooses their food equivalent and define its kcal. Application of this method can be found in Helsinki "chocolate calculator" in the journey planner[1].

3.1.3 Affecting factors calculator

Based on the applied methodology, described in D4.1, the living labs have their list of performance indicators composed by KPIs and Affecting factors that apply to their specific transport conditions and objectives.

The decision of the user is affected by the parameters so in that case the final user value will be calculated with the following formula.

From CO_2 calculator->

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[1] For more information about Helsinki "chocolate calculator" visit "Journey Planner." Available: http://www.reittiopas.fi/en/.

$$User\ Total\ Private\ Vehicle\ Emissions\ (UTPVE) = (car\ emissions\ or\ motobike\ emissions) * \left(1 + \sum Ff_{PV}\right)$$

$$User\ Total\ Public\ Transport\ Emissions (UTPTE) = Public\ Transport\ Emissions * \left(1 + \sum Ff_{PT}\right)$$

From the food calculator ->

$$User\ Total\ ALM = total\ kcal\ in\ alternative\ modejourney * \left(1 + \sum Ff_{ALM}\right)$$

Where

Ff_m = Factor affecting energy efficiency by each m.

m = Each transport mode, ALM, PT and PV.

(Table 4) summarizes the affecting parameters and their respective values depending of the transport mode.

	Calculator			**Modes**		
	User	**System**	**Percentage**	**ALM**	**PT**	**PV**
Transport and Mobility offers						
Station/Stops distance	✓		Increasing the stop distance by 100 meters the use of PT decrease by 39%	**-**	**-0,39**	**-**
Share facilities	✓		Increase the use of bicycle by 60% Increase use of PT by 15%	**+0,6**	**+0,15**	**-**
Fuel	✓		Eliminating fuel subsides could reduce global greenhouse emissions by 10%	**-**	**-**	**-0,1**
Ticket PT	✓		Lower PT reduce car trips 19% and increase walking 13% and cycling 19%	**+0,32**	**-**	**-0,19**
Specific facilities	✓		57.5 per cent of all people with disability do not use public transport and 36% families with young children don't either?	**-**	**+0,1**	**-**
Car/ Motorbike	✓		Increasing car ownership 0.35 (cars per household) public transport (buses) fallen by 1/3	**-**	**-0,3**	**+0,35**
Bicycles/ Buses	✓		Increase the use of public transport by 31% with respect of the average	**-**	**+0,31**	**-**

			regional accessibility			
Trip characteristics						
Travel distance	✓		An increment of 5km: decrease walking and cycling by 88%, increase private car by 70% and increase PT by 27%	**-0,8**	**+0,27**	**+0,7**
Travel time	✓		Congestion increase in 30% the travel time	**-**	**+0,3**	**+0,3**
Environment/weather conditions						
Temperature		✓	The total number of car trips increased by 27% during winter in comparison with summer. At the same time, bicycle decreased by 47%	**-0,47**	**-**	**+0,27**
Precipitation		✓	Reductions in speed 10%-16% for heavy raining and heavy snow 15%-40%	**-**	**+0,15**	**+0,40**
Fog		✓	Reductions in speed 13%	**-**	**+0,13**	**+0,13**
Infrastructure						
Support during winter (cleaning)		✓	By improving winter maintenance service levels on cycle-ways, increase the number of bicycle trips during winter by 18%, representing a corresponding decrease in the number of car trips of 6%	**+0,18**	**-**	**-0,6**
Bike parking		✓	People typically drive 5-15% less in communities with good walking and cycling conditions than in more automobile-dependent areas	**+0,15**	**-**	**-**
Car parking		✓	Cost-based parking pricing typically reduce vehicle trips in 10-30% compared with unpriced parking	**-**	**-**	**-0,20**

Table 4: Factors affecting energy efficiency and selection of the calculator[2].

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[2] Alternative Transport Modes (ATM), Public Transport (PT), Private Vehicles (PV).

Calculator			
	Equation	**Variables**	**Description**
Transport and Mobility offers			
Station/Stops distance	$LS_i - LS_{i-1} > 100$	LS_i = Average distance between PT stops in time unit i [m] LS_{i-1} = Average distance between PT stops in time unit $i-1$ [m]	Increasing the stop distance by 100 meters the use of PT decrease by 39%
Share facilities or intermodal connectivity	$OF_i - OF_{i-1} > 1$	OF_i= overall intermodal facility in time unit i OF_{i-1}= overall intermodal facility in time unit $i-1$	Increase the use of bicycle by 60% Increase use of PT by 15%
Fuel	$\frac{FP_i - FP_{i-1}}{FP_{i-1}} * 100 \geq 18\%$	FP_i=fuel price in time unit i FP_{i-1}= fuel price in time unit $i-1$	Increasing price of fuels, reduce short trips (car) by 5.3% and 2% in car kilometers
Ticket PT (Price reduction)	$\frac{PTP_{i-1} - PTP_i}{PTP_{i-1}} * 100 \geq 20\%$	PTP_i=PT price in time unit i PTP_{i-1}= PT price in time unit $i-1$	Lower PT reduce car trips 7.3% and increase walking 13% and cycling 19%
Specific facilities	$SF_i - SF_{i-1} > 1$	SF_i= specific facilities in time unit i SF_{i-1}= specific facilities in time unit $i-1$	57.5 per cent of all people with disability do not use public transport and 36% families with young children
Car/ Motorbike	$\frac{CW_i - CW_{i-1}}{CW_{i-1}} \geq 0.35$ $CW = \frac{V_{pi}}{H}$	H =Total number of inhabitants V_{pi} =number of private vehicles CW_i= car ownership level in time unit i CW_{i-1}= car ownership level in time unit $i-1$	Increasing car ownership 0.35 (cars per household) public transport (buses) fallen by 1/3
Bicycles/ Buses	$\frac{BS_i - BS_{i-1}}{BS_{i-1}} * 100 \geq 5\%$	BS_i= average number of bus lines by city area in time unit i BS_{i-1}= average	Increase the use of public transport by 31% with respect of the average regional accessibility

		number of bus lines by city area in time unit $i-1$	
Trip characteristics			
Travel distance	$DT_i - DT_{i-1} \geq 5km$	DT_i= Average distance travelled [Km] in time unit i. DT_{i-1}= Average distance travelled [Km] in time unit $i-1$.	An increment of 5km: decrease walking and cycling by 88%, increase private car by 70% and increase PT by 27%
Travel time	$\frac{T_i - T_{i-1}}{T_{i-1}} * 100 \geq 1\%$	T_i= Average travel time in time unit i T_{i-1}= Average travel time in time unit $i-1$	Estimate travel time elasticity for car use is -0.12 for PT is +0.39 and slow modes (ALM) is +0.19
Environment/weather conditions			
Temperature	Se	Se=season [winter, summer]	The total number of car trips increased by 27% during winter in comparison with summer. At the same time, bicycle decreased by 47% Summer= car distance increase for recreational purposes by 25%; one degree increase raised the likelihood of biking by about 3%
Precipitation	Pt	Pt= presence of precipitation type [rain or snow]	Reductions in car speed 10%-16% for heavy raining and heavy snow 15%-40% Raining reduce biking by 65% One inch of snow on the ground reduced the likelihood of biking by about 10%.
Fog	Fg	Fg= presence of fog	Reductions in car speed; 13% increase in fog decreased commuter biking likelihood by about 5%.

Infrastructure			
Support during winter (cleaning)	$\frac{A_r - A_{rW}}{A_r} \geq 0.6$	A_r= Total traffic-free (TF) and on-road (OR) routes in km A_{rW}= Total TF and OR routes clean during winter in km	By improving winter maintenance service levels on cycle-ways, increase the number of bicycle trips during winter by 18%, representing a corresponding decrease in the number of car trips of 6%.
Bike parking	$Bp_i - Bp_{i-1} \geq 1$	Bp_i= number of areas with bicycle parking in time unit i Bp_{i-1}= number of areas with bicycle parking in time unit $i-1$	People typically drive 5-15% less in communities with good walking and cycling conditions than in more automobile-dependent areas
Car parking	$\frac{Cp_e - Cp_f}{Cp_e} \geq 0.6$	Cp_e =number of cost-based car parking Cp_f= number of free-cost car parking	Cost-based parking pricing typically reduce vehicle trips in 10-30% compared with unpriced parking

Table 5: List of specifications of the affecting parameters.

3.2 Satisfaction calculator

The satisfaction calculator is composed by two factors: the parameters that affect the modal choice and the mode-specific attributes. In this section it is described how these factors and attributes affect user satisfaction with travel and the optional modes.

The parameters that affect modal choice were described in D4.1 in section 4 and the attributes in the Appendix B in this document.

The mode-specific attributes pretend to measure satisfaction as the degree in that a transport mode providing a service that fulfil travel needs. This way of measuring satisfaction had been under study for several years, being car and PT modes the most studied ones. The following table summarizes the modes attributes for PT, PV and ALM:

ATTRIBUTES
Access to bus stop

Wait time or frequency
Reliability
Travel price
Trip length
Vehicle design
• Relating comfort
• Security
• Cleanliness
• Privacy
Drivers interaction with users
• Willingness to serve
• Knowledge
• Competences
Stress
Travel Information
• Departure
• Destination
• Personalization
Type of pavement
Social interaction
• Boring
• Fun
• Lifestyle match
Scenery
Crowdedness
Air quality
Presence of nature
Exercise
Seat availability

Table 6: Modal attributes for PT, PV and ALM

The calculator initially asks the users to rank the attributes in order of how much they impact in his/her satisfaction. After the ranking, the user should select for each of the attributes the position in where he thinks each of the modes should be. For example the user XXX choose Lifestyle match as the most important attribute for him. Then, the calculator ask which of the modes match more with XXX's lifestyle, to where user respond: PV, ALM, PT. In that way, the calculator will know that when the journey planner gives the journey options the value for satisfaction in PV will be high and PT will be low. The sequence of the calculator can be seeing in (Figure 5)

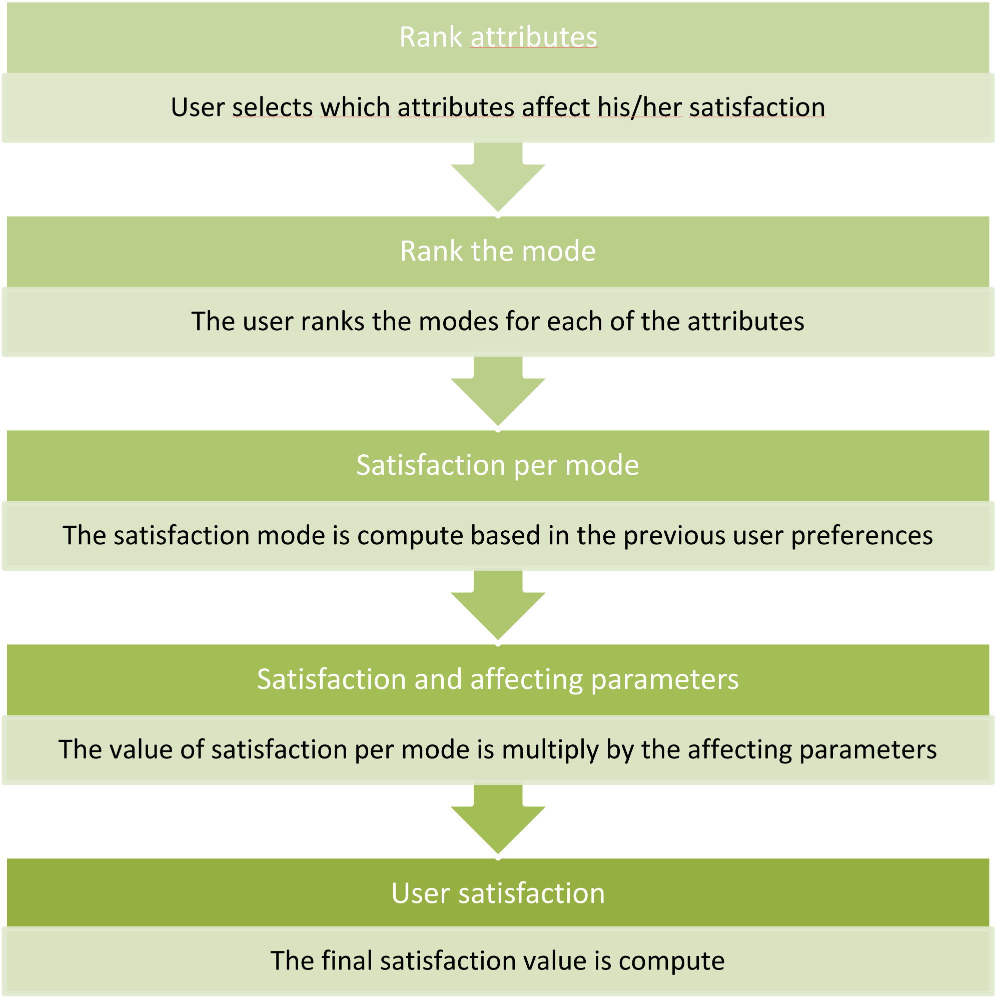


Figure 5: Satisfaction calculator steps

3.3 Energy consumption of ICT solutions for the transportation domain

ICT (Information and Communication Technologies) have the potential to provide change on how people drive and their mobility patterns, thus potentially reducing the Green House Gases emissions, air pollutants and fatalities. In this section we will look into a brief review of the energy consumption and environmental impact of implementing ICT solutions in the Transportation domain [61]

ICT can be a very powerful drive to promote change, as if applied to vehicles through on board user aid devices for educating the driver, improving efficiency, reducing costs and environmental impacts of urban mobility. ICT deployed in the road network are more traditional ways for enforcing a change, by using stricter Variable Speed limits (VSL) depending on traffic, infrastructure and weather information. As for ICT applied on the vehicle, several on-board user aid technologies and for bus fleets have proved that potential to educate the driver towards better driving habits that can reduce fuel consumption up to several percent less in over few months [61].

ICT has impact in total energy consumption of any system, so they, should be properly evaluated. ICT equipment in a typical manufacturing facility consists of routers, switches, energy meters, NFC/RFID, etc. ICT sector is responsible for 2% of global carbon emissions. With the rapid increase in ICT, the energy consumption and carbon emissions are also growing rapidly.

Intelligent Transport Systems (ITS) are being developed to help resolve various problems and social issues caused by the modern transportation environment through the adoption of innovation technologies. Examples of these problems include traffic accidents, congestion, the increasing load placed on environment by emissions and so on. An ICT infrastructure is a necessary condition for the deployment of ITS services [59].

The connected ICT infrastructure should consist of the following three dimensions:

- Systems for collection of data (Monitoring and positioning systems)
- Systems and protocols for communicating data (Between traffic control centers and to and from vehicles)
- Quality of the data (Accuracy, timeliness) [56]

Data collection: Data collection is done by road operators using sensors, induction loops, cameras and information from police or road users. Data is then processed in traffic control centers and information disseminated via radio, Internet or other means. For better data quality at a lower price, the conventional systems are complemented with detection based on objects floating with traffic.

Satellite navigation: Satellite navigation is needed for any services based on location such as tolling, navigation systems or travel information (i.e. local transport).

Accuracy, reliability and quality of data: Data should be available for effective traffic management and information services [56].

For the calculations of energy consumption of the ICT infrastructure, first of all it is needed to identify the sytems that are present inside the infrastructure and to identify the devices (e.g. Traffic sensors, induction loops, surveillance/CCTV cameras, data centers, traffic management system, servers, system networks, etc.) that contribute to ITS infrastructure. The pilot cities have adopted the plans and measures, to deal with the urban mobility in strategic terms also talking advantage of technology development of ITS sytems.

A generic ICT infrastructure example is presented in (Figure 6). As can be seen, the infrastructure include the devices that are used to gather the data (e.g. sensors), the servers and the systems that are used to process the data and generate new relevant information and the systems where the information is used for different purposes, e.g. user interface like MoveUs journey planner and 3rd party applications.

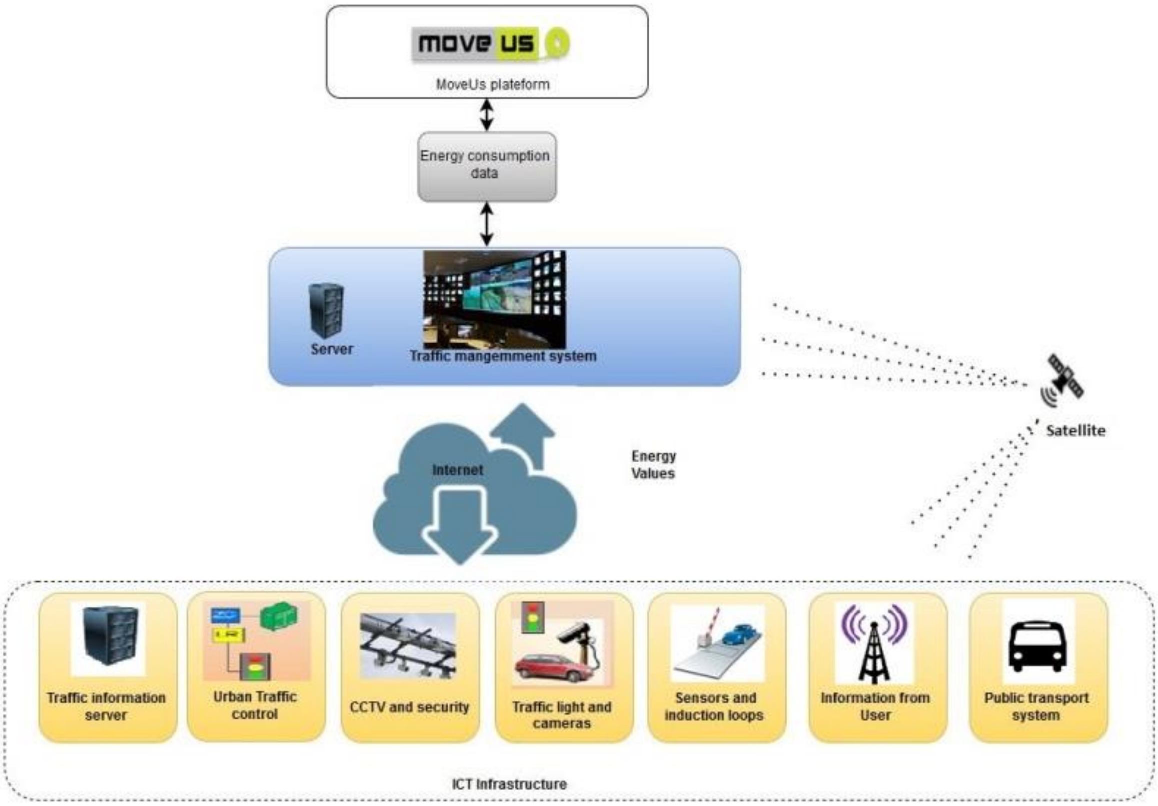


Figure 6: ICT infrastructure energy calculation

In order to make a proper assessment of the energy efficiency of MoveUs solutions for the three pilots of the project, the energy savings that will be obtained from MoveUs's users will be compared with the total energy consumption of the ICT infrastructure in the corresponding city.

For example, assume the following energy consumption of a simple system included in (Table 7), which consists or the sensors, switches, energy meters, routers/hubs, server, and data center. The example is presented using the fixed values from data sheets, of the mentioned equipment.

No.	ICT Equipment	Count	Equipment Details	Energy consumption (Watts)
1	Controller	25	Inico S1000	8*25 =200 W
2	Switches	10	HP 1410-8G Switch	12*10 =120 W
3	Switches	3	Cisco 2950 Series Switch (WS-C2950-48-EI)	45*3 =135 W

4	Server	1	Server (Lenovo-T410)	90*1=90 W
			Total	545 Watt

Table 7: Example for energy Consumption in MWh of a simple ITS system [57]

The total power consumed by the assumed system is 545 Watt. In the same way, the devices and systems in the infrastructures of Madrid, Genoa and Tampere will be evaluated to obtain the total energy that is consumed to generate the final information that is provided to MoveUs users to influence their choices.

As first step, the infrastructure of the cities will be identified including, the developments for MoveUs project like Multimodal Journey Planners and Energy Consumption Calculator. In this deliverable, we will include a general view of the infrastructure and the detailed information related to energy consumption and the comparison with the energy savings will be presented in D4.3.

The general infrastructure of the cities is as follows:

Madrid:

For the city of Madrid, infrastructure description of the overall architecture and systems includes the Traffic Management Systems, the Public bus operating system, the public bus information system and the public bike system. Traffic Management System provides the capability to support and operate a wide variety of subsystems from mobility control system, SICTRAM, Urban traffic Centralized Sytems (UTCs), M30 Surveillance and Control Application (SCA), Tunnel Surveillance and control Application (T-SCA), Closed Circuit television (CCTV), Access Control systems to restricted urban areas, Red light cameras, Speed cameras, Traffic information web servers, Mobility information Website and Bus Fleet Management System [67].

Systems Already deployed	Systems Developed in MoveUS
Urban traffic management System	Smartcrossing system
Madrid open data portal, including: - **Traffic Information** - **Road static Information** - **Incidents Information** - **Bike parking places information**	Times of road travel prediction system, based on: - Bluetooth-based road detectors
Public bus operating system **Public bus information system, including:** - **Public bus journey planner**	Multimodal journey planner, including: - On-trip incidents warning, - Re-routing functionality, for eco-efficient drivers.

	Prioritization of vehicles (buses) system
Madrid public bike system	

Table 8: Systems developed and the systems(to be developed)for MoveUs,Madrid

Genoa:

In Genoa, the current technological infrastructures for mobility users includes a WIFI networks in proximity of the main points of interest of the city, the public network is directly managed by the municipality or by other Public administrations. Apart from public WIFI network, other private owned networks are also installed. The main ITS system currently available in Genoa are: Sigma and Traffic lights control, TCT system (Traffic Monitoring System) Incident control database, pollutant emission data collection, MobiGIS, Public Transport management, Electronic Fee collection. Most of the systems mentioned, are connected to a central control system. Traffic Supervision System for Genoa was developed during the period 2012 and 2013 [67].

Systems Already deployed	Systems Developed in MoveUS
WiFi networks (Municipality of Genoa) Rest-JSON Web Service	Multimodal Journey planner
MobiGIS and different GIS layers based on GEOSERVER Infrastructure	Consumption estimator calculator (EC and CF)
Public transport management (Transit in Real Time - SIMON, AMT GTFS schedule)	Incentive Model
Traffic Supervisor system	Crowd data management
Historical Incidents information	
Weather Sensors (Civil Protection) Rest-JSON Web Service	
Air Sensors (Metropolitan City) Rest-JSON Web Service	
Monica (Roadwork) Rest-JSON Web Service	
e-miXer Infrastructure (Infomobility Dispatcher)	
Open Trip Planner (OTP) Infrastructure	

Table 9:Systems developed and the systems (to be developed)for MoveUs, Genoa

Tampere:

Tampere’s target is to enable integrated awareness of Energy consumption of all possible journey options (i.e. mobility and routing), per user. The general objective is to reduce the environmental impact of the urban traffic in Tampere allowing fluent, environmental friendly and safe flow of public and private vehicles. MoveUs developments in Tampere will rely on ITS Factory a new innovation experimentation can development environment, where companies and individual developers can develop, test and productize traffic solutions. The solutions can be built on top of a continuously updated traffic open data. The target users are public transport user, municipality of Tampere, Managers of public transport services, Engineers of public transportation services.

Tampere's Infrastructure is quite convenient for MoveUs; the Municipality of Tampere owns the entire traffic infrastructure, data and services for public transportation, parking facilities, charging stations for electrical vehicles. Tampere provides its mobility users 21 information displays at various bus stops, 170 crossing with traffic detection sensors, 30 intelligent traffic monitoring units and the ITS Factory plate form, providing open data about traffic in Tampere. The infrastructure is very convenient to work with, and open data is readily available [67].

Systems Already deployed	Systems Developed in MoveUS
Traffic information providers	Car journey planner Free parking spaces
Bus journey planner	Energy efficiency calculator
Journey planner for cycling and walking	Incentive model

Table 10: Systems developed and the systems(to be developed) for MoveUs,Tampere

4 Energy labels for user awareness and automatic transformation of energy values into meaningful information

4.1 Energy labels for user awareness

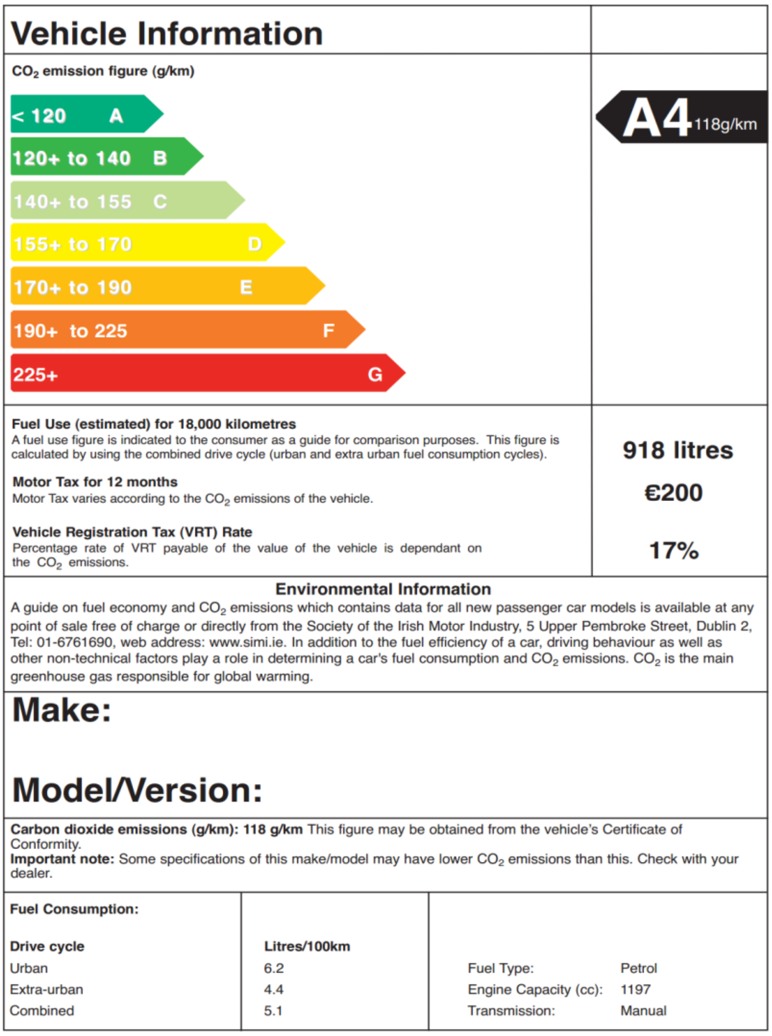
4.1.1 Factors to be considered while assigning eco-labels

Ecolabels are a means for people to make aware about the environmental savings done. Now, most of the people do not understand its significance. People do not have enough environmental information or awareness hence doesn't follow the eco labels. There is not enough information about the environmental impacts created by the different type of vehicles and how the pollution varies from vehicle to vehicles. For example, it was seen by EPA that cars were cleaner, and the light duty vehicles like trucks and SUV's were major contributors in pollution. It is necessary for people to be given eco-information and more importantly to see if this acquired information is put into practice. Thus consumer behaviour, attitude towards eco information, gained different reactions of consumers towards eco labels need to be studied. A survey was carried out in Maine on people who had registered their vehicles. The respondents were provided with a questionnaire of 41 questions and 7 sections. Five distinct eco-labels were provided with varying text or information levels. Questions asked were if the respondents gained the required environmental information, whether they were ready to buy the product if both labelled and non-labelled carried same piece of information. The results obtained by people's ratings on various factors like perceived environmental friendliness, obtained label information, interest to purchase such vehicles concluded following things. People responded positively where vehicles were compared with vehicles of other class. Also it depended on how much familiar are people about the particular label. Thus it is very necessary to provide eco-information and eco-marketing strategies.[43]

4.1.2 Eco-labels in various domains

EU Directive 92/75/EC has set the energy labels for various domains suggesting labelling pattern from A to G and rating 'A' as the 'highest energy efficiency' one and 'G' as the 'lowest energy efficiency'. Following are the various labels set by it:

For vehicles, as we saw in the previous section, the most common method is showing the fuel economy values. This would enhance selection of vehicles contributing fewer emissions. Below is the example of this wherein different levels of CO_2 are set from A to G. Also there is additional information provided on brand, model, version, fuel, transmission type, weight, and different consumptions of fuel.



Vehicle Information

CO$_2$ emission figure (g/km)

< 120 A	
120+ to 140 B	
140+ to 155 C	
155+ to 170 D	
170+ to 190 E	
190+ to 225 F	
225+ G	

A4 118g/km

Fuel Use (estimated) for 18,000 kilometres A fuel use figure is indicated to the consumer as a guide for comparison purposes. This figure is calculated by using the combined drive cycle (urban and extra urban fuel consumption cycles).	**918 litres**
Motor Tax for 12 months Motor Tax varies according to the CO$_2$ emissions of the vehicle.	**€200**
Vehicle Registration Tax (VRT) Rate Percentage rate of VRT payable of the value of the vehicle is dependant on the CO$_2$ emissions.	**17%**

Environmental Information

A guide on fuel economy and CO$_2$ emissions which contains data for all new passenger car models is available at any point of sale free of charge or directly from the Society of the Irish Motor Industry, 5 Upper Pembroke Street, Dublin 2, Tel: 01-6761690, web address: www.simi.ie. In addition to the fuel efficiency of a car, driving behaviour as well as other non-technical factors play a role in determining a car's fuel consumption and CO$_2$ emissions. CO$_2$ is the main greenhouse gas responsible for global warming.

Make:

Model/Version:

Carbon dioxide emissions (g/km): 118 g/km This figure may be obtained from the vehicle's Certificate of Conformity.
Important note: Some specifications of this make/model may have lower CO$_2$ emissions than this. Check with your dealer.

Fuel Consumption:

Drive cycle	**Litres/100km**		
Urban	6.2	Fuel Type:	Petrol
Extra-urban	4.4	Engine Capacity (cc):	1197
Combined	5.1	Transmission:	Manual

Figure 7: Energy label for vehicles [44]

Below shown is the energy label for energy consumption of bulbs and luminaires proposed as per European directive Energy Label 874/2012. Here, A++ indicates high energy efficiency going till E which denotes very low energy efficiency.

Figure 8: Energy label for bulbs and luminaires[45]

European commission has proposed the following label for tyres enabling saving of fuel.

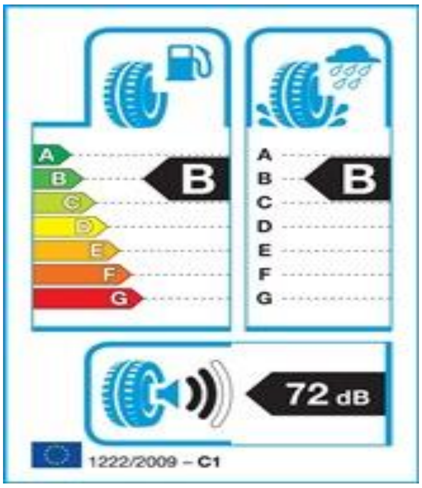


Figure 9: Energy label for tyres[54]

The tyres are marked as A for best and G for bad also considering various other parameters that includes fuel efficiency, wet grip and external rolling noise. Here the wet grip and rolling resistance, which should be lower for energy efficiency is denoted from A to G. And the noise levels can be indicated as one black wave signifying lowest noise level and 3 signifying maximum noise level.

4.1.3 Definition of Energy Label for MoveUs

The energy label for MoveUs will be developed for MoveUs smart phone App. The input to this application will be the starting point and destination where the user wants to go. It is proposed to assign energy labels for different mobility options. The mobility options would be the output of the MJP which are bus, car, cycling, walking. Thus, there should be some approach in order to define an energy label in such a way that it would give completely the desired information and the user would be able to understand its ecological importance. Normally, the output of the App would be gCO_2 for car and bus and it would be calories spent for ALM. These calculations as seen in section 3 of this deliverable are a result of the energy calculator module. The information provided on savings is gCO_2 and calories, which should be utilized to generate proper energy label.

But this information on label is not very clearly understood by people. To bring a change in behavioural pattern of people is one of the main concern for MoveUs project and most of the energy project, which is the most critical thing. There has to be proposed some means by which the CO_2 values are translated in such a way that the whole meaning about the environmental concern is fully understood and interest is shown to do something to aid eco-friendly behaviour, in our case, usage of public transport or ALM.

Thus, along with energy label comes the automatic translation of emission and calories values, which could be easily understood by people to bring about a change in behavioural pattern of people.

4.2 Automatic translation

Following are certain ways proposed by US EPA for greenhouse gas equivalencies (CO_2 equivalents):

Sr. no	**Equivalent name**	**Calculation method**	**CO2 equivalent to**
1	Barrels of oil consumed	5.80 mmbtu[3]/barrel × 20.31 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg	0.43 metric tons CO_2/barrel
2	Tanker trucks filled with gasoline	8.89 × 10^{-3} metric tons CO_2/gallon × 8,500 gallons/tanker truck	75.54 metric tons CO_2/tanker truck
3	Number of incandescent bulbs switched to compact fluorescent bulbs	47 watts x 3 hours / day x 365 days / year x 1 kWh / 1,000 Wh 51.5 kWh / bulb / year x 1,637.5 pounds[4] CO_2 / MWh delivered electricity x 1 MWh / 1,000 kWh x 1 metric ton / 2,204.6 lbs	51.5 kWh / year / bulb replaced 3.82 x 10^{-2} metric tons CO_2 / bulb replaced
4	Home electricity use	12,069 kWh per home × 1,232.4 lbs CO_2 per megawatt-hour generated × 1/(1-0.072) MWh delivered/MWh generated × 1 MWh/1,000 kWh × 1 metric ton/2,204.6 lb	7.270 metric tons CO_2/home
5	Home energy use	Electricity: 12,069 kWh per home × 1,232 lbs CO_2 per megawatt-hour generated × (1/(1-0.072)) MWh generated/MWh delivered × 1 MWh/1,000 kWh × 1 metric ton/2,204.6 lb Natural gas: 52,372 cubic feet per home × 0.0544 kg CO_2/cubic foot × 1/1,000 kg/metric ton Liquid petroleum gas: 70.4 gallons per home × 1/42 barrels/gallon × 219.3 kg CO_2/barrel × 1/1,000 kg/metric ton Fuel oil: 47 gallons per home × 1/42 barrels/gallon × 429.61 kg CO_2/barrel × 1/1,000 kg/metric ton Total CO_2 emissions for energy use per home: 7.270 metric tons CO_2 for	7.270 metric tons CO_2/home 2.85 metric tons CO_2/home 0.37 metric tons CO_2/home 0.48 metric tons

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[3] 1 BTU= 1055joules

[4] 1 lbs = 0.45359237 kg

		electricity + 2.85 metric tons CO$_2$ for natural gas + 0.37 metric tons CO$_2$ for liquid petroleum gas + 0.48 metric tons CO$_2$ for fuel oil	CO$_2$/home 10.97 metric tons CO$_2$ per home per year
6	Number of tree seedlings grown for 10 years	23.2 lbs C/tree × (44 units CO$_2$ ÷ 12 units C) × 1 metric ton ÷ 2,204.6 lbs	0.039 metric ton CO$_2$ per urban tree planted
***7**	Acres of U.S. forests storing carbon for one year	-0.33 metric ton C/acre/year* (44 units CO$_2$ ÷ 12 units C)	-1.22 metric ton CO$_2$ sequestered annually by one acre of average U.S. forest
***8**	Acres of U.S. forest preserved from conversion to cropland	-35.32 metric tons C/acre/year* (44 units CO2 ÷ 12 units C)	-129.51 metric tons CO$_2$/acre/year
9	Propane cylinders used for home barbecues	18 pounds propane/1 cylinder × 0.817 pounds C/pound propane × 0.4536 kilograms/pound × 44 kg CO$_2$/12 kg C × 1 metric ton/1,000 kg	0.024 metric tons CO$_2$/cylinder
10	Railcars of coal burned	21.48 mmbtu/metric ton coal × 26.05 kg C/mmbtu × 44 kg CO2/12 kg C × 90.89 metric tons coal/railcar × 1 metric ton/1,000 kg	186.50 metric tons CO2/railcar
11	Pounds of coal burned	21.48 mmbtu/metric ton coal × 26.05 kg C/mmbtu × 44 kg CO$_2$/12 kg C × 1 metric ton coal / 2,204.6 pound of coal x 1 metric ton/1,000 kg	9.31 x 10-4 metric tons CO2/pound of coal
12	Tons of waste recycled instead of landfilled	0.76 metric tons of carbon equivalent/ton × 44 kg CO$_2$/12 kg C	2.79 metric tons CO$_2$ equivalent /ton of waste recycled instead of landfilled
13	Number of garbage trucks of waste recycled instead of landfilled	2.79 metric tons CO$_2$ equivalent /ton of waste recycled instead of landfilled x 7 tons / garbage truck	19.51 metric tons CO$_2$E /garbage truck of waste recycled instead of landfilled
14	Coal-fired power plant emissions for	1,729,127,770.8 metric tons of CO$_2$ × 1/454 power plants	3,808,651 metric tons CO2/power plant

	one year		
15	Number of wind turbines installed	1.94 MWaverage capacity x 0.31 x 8,760 hours / year x 1,000 kWh/MWh x 6.89551 x 10-4 metric tons[5] CO2 / kWh reduced	3,633 metric tons CO2 / wind turbine installed
16	Electricity Reductions (kilowatt-hours)		6.89551 × 10-4 metric tons CO_2 / kWh
17	Gallons of gasoline consumed	8,887 grams of CO_2 /gallon[6] of gasoline	8.887 × 10-3 metric tons CO_2/gallon of gasoline
18	Passenger vehicles per year	8.89 × 10^{-3} metric tons CO_2/gallon gasoline × 11,318 VMT $_{\text{car/truck average}}$ × 1/21.4 miles per gallon $_{\text{car/truck average}}$ × 1 CO_2, CH_4, and N_2O/0.988 CO_2	4.75 metric tons CO2E /vehicle/year
19	Miles driven by the average passenger vehicle	8.89 × 10-3 metric tons CO_2/gallon gasoline × 1/21.4 miles per gallon car/truck average × 1 CO_2, CH4, and N2O/0.988 CO_2	4.20 x 10-4 metric tons CO_2E /mile
20	Therms of natural gas	0.1 mmbtu/1 therm × 14.46 kg C/mmbtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg	0.005302 metric tons CO_2/therm

Table 11: Carbon equivalents according to US EPA [52]

In order to select the best option from above mentioned equivalencies it is needed to understand the working of the app described below.

The MoveUs Journey Planner will provide users with different travel options according to their preferences.

The trip options could be:

- The fastest
- The least expensive
- The shortest
- With minimum number of exchanges
- Available for unpaired people
- The most comfortable
- Using only one mode
- The least expensive in term of energy consumption

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[5] 1 ton = 10^3 kg

[6] 1 gallon= 4.54609E-03 m^3

- etc.
- or a mix of all options above.

Accordingly, the measurements units would be time, euro, energy, distance, number of exchanges, number of modes, various qualitative units, etc. The energy consumption is common to all options; therefore, we propose to use this measurement unit for each trip option, which is fully compliant with the purpose of MoveUs, focused on energy savings.

Energy consumption is usually measured in kWh; this unit is not fully understandable by users, with a few exceptions, and then we propose to convert kWh into euros using the average price of home electricity in each country: Spain, Finland and Italy. In Italy the domestic electricity price is about 0,3 euro/kWh. Having a common unit is useful for the incentive section of the project; in Deliverable D2.2 par 3.4.7.4, a methodology for measuring the mobility and calculating the incentives was described.

Beside Monetary and In-kind incentives, credits can be assigned to users if they save energy, for example according to the inverse proportion to energy consumption of the chosen trip option. So now as the energy label and transformations are understood we can merge them both to create both visual and understandable impact. For the information now to be visualized in an eco-way we could make use of leaves. A structure could be shown as below:

The scale can be calibrated having one side as gCO_2 and the other as Euros which is the translated value. So as the user enters start and end location, every mode of transport will have each energy label. The scale is divided as very good, average and worse. And on the other side would be the euros spent in electricity as minimum, moderate, maximum. The car would act as a pointer shifting on the euro and gCO_2 scale depending on levels of CO_2 emitted.

Now, for each mode of transport the appropriate equivalent could be kWh of electricity consumption. This can be also related to the daily electrical equipment we use like kWh of refrigerator, kWh of washing machine and so on. Now naturally the consumption for Bus would be less. This kWh can be converted to euros according to the daily electricity pricing in Europe. The user option is saved each time a choice is made. Then if the user chooses PT next time then the savings in euros can be seen. Each saving could be shown as a happy Eco leaf. Thus, at the end of the month the user profile can be seen with the registered user having particular number of happy leaves according to the savings made. Now, these leaves can be used for granting incentives. For particular amount of leaves would be corresponding incentives.

Another option could be the carbon sequestration concept. A case study was done in Italy to check how the urban streetscape aid in offsetting the CO_2 produced by transportation sector. The study results showed that it was possible to offset 0.08% of the total CO2 emitted by transportation sector.[68]

Forest proves as a great source for carbon sink. It is seen through reports that 30-50% of the total greenhouse gases are sink in Finland’s forests. Thus, carbon sequestration concept can be very beneficial in terms of Carbon storage.[49]

Moreover, the Finnish culture is very close towards nature as the trees serve as a source of relieving stress, peace of mind and recreation [50]. Also the trees lay their grounds in ancient Finnish myths and culture signifying sacred places in forests for worshipping God [51]. Similarly it is seen that trees are of utmost importance in every culture. Thus another proposal for translation of energy consumption values is the number of trees equivalent.

In order to increase the impact of the solution, the conversion will be done for each pilot to specific trees that are relevant in their cultural or natural aspects. Therefore, the following trees are chosen as an equivalent to every pilot:

- Madrid: Encina (evergreen oak), Quercus ilex (National tree of Spain)

Figure 10: Tree selected for Madrid pilot

- Genoa: Olive, Oak, Olea europaea (National tree of Italy)

Figure 11: Tree selected for Genoa pilot

- Tampere: Silver birch, Betula Pendula (National tree of Finland)

Figure 12: Tree selected for Tampere pilot

4.2.1 Transformation method 2 (Carbon sequestration method)

Carbon sequestration is a process of capturing and storing the atmospheric CO_2 on a long tenure [53]. Every tree has different amount of carbon sequestration rate depending on various environmental factors. But in order to generalize we assume a common factor relying on following statement. According to US EPA an urban tree stores 0,039 metric ton of CO_2 for 1 year i.e. 3900 gCO_2 in 1 year [52].

Algorithm:

The output of the MoveUs app, after the user start-end location is specified, includes the emissions (i.e. g CO_2) produced by PT and private vehicle modes. Following formula as per US EPA shows the CO_2 storage of an urban tree.

23,2 lbs C/tree × (44 units CO_2 ÷ 12 units C) × 1 metric ton ÷ 2,204.6 lbs =0,039 metric ton CO_2 per urban tree planted [52]:

$$\frac{(23{,}2\ \text{lbs C/tree}) * (44\ \text{units CO2}\ \div\ 12\ \text{units C}) * (1\ \text{metric ton})}{2{,}204.6\text{lbs}} = 0.039\ \text{metric ton CO2 per urban tree planted}$$

The algorithm thus for the translation to number of trees is as follows:

1. Consider the emissions output obtained for each mode of transport after the user enters start end locations.

2. We know that one urban tree sequesters 0.039 metric ton CO_2 for one year.

3. Now divide this emission output from each mode of transport by the amount of CO_2 sequestered by one urban tree i.e. ($AgCO_2/39000$)

Where, A is the gCO_2 emitted by transport mode. A should be multiplied by 365 to get the amount of CO2 emitted if the same kind of trip option is used for a year.

4. Thus, the division rate would be the number of trees required to offset the emissions caused by vehicles for one year.

Amount	Unit	Gas
0.039	Metric Tons ▾	CO_2 - Carbon Dioxide or CO_2 Equivalent*

Carbon sequestered by

1

tree seedlings grown for 10 years

Figure 13: Conversion from emissions to trees equivalent [52]

The conversion can be seen from the above figure. It is expected that this additional information would encourage users to shift to PT. Moreover, for encouraging the use of ALM it is proposed the translation of calories into number of chocolates, which is discussed in section 3.1.2 of this deliverable. A means of healthy life by burning more calories and gaining more chocolates is the ideology behind this.

So the energy label could also be shown as a beam balance with earth balancing. On one side the weight could be shown as a transport mode and on other side the weight would be equivalent number of trees to sustain the gCO_2 generated by that transportation mode.

5 Energy efficiency assessment plan and report

5.1 Plan for energy efficiency assessment plan and report

MoveUs focuses on services that would lead to reduction of CO_2 emissions in cities, which are a result of inappropriate user mobility behaviour's. Now, in order to see how much these services have influenced people's choice it is required an evaluation. Hence it is needed to perform an energy assessment task. Energy assessment could be defined as the result obtained after comparison between initial values of energy consumed and the new values obtained after deploying the MoveUs services.

For energy assessment of the pilot cities it is needed to know what is the energy consumed by each of the cities and on what parameters does it depend upon. Hence, KPI's are defined whose values would help to determine the energy utilized in transportation considering all the different environmental and user choice parameters.

Thus MoveUs has provided City services to the 3 pilot cities depending on their needs and goals to achieve energy efficient transportation. The use of this city services would be available to end users via applications in their smartphones. The users are guided by this application to choose proper mode of transportation depending on the time, distance and energy consumption. The carbon emissions value for each mode of transport would be provided making user to decide on energy efficient transport. But this value doesn't prove helpful to user. In order to impact user behaviour some other means are required. Thus MoveUs provides the translation of values into user understandable manner, which is of highly importance to the user for e.g. euros.

An effective assessment report can be generated so that it is clearly known what positive results are seen and where are the weak points needed to be focused upon to obtain a more successful result.

A generic report is defined and then a tailored version for each one of the pilots. The tailored report will be generated depending upon the targets that each city had set to be achieved by the deployment of particular services. Now the assessment is made both from users and cities point of view.

- **Energy Assessment for Users:**

The users are provided with different travel options in the journey planner. Depending on the user choice there would be generated energy label and the translation of emission values to number of trees required to offset CO2 from transport mode. There can be case that the user next time switches to greener mode of transport like walking, bicycle, PT. Now the emitted CO_2 would be less. Thus, a comparison is made between the previous and new travel choice and a clear comparison could be seen how user is moving towards greener transportation mode.

- **Energy assessment for Cities:**

The KPI's consist of all the valuable important data regarding energy consumption. There were limits set in D4.1 Now, there would be continuous measurement of this open data available on the MoveUs platform. At the end of the year a comparison would be made whether the set targets are achieved or not. Thus, it would be reflected how the different services provided and the provision of open data has helped to achieve the main aim of energy efficiency in smart mobility.

5.1.1 State of art for energy assessment

A case study from Istanbul performed an assessment of Electrically Driven vehicles to see the impact of reduction of CO_2. Also the recharging points and ease of availability of the EDV's were considered. The assessment was done to check the effects of CO_2 changes and need of using alternative energy resource like wind energy for fulfilling energy requirements charging for utilizing EDV's. For this the total electricity consumption for a year for Istanbul was predicted using RBFN structure. The required inputs for the training set comprising of electrical consumption in residential areas, commercial areas, public institutes, industrial areas, lighting areas of the model were estimated. The real values i.e. the inputs were considered between 1998 to 2008. The RBFN structure estimated the value of electricity consumption for the year 2009. And it was seen that the estimated value was very close to real value showing negligible error. Similarly results were obtained for upcoming years until 2020, which showed a rising trend in electricity consumption indicating the boost in the consumption of electricity due to the introduction of EDV's. Thus, next step was to consider renewable energy like wind energy which would suffice the needs of electricity for recharging. Assessment was done in a part named Catalca to see the characteristics and the technical information of wind farms to find out the potential of usage. It was assumed that the penetration rates of the EDV's are 2%, 5%, 10% of light vehicles. The results obtained after analysing the total electricity consumption up to 2020 and the penetration rates of EDV's in upcoming years along with usage as wind energy as a renewable resource for charging the EDV's were promising. There was both social, as well as economic betterment. The reductions seen in CO_2 emissions were 157, 393 and 787 thousand tons according to the penetration rates of 2%, 5%, 10% for EDV's and the economic benefits due to these reductions were 4, 9 and 18 million euro respectively [46].

A research was carried out in Modena and Firenze provinces of Italy whereby, mobility patterns where analysed for a period of one month by employing GPS devices connected to remote storage unit via GSM to electric vehicles. The results comprised of determination of number of trips carried out, distances travelled, parking durations and geographical distribution of trips. The main aim here was the assessment of electrification of urban road transport based on real time information on mobility [47].

ieCOtrans is one of the projects that dealt with the socio-economic, environmental assessment of the measures that were taken for the transport sector. Here different measures were taken with respect to energy and then it was assessed how the involvement of those measures created some change. Measures applied were like making some technological innovations in transportation means, trying to increase the occupancy by physically intervening the transport sector, making modal change so as to choose transportation with less energy consumption. Also promoting efficient driving behavior by reducing consumption and reducing demand were the measures. Economic factors were also assessed because along with the economic development there is simultaneous increase in the mobility bringing about addition to emissions [48].

5.2 Final data for energy assessment plan

The selected KPI's that will be used to determine the energy performances for each pilot city were described in Deliverable D4.1. But out of these not all of them were possible to obtain as there were certain KPI's with missing data sources and hence the KPI could not be calculated. Therefore, the list of KPI's, which could be fully computed for each pilot, is included below.

5.2.1 Final KPIs and parameters for Madrid

List of available KPI's for Madrid:

Sr.no	KPI's	KPI's Description
1	KP10	Private vehicles density rate
2	KP18	Traffic free and OR routes
3	KP20	Facilities density in alternative modes
4	KP26	Public transport reliability
5	KP29	Private vehicles cubic capacity average

Table 12: List of KPI's for Madrid pilot

According to defined KPI sets it is not possible to obtain all of them. The EMT backend data could not be accessed and hence it was not possible to calculate all the KPI's due to missing data sources in public sector domain. The information we can obtain is as per the tables mentioned here. The following KPI's were evaluated again as a feedback to the 2nd LL workshop. KPI's like facility density in alternative mode, traffic free and or routes support the aim of considering other transport means. It was suggested to have KPI's related to environmental pollution. Thus Private vehicle emissions density rate, Average emission equivalent from average vehicle cubic capacity supports this.

KPI conversions for Madrid:

Sr. no	KPI's	KPI's Description
1	KP10e	Private vehicle emissions density rate
2	KP18s	Emission saved in TF and OR routes
3	KP29e	Average emission equivalent from average vehicle cubic capacity

Table 13: List of available KPI conversion for Madrid pilot

Affecting Parameters for Madrid:

Sr.no	Affecting Parameters
1	Station/Stops distance
2	Fuel: Price increment

3	Car/ Motorbike: Amount available
4	Temperature: Environment/weather conditions
5	Precipitation: Environment/weather conditions
6	Fog: Environment/weather conditions
7	Bike parking: Infrastructure
8	Car parking: Infrastructure
9	Lights

Table 14: List of affecting parameters for Madrid pilot

5.2.2 Final KPIs and parameters for Genoa

List of available KPI's for Genoa:

	KPI's	**KPI Description**
1	KP4	Density of passenger transport
2	KP5	Number of passenger transported by fuel unit
3	KP6	Number of fuel units per passenger
4	KP10	Private vehicles density rate
5	KP12	Share of diesel engine in total vehicles
6	KP23	KPI's change per time unit
7	KP24	Annual usage estimation in alternative modes
8	KP28	KPI's percentage of change

Table 15: List of available KPI's for Genoa

It was possible to obtain all of the KPI's decided for Genoa. A better evaluation can thus be obtained in the assessment phase.

KPI conversions for Genoa:

Sr. No	**KPI's (Conversion)**	**KPI description**

1	KP4e	Emissions per km of passengers
2	KP4s	Emissions saved by passengers in public transport
3	KP5e	Number of passengers per fuel emissions
4	KP6e	Total emissions per passenger
5	KP10e	Private vehicle emissions density rate
6	KP12s	Share of diesel engine in total vehicles emissions savings
7	KP28	Administrative

Table 16: List of available KPI conversion for Genoa

Affecting Parameters for Genoa:

Sr. no	**Affecting Parameters**
1	Station Stop distances
2	Share facilities
3	Fuel Price increment
4	Ticket Price increment
5	Special facilities
6	Travel distance: Trip characteristics
7	Travel time: Trip characteristics
8	Temperature: Environment/weather conditions
9	Precipitation: Environment/weather conditions
10	Lights

Table 17: List of availableaffecting parameter for Genoa

5.2.3 Final KPIs and parameters for Tampere

List of Available KPI's for City of Tampere:

	KPI's	KPI Description
1	KP4	Density of passenger transport
2	KP5	Number of passenger transported by fuel unit
3	KP6	Number of fuel units per passenger
4	KP8	Total CO_2 emissions for travel (multiple modes) freight
5	KP10	Private vehicles density rate
6	KP13	Share of public transport in total passenger traffic
7	KP16	Presence of alternative fuels vehicles
8	KP18	Traffic-free (TF) and on-road (OR) routes
9	KP19	Annual usage estimation in alternative modes

Table 18: List of available KPI's for Tampere pilot

The above table is the final list of KPI's that could be obtained with all the necessary data sources from the City. It is seen that almost all of the defined KPI's for Tampere pilot were possible to obtain because of its open data approach. The remaining KP23 and KP24 need not be defined in this as they account for percent and time changes to be applied for all the KPI's.

KPI conversions list:

The KPI conversions were required to obtain the performance parameters in terms of emissions. All of these were possible to access and hence could be calculated.

Sr. No	KPI's (Conversion)	KPI description
1	KP4e	Emissions per km of passengers
2	KP4s	Emissions saved by passengers in public transport
3	KP5e	Number of passengers per fuel emissions
4	KP6e	Total emissions per passenger
5	KP10e	Private vehicle emissions density rate

6	KP13s	Share of PT in total passengers traffic emissions savings
6	KP16s	Presence of alternative fuels vehicles emissions savings
7	KP18s	Emission saved in TF and OR routes
8	KP19s	Savings from TF and OR usability

Table 19: List of available KPI conversions for Tampere pilot

Affecting parameters for Tampere:

Sr. no	Affecting Parameters
1	Station Stop distances
2	Car/ Motorbike: Amount available
3	Travel distance: Trip characteristics
4	Travel time: Trip characteristics
5	Temperature: Environment/weather conditions
6	Precipitation: Environment/weather conditions
7	Fog: Environment/weather conditions
8	Support during winter (cleaning): Infrastructure
9	Bike parking: Infrastructure
10	Car parking: Infrastructure
11	Lights

Table 20: List of affecting parameters for Tampere pilot

It was also possible to obtain all of the affecting parameters. But not all of these could be used for actual evaluation. The reason is that some of the data sources for affecting parameters have static values. For e.g. considering the station stop distances, as the distance remains same for the different time units, there is no change attained. Thus, in calculation we obtain a null output. So the useful affecting parameters out of this are weather conditions and lights.

The feedback provided in the 2nd LL workshop was hereby considered as sustainabie modes were considered by having measurement of KPI's like total traffic free and on road routes, bike parking infrastructure, annual usage estimation in alternative modes. It is also promoted in the Mobile App by showing a healthy life with calories burnt using ALM. The concern on focus of usage of bio-fuels was resolved with KPI's like presence of Alternative Fuel Vehicles. Although there is an affecting parameter, which gives a measure of support during winter (cleaning) infrastructure, the question regarding starting of car in cold weather could be considered as an extension to affecting parameters in future.

5.3 Energy efficiency report for the 3 pilot cities

To generalize an assessment plan for the cities it is needed to consider the common factors in the 3 pilots. The KPI's can be classified into 2 groups and then the scenarios generated in each group can be analysed. Following are the 2 groups.

1. KPI's about modal change and increase the capacity
2. KPIs' related to technological efficiency

1. KPI's about modal change:

In this group are included the KPI's which deal with prioritizing the use of public transport and ALM and to minimize the use of Private transport. Thus the measured parameters here include number of inhabitants, nº of private vehicles, share of public transport in total passenger traffic. By measuring these it is ensured how many people use public transport and how many use private transport.

2. KPI's related to technological efficiency:

Now this group includes the KPI's which measure the efficiency by means of the physical changes brought about in the means of transport. The measured parameters here are number of passengers travelling by a fuel unit, nº of fuel units required per passenger, total CO_2 emitted for a transport mode. Thus, it can be seen how technological interventions deal with enhancing the transport efficiency.

As the common assessment measures are defined, now we can see the plan for each city and the effect of the services deployed for each of the pilot city can now be assessed.

5.3.1 Madrid pilot

The city specific service for Madrid is priority for public transport vehicles. In order to increase the public transportation there would be priority given to public transport at intersections controlled by traffic lights. Now continuously measuring of the KPI's related to this, like private vehicle density rate, public transport reliability would check how this service has helped to increase share of PT.

According to KPI10 the number of private vehicles for the 2013 are available along with the number of inhabitants updated every year upto 2014. Thus, according to this data the private vehicle density rate would be 504,17 with the number of inhabitants as 6 454 440 and the number for private vehicles as 3 254 153. The km of Traffic free and ON road routes is a fixed value obtained for 2012. 283km are available for cycling and 13,7 Ha for walking. For the facilities available in alternative mode i.e. nº of bike parking available for 2012 is 1,242, and for 2014 is 3,126. The road length available as of 2012 was 92km and the TF-OR route as mentioned before. Then the percent of public transport reliability obtained for 2012 is 92%.

The following comparisons can be made for energy assessments:

1. Kp10 Vs Kp26M: Private Vehicle Density rate Vs Public transport reliability
2. Kp18 Vs Kp20: Traffic-free and On-road routes vs Facilities density in alternative modes
3. Effect of weather conditions on PT, PVT and ALM
4. Effect of fuel price increment on PT

Following evaluations could be possible if all of the KPI’s defined for Madrid in D4.1 are possible to be obtained.

1. KP4 Vs KP10: Density of passenger transport Vs Private vehicles density rate
2. KP25 Vs KP26: User spending in transport Vs Public transport reliability
3. Total number of vehicles Vs Total units with diesel engine (KP12)
4. KP6 Vs KP4: Number of fuel units per passenger
5. Annual distance travelled by unit Vs Area where the unit travels (KP7)
6. Total vehicles Vs Total vehicles with new technology

The remaining KPI’s from the finalized list can be analysed with their changes along time scale.

5.3.2 Genoa pilot

The city specific service of Genoa pilot is Operator console for feedback information management. This service enables the integration of crowd-sourced data into the Genoa traffic supervisor. Following obtained KPI’s for Genoa would help in assessing the way the city travels (Preference of transport mode depending on various factors).

From the available data sources we can find the comparison between density of passenger transport (data available from 1996 to 2013) and private vehicle density rate (data available from 2000 to 2013). The trend for number of passengers per km can be found as we have the above data. It is seen that the number of passengers per km has increased from 4,51 to 5,80 between 1996 to 2013. Also by considering the data for unit of fuel consumption i.e. km/ltr the number of passengers which can be carried out by particular fuel unit can be evaluated. The share of diesel engines is available from 2000 to 2013 which will help to find the amount of CO_2 produced by diesel engines. The pollution concentration generated from transportation is also evaluated.

1. Density of passenger transport Vs Private vehicle density rate

2. Effect of fuel price increment Vs Passenger transported by a unit

3. Effect of ticket price increment Vs Passenger transported by a unit

4. Pollution concentration due to emissions.

5. Total number of vehicles for a year Vs Share of diesel engines in total vehicles

The trend of remaining KPI’s can be analysed on time scale.

5.3.3 Tampere pilot

As seen previously in section 5.2 all of the KPI’s defined for Tampere were possible to be retrieved. Thus there is a possibility of having analysis of many features.

The Tampere specific city service is the energy consumption status and suggestions. An energy consumption module is developed which would measure the energy equivalent in the form of gCO_2 for each journey option for a particular trip (source and destination). An energy calculator algorithm, as explained previously, is used to give the emissions for each mobility option. Moreover, these emissions are then transformed into a meaningful equivalent value understood by the user easily. An automatic transformation algorithm is used to do so. Now deployment of this service through the MoveUs mobile app would help to assess the user’s energy consumption. The current choices made by the user and the historical energy consumption value will be stored. The mobile app also provides with a list of incentives available for low energy consumptions.

The energy consumption module would also enable the measurements of the KPI’s calculated as below.

The annual total passengers transported by unit were 241000 with the annual distance travelled as 101000km thus making the density of passenger transport as 2,386 passenger per km. The number of fuel units per passenger can be calculated with previous data along with additional 0,444 l/km.

Hence a fuel unit is able to carry 5,84 passengers(5,84 passengers/ltr) and a passenger requires 0,186 (0,186ltr fuel/1 passenger)units of fuel for 2013. The modal share for 2012 was 17

The annual use of alternative mode of transport is taken as 17 from the value obtained on 2012. According to the acquired data following comparisons and analysis can be made:

1. Density of passenger transport Vs Private vehicle density rate
2. Number of passenger transported by fuel unit Vs Private vehicles density rate
3. Density of Passenger transport Vs Total CO_2 emissions for travel (multiple modes) freight.
4. Share of PT in total passenger traffic Vs Private vehicle density rate
5. Emissions per km of passengers Vs Density of passenger transport and private vehicle density rate
6. Annual usage estimation in alternative modes Vs time period (Years)
7. Total traffic and On-road routes available Vs No of ALM used
8. Temperature conditions Vs Choice of transport(Density of passenger transport and private vehicle density rate)
9. Number of private vehicles Vs Number of parking places
10. The consumption of electricity in street lights and bus stops

And the remaining KPI’s could be studied gradually in days months or years depending on its occurrences of variations.

5.3.4 Visualization of KPI’s

The KPIs that are measured can be visualized in the form of graphs so that the monitoring city authorities better understand the information. As described earlier in energy labels section, it is important to deliver information in an easy and understandable manner. Such information can be visualized with the help of bar graphs, pie charts so that the trend can easily be clear as the changes occur.

Some examples of the visualization are shown as below:

1. To show the number of users for PT and PVT before and after the deployment of city specific services

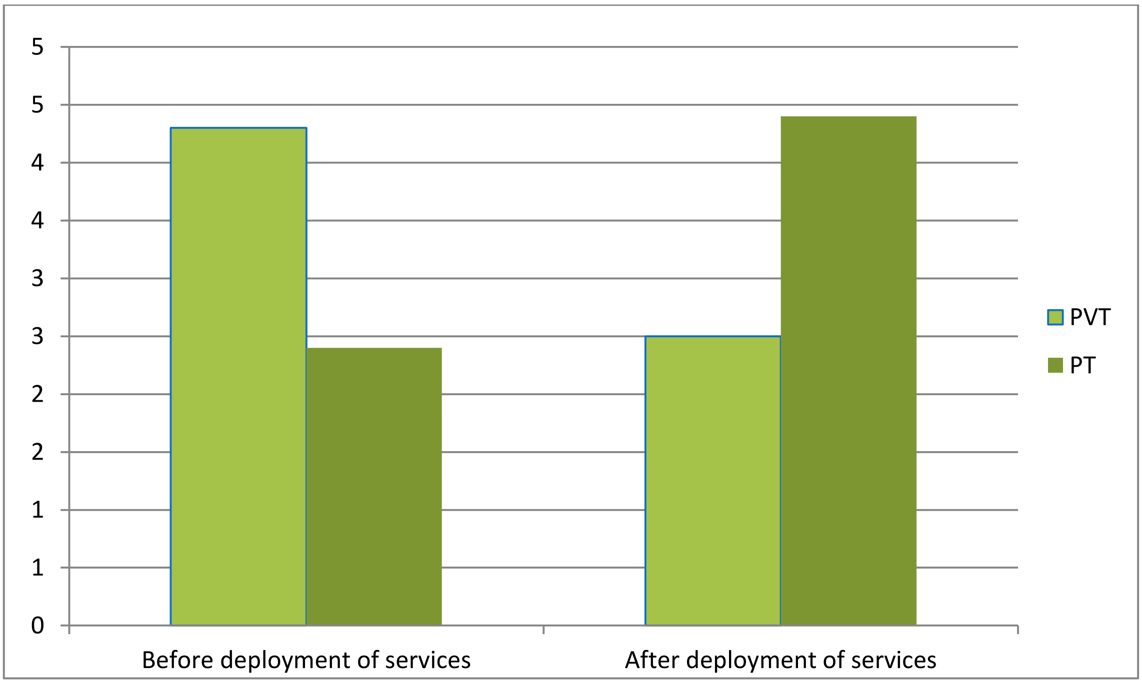


Figure 14: Bar graph showing impact of city services

There are certain services unique to every pilot. After deployment of those services there could be some changes being visible in the transportation domain. This results can be positive as well as negative. Now a bar graph like above helps to visualize the effects of deployment of such services. The vertical axis will show the number of users of PVT or PT and the horizontal axis shows transition from before to after.

2. To show positive trend of a user

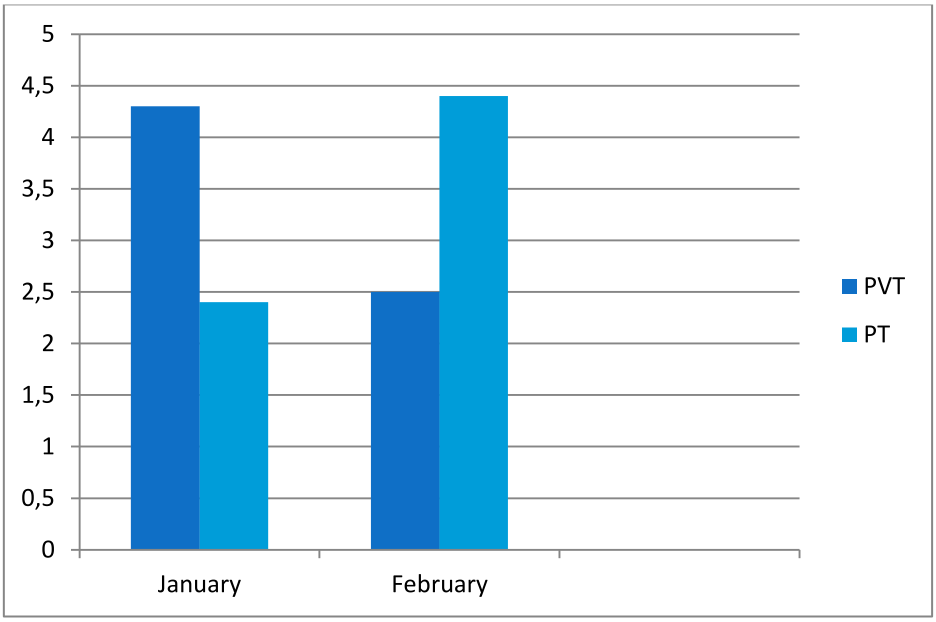


Figure 15. Bar graph showing the user choice Vs emissions

Now the MoveUs mobile App has a feature of logging the user choices made while selecting a trip. Thus, the emissions generated by PT and PVT when user makes a choice for a trip can be seen for each month. This would prove beneficial to provide incentives if a positive trend is seen in a user.

3. Availability of Parking spaces:

Figure 16: Pie chart-Availability of Parking places

A pie chart can be used to show region wise percentage of the vacant parking spaces. Also it might help to show the nº of parking places in particular region. This information would give answer to the questions like which place is utilized most for parking places, which areas should be provide more parking places so that less time is spent by vehicle is making choices to park.

Similarly, there could be other information shown like above, like heat map showing region wise emissions of CO_2, a graph showing weather effects and choice of transport and so on.

Below is an example which shows the KPI historical values in form of bars retrieved from Consumption Estimation Calculator. The graph shows the changing values of the KPI on time basis.

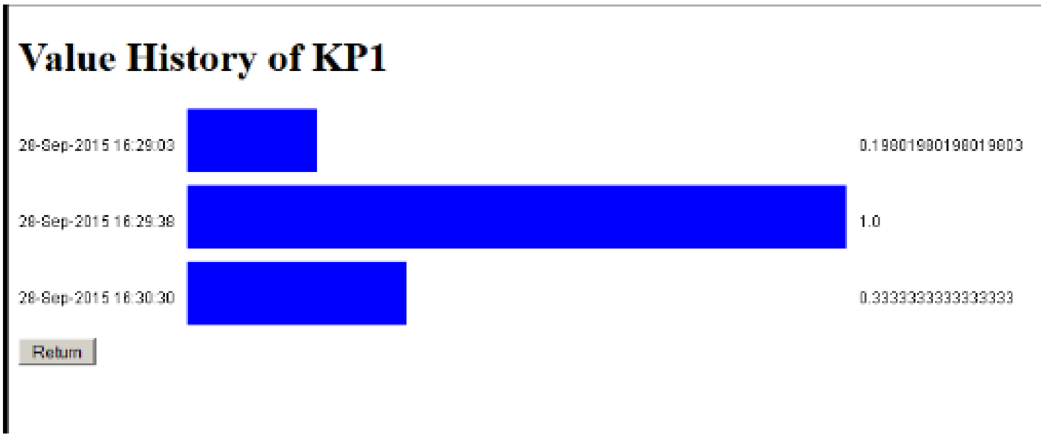
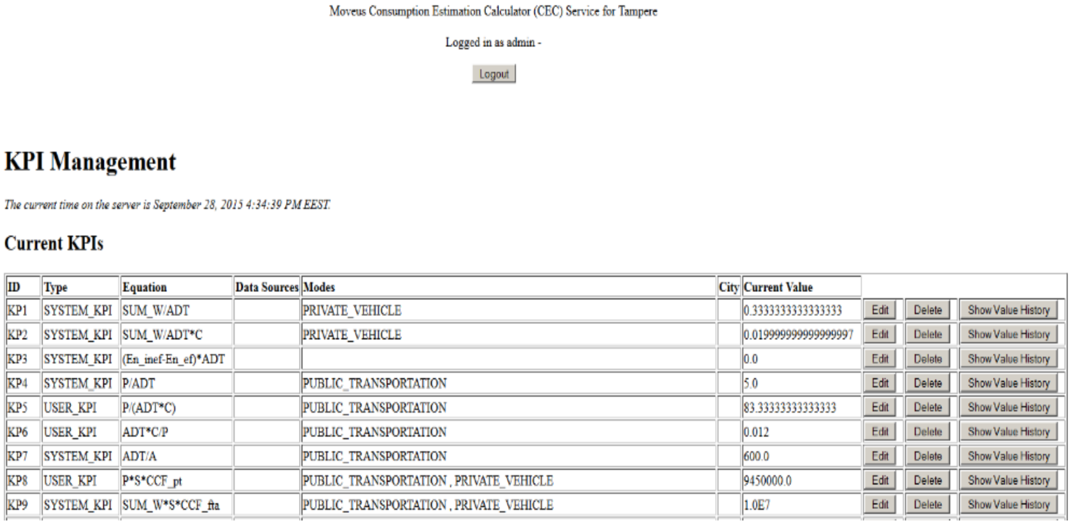


Figure 17: Changing KPI values

There was concern about addition of new data in the future in case of changes in infrastructure made in 2nd LL workshop for Tampere. This was made possible by allowing city admin personnel to integrate new information when the availability of the data sources increases in future. Also the same is applicable for energy Labels.

The user type UT10_CityAdm has the authority to change or update KPI's for each city. The following table gives a glimpse of the view wherein the designated user type can make change



KPI Management

The current time on the server is September 28, 2015 4:34:39 PM EEST.

Current KPIs

ID	Type	Equation	Data Sources	Modes	City	Current Value			
KP1	SYSTEM_KPI	SUM_W/ADT		PRIVATE_VEHICLE		0.3333333333333333	Edit	Delete	Show Value History
KP2	SYSTEM_KPI	SUM_W/ADT*C		PRIVATE_VEHICLE		0.019999999999999997	Edit	Delete	Show Value History
KP3	SYSTEM_KPI	(En_inef-En_ef)*ADT				0.0	Edit	Delete	Show Value History
KP4	SYSTEM_KPI	P/ADT		PUBLIC_TRANSPORTATION		5.0	Edit	Delete	Show Value History
KP5	USER_KPI	P/(ADT*C)		PUBLIC_TRANSPORTATION		83.33333333333333	Edit	Delete	Show Value History
KP6	USER_KPI	ADT*C/P		PUBLIC_TRANSPORTATION		0.012	Edit	Delete	Show Value History
KP7	SYSTEM_KPI	ADT/A		PUBLIC_TRANSPORTATION		600.0	Edit	Delete	Show Value History
KP8	USER_KPI	P*S*CCF_pt		PUBLIC_TRANSPORTATION , PRIVATE_VEHICLE		9450000.0	Edit	Delete	Show Value History
KP9	SYSTEM_KPI	SUM_W*S*CCF_fta		PUBLIC_TRANSPORTATION , PRIVATE_VEHICLE		1.0E7	Edit	Delete	Show Value History

Figure 18: Tabular view of KPI's in the CEC

5.4 Energy Assessment Template

To make energy assessment there should be some tables representing what information is important, and how it is been compared to get useful result.

Below are the templates for each of the 3 pilots. These templates will be used while the actual assessment phase. The data would be collected based on the variables provided in the template. And after acquiring the data the comparison is possible and an effective result can be seen.

5.4.1 Template for Madrid pilot

Below is the template for Madrid. The comparison is done between Private vehicle density rate and Public transport reliability based on the weather conditions. Weather condition would be based on average temperature during that month.

Month	Weather condition	Private vehicle density rate(%)	Public transport reliability(%)

Table 21: Template for Madrid pilot

The following table is common between all three pilots. It helps to evaluate the user travelling trend. It is possible to know the by how much percent is either PT or PVT or ALM used month wise.

Month	User identity	PV usage(%)	PT usage(%)	ALM usage(%)

Table 22: User assessment template-Madrid

5.4.2 Template for Genoa pilot

The template table for Genoa is as below. Comparison would be made between PV density rate and Public transport density. The pollution concentration because of the emissions can be noted.

Month	Weather information(precipitation/rain/snow)	Private vehicle density rate(%)	Public transport density(passenger/km)	Pollution concentration due to emissions(ug/m3)

Table 23: Template for Genoa pilot

The following table is for energy assessment of users making use of MoveUs App.It would determine the percentage of the mobility choice made by the user. Moreover, these would help to select to which user the incentives should be granted.

Month	User identity	PV usage(%)	PT usage(%)	ALM usage(%)

5.4.3 Template for Tampere pilot

The below table will have month-wise data for PT, PVT, Presence of alternative fuel vehicles. Also the weather conditions are noted. Hence, the values obtained would indicate which mode of transport is chosen more often along with the consideration of weather impact. The column indicating total CO2 emissions will provide emissions provided from PT as well as PVT and alternative fuel vehicles. And thus would help to calculate the percentage of CO2 emission for PT, PVT and alternative fuel vehicles.

Month	Weather details (Precipitation/Fog)/Snow/Rain)	Private vehicle density rate(%)	Public vehicle density rate(passenger/km)	Presence of alternative fuel vehicles (%)	Total density of PT and PV(%)	Total CO_2 emissions	% Emission of PT	%Emission of PVT

Table 24: Template for Tampere pilot

For the assessment of the users' mobility mode usage in a specific period there could be the table below. It would be possible to check the percentage of each mobility option chosen by the user for particular month.

Month	User identity	PV usage(%)	PT usage(%)	ALM usage(%)

Table 25: User assessment template-Tampere

6 Conclusions

This deliverable includes a definition of how to show the energy consumption to transport users and an implementation of energy calculator through journey planner in some European cities, Madrid, Genoa and Tampere. It was possible to successfully implement the energy consumption module. The emissions algorithm has been made suggesting the energy consumed in the form of the translated value. The user thus on specifying start-end location and transport mode, gets the translated value in the form of nº of trees needed to capture the gCO_2 generated.

Moreover, the assessment is possible due to comparison of user profile and the historic values, which are saved in the user profile in MoveUs platform. The assessment plan would serve as basis for the actual analysis to be carried out in the living labs. The comparisons defined here can be experimented on particular study groups in every pilot city.

Thus it is seen that by comparing the KPI’s, as well as measuring and monitoring them individually along a time scale, can help the city authorities to see all the necessary traffic, user, infrastructure, transport modes energy consumption information in a convenient manner. The assessment results that will be obtained at the end of the project will help to understand how much MoveUs methodology and services have been useful to change the travelling habits of city inhabitants. Also, if major change is not seen then it would help to pinpoint the areas of interest which should be looked upon in more depth to bring about the behavioral change as desired and would initiate new ways to be deployed for the reduction of CO_2. The assessment will provide solutions to questions whether it’s the Public transport which should be focused on, is the infrastructure needed to be intervened for more facilities, are new technologies developed in PVT helpful to reduce emissions, is the use of eco cars like Battery vehicles or Electric Driven Vehicles a solution to reduction of CO_2. All of these factors can be evaluated as a result of the assessment.

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Appendix A

Table of equation

Name	Equation	Units
Affecting Parameters		
Station/Stops distance	$LS_i - LS_{i-1} > 100$	[m]
Share facilities	$OF_i - OF_{i-1} > 1$	[Number of intermodal facilities]
Fuel (Price increment)	$\frac{FP_i - FP_{i-1}}{FP_{i-1}} * 100 \geq 18\%$	[%]
Ticket PT (Price increment)	$\frac{PTP_i - PTP_{i-1}}{PTP_{i-1}} * 100 \geq 20\%$	[%]
Specific facilities	$SF_i - SF_{i-1} > 1$	[Number of specific facilities]
Car/ Motorbike (Amount available)	$\frac{CW_i - CW_{i-1}}{CW_{i-1}} \geq 0.35$ $CW = \frac{V_{pi}}{H}$	[number of private cars per inhabitant]
Bicycles/ Buses (Amount available)	$\frac{BS_i - BS_{i-1}}{BS_{i-1}} * 100 \geq 5$	[%]
Travel distance	$DT_i - DT_{i-1} \geq 5km$	[km]
Travel time	$\frac{T_i - T_{i-1}}{T_{i-1}} * 100 \geq 1\%$	[%]
Temperature	Se	[season = winter,summer]
Precipitation	Pt	$[presence\ of\ precipitation\ type = rain\ or\ snow]$
Fog	Fg	$[presence\ of\ fog]$
Support during winter (cleaning)	$\frac{A_r - A_{rW}}{A_r} \geq 0.6$	[%]
Bike parking	$Bp_i - Bp_{i-1} \geq 1$	$[number\ of\ areas\ with\ bicycle\ parking]$
Car parking	$\frac{Cp_e - Cp_f}{Cp_e} \geq 0.6$	[%]

Energy Efficiency Calculators		
Car emissions	$\frac{Distance * CCF_{car}}{vehicle\ occupants}$	$\frac{km * \left[\frac{gCO_2}{km}\right]}{vehicle\ occupants}$
Motorbike emissions	$\frac{Distance * CCF_{mb}}{vehicle\ occupants}$	$\frac{km * \left[\frac{gCO_2}{km}\right]}{vehicle\ occupants}$
Public transport emissions	$Distance * CCF_{PT}$	$km * \left[\frac{gCO_2}{pkm}\right]$
Cycling expenditure	$0{,}4 * user's\ weigh * Distance$	$\frac{0{,}4\ Kcal}{km * kg} * [kg] * [km]$
Walking expenditure	$(0{,}8 * user's\ weigh + 1.5) * Distance$	$\left(\frac{0{,}8\ Kcal}{km * kg} * [kg] + 1.5\right) * [km]$
Food equivalent	$\frac{total\ kcal\ in\ alternative\ modejourney}{food\ kcal}$	$\frac{Kcal}{Kcal}$
Satisfaction	Going to be define during march	
User Total Private Vehicle Emissions (UTPVE)	$(car\ emissions + Motobike\ emissions) * \left(1 + \sum Ff_{PV}\right)$	Ff_{PV} = Factor affecting energy efficiency by PV. $[gCO2]$
User Total Public Transport Emissions (UTPTE)	$Public\ Transport\ Emissions * \left(1 + \sum Ff_{PT}\right)$	Ff_{PT} = Factor affecting energy efficiency by PT. $[gCO2]$
User Total ALM	$total\ kcal\ in\ alternative\ modejourney * \left(1 + \sum Ff_{ALM}\right)$	Ff_{ALM} = Factor affecting energy efficiency by ALM. $[kcal]$

Appendix B

Satisfaction in transport systems

As it is mention in several occasions cities authorities around the world are targeting citizens' individual changes of travel, from PV-use to PT or ALM. Several studies had been focus on determinate how modal choice can be influenced, some of them are centre in soft measures or travel feedback programs, which are based in personalize travel information that will lead to car users to voluntarily change to a more friendly travel modes [27][28]. However these measurements are limited by the satisfactions that users perceive from each of the modes that they have access to.

Particular number of studies has focus in measure the satisfaction effects of using a determinate mode of transport , additionally most of them are based in utility theory, that try to find how travel-related choices of destination and travel mode are made [29] . Other studies have developed methods for measuring satisfaction with travel, well known as subjective well-being (SWB). SWB include the cognitive and effective components of users' satisfaction, basically the components activate positively or negatively users' satisfaction [30][31]. At the end they give an overview of the satisfaction with the experienced outcome of the choice (liked or disliked). Additionally in the analysis of Friman et al. (2013) [30] found that satisfaction is connected with the size of the city and the mode (being ALM more satisfied than other travel modes).

In order to measure the cognitive component of travel satisfaction, it is necessary to know its sensibility to events experienced used the travel mode (high traffic, PT delays, etc.), those events can have a strong impact on users transport mode choices and satisfaction [32]. Other aspect that has great impact in the satisfaction is the connected emotions, being car as the most study mode, emotions like pleasure and freedom had been reported as the main reason to choose car [33]. Studies from Friman et al. show that those incidents or experiences (record in users' memory) combined with users' expectations have an emotional impact on the satisfaction, particularly in the case of PT [34][35].

In the research made by Friman et al (2013) [30] the model of satisfaction try to include all the different components previously described, in the Table below the indicator used are resume. The indicators were used to evaluate user's satisfaction for PT, car and ALM modes. As a result they found that car is usually matched with comfort, driving pleasure and feeling of self-control, and traffic congestion was one of the unsatisfactory causes. For PT the possibility to do other leisure activities (such reading or watching videos etc.) during the journey was a satisfactory parameter. ALM were conceive as the most satisfactory modes of transport in overall compare with PT and PV, mainly because they are strongly perceive as a healthy physical activity.

Global Satisfaction	Positive Activation	Enthusiastic-Bored
		Engaged-Fed up
		Alert- Tired
	Positive Deactivation	calm-stressed
		confident-worried
		Relaxed-hurried
	cognitive evaluation	Worked: well-Poorly
		standard: High-Low
		Imaginable: Best- Worst

Table 26: Global user's satisfaction evaluation, modify from[30]

Further studies based in Friman work, add other factors. Initial studies focus in access to the bus stops, waiting time, trip length, vehicle design, drivers' interaction with users and travel information. Other studies focus specially in the travel time, and fares. As a result they found that these last ones have great influence on dissatisfaction, and frequency of the service and seat availability are the largest source of satisfaction. Other attributes that increase the dissatisfaction are lack of punctuality, inaccuracy or missing information, technical malfunctioning, bad vehicle design, and insufficient traffic planning. Vehicle design is understand as the perception of relating to comfort, security, and cleanliness. Additionally recent experiments have found that users demand mobility experiences that are enjoyable and social that offers value in addition to performance efficiency [34][36][37][38]. The following table resume the attributes is PV, PT and ALM that determinates users' satisfaction with the travel mode.

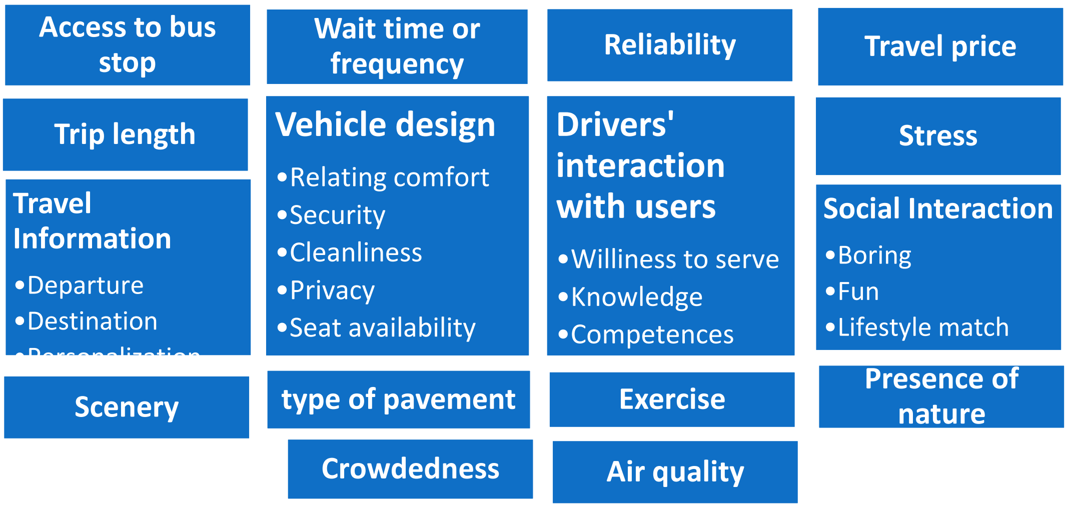


Figure 19: Attributes of PV, PT and ALM

The use of satisfaction calculator by the cities can bring a new perspective of their transport systems, mainly in the indicators that are relevant for the citizens' satisfaction. This new perspective might be used to support policies to improve some of the attributes of different travel modes within a city or area. In order to achieve sustainable transport cities, authorities should have in mind that each of the citizens' mobility decision influence greatly the system, so in that sense, it is logic to declare that users satisfaction travel experience is a key to achieve sustainable transport systems. The satisfaction data can also be implemented in incentives policies that can push citizens to switch to sustainable travel modes, and maintain switches if they experience satisfaction with what they have chosen. Finally the information would allow policy makers to evaluate the effects of various mobility projects.

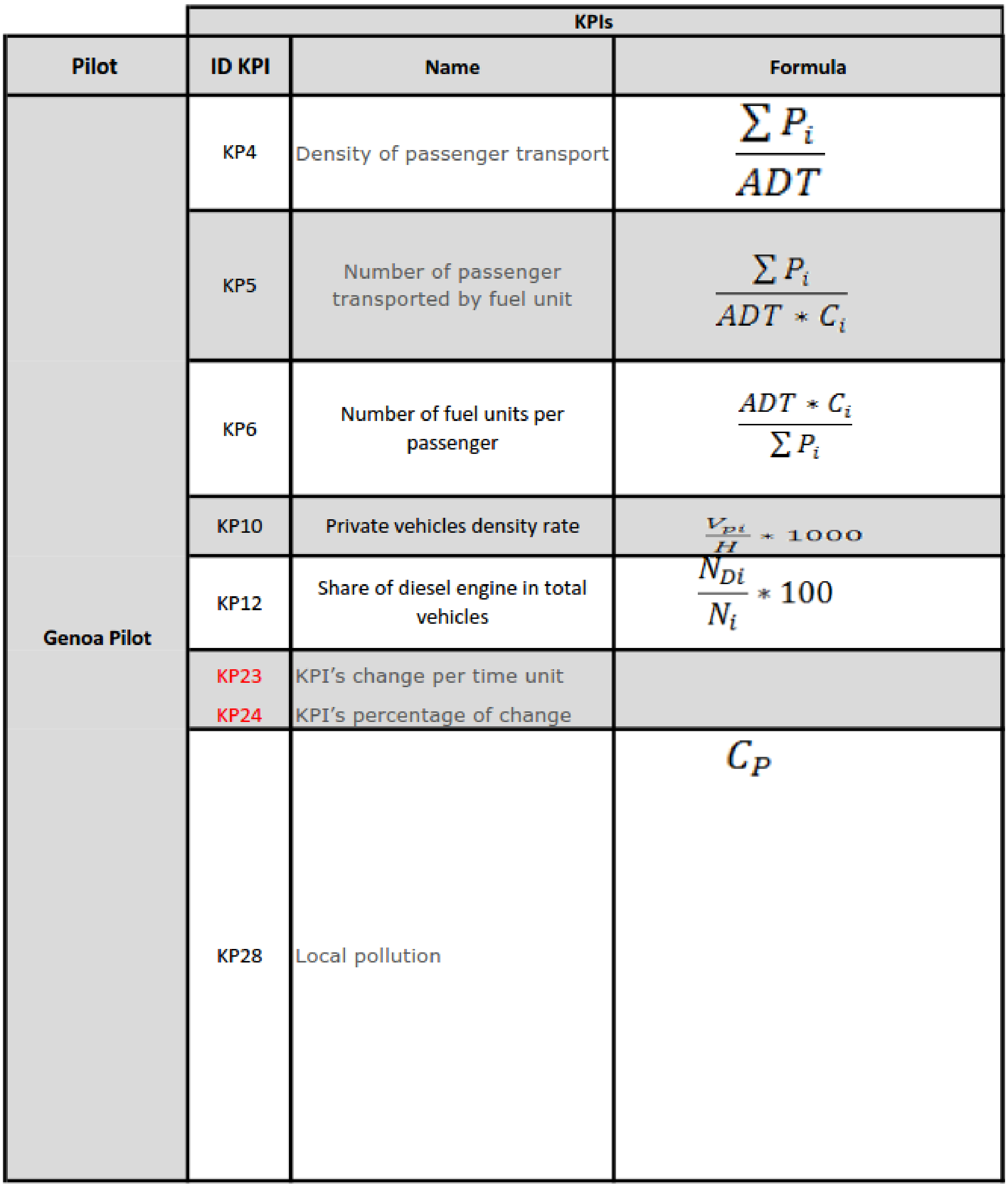
Appendix C

Madrid KPI list

Pilot	ID KPI	Name	Formula
Madrid Pilot	KP4	Density of passenger transport	$\frac{\sum P_i}{ADT}$
	KP5	Number of passenger transported by fuel unit	$\frac{\sum P_i}{ADT * C_i}$
	KP6	Number of fuel units per passenger	$\frac{ADT * C_i}{\sum P_i}$
	KP7	Offer volume in public transport	$\frac{ADT}{A}$
	KP10	Private vehicles density rate	$\frac{V_{pi}}{H} * 1000$
	KP12	Share of diesel engine in total vehicles	$\frac{N_{Di}}{N_i} * 100$
	KP15	Share of new units in vehicles fleet	$\frac{V_{yi}}{V_i} * 100$
	KP16	Presence of alternative fuels vehicles	$\frac{V_{Ai}}{V_i} * 100$
	KP18	Traffic-free (TF) and on-road (OR) routes	$\sum A_r$
	KP20	Facilities density in alternative modes	$\frac{\sum A_f}{\sum A_r}$
	KP23 KP24	KPI's change per time unit KPI's percentage of change	
	KP25	User spending in transport	$\sum s_{UT_i}$
	KP26	Public transport reliability	$\frac{T_{IT}}{T_T} * 100$
	KP27	Cycling intensity	$\frac{B_i}{Ti} * 100$
	KP28	Local pollution	C_P
	KP29	Private vehicles cubic capacity	CC
	KP30	Share of NCG engine in total vehicles	$\sum Fleet\ [N^{o}\ vehicle]$

Appendix D

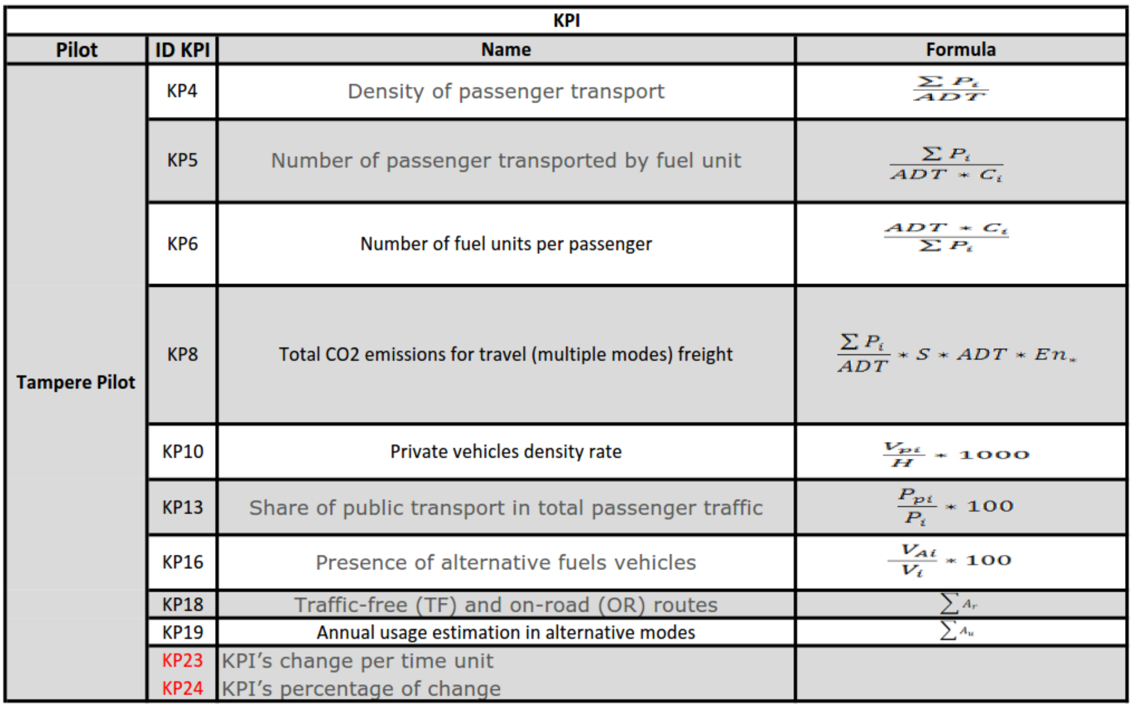
Genoa KPI list



	KPIs		
Pilot	**ID KPI**	**Name**	**Formula**
Genoa Pilot	KP4	Density of passenger transport	$\frac{\sum P_i}{ADT}$
	KP5	Number of passenger transported by fuel unit	$\frac{\sum P_i}{ADT * C_i}$
	KP6	Number of fuel units per passenger	$\frac{ADT * C_i}{\sum P_i}$
	KP10	Private vehicles density rate	$\frac{V_{Pi}}{H} * 1000$
	KP12	Share of diesel engine in total vehicles	$\frac{N_{Di}}{N_i} * 100$
	KP23 KP24	KPI’s change per time unit KPI’s percentage of change	
	KP28	Local pollution	C_P

Appendix E

Tampere KPI list



KPI			
Pilot	**ID KPI**	**Name**	**Formula**
Tampere Pilot	KP4	Density of passenger transport	$\frac{\sum P_i}{ADT}$
	KP5	Number of passenger transported by fuel unit	$\frac{\sum P_i}{ADT * C_i}$
	KP6	Number of fuel units per passenger	$\frac{ADT * C_i}{\sum P_i}$
	KP8	Total CO2 emissions for travel (multiple modes) freight	$\frac{\sum P_i}{ADT} * S * ADT * En_*$
	KP10	Private vehicles density rate	$\frac{V_{pi}}{H} * 1000$
	KP13	Share of public transport in total passenger traffic	$\frac{P_{pi}}{P_i} * 100$
	KP16	Presence of alternative fuels vehicles	$\frac{V_{Ai}}{V_i} * 100$
	KP18	Traffic-free (TF) and on-road (OR) routes	$\sum A_r$
	KP19	Annual usage estimation in alternative modes	$\sum A_u$
	KP23	KPI's change per time unit	
	KP24	KPI's percentage of change	