D1.2 Evaluation Framework

December 2021

Document Identification			
Status	Revision	Due Date	31 Dec. 2020
Version	V2.0	Submission Date	31 Jan. 2022

Deliverable Number	D1.2
Deliverable name	Evaluation Framework
Work Package number	WP1
Delivery due date	31 Dec. 2020
Actual date of submission	31 Dec. 2020
Dissemination level	PU
Lead beneficiary	TNO
Beneficiaries	VTT, DLR, DTU, ERTICO, FIER, IDIADA, V2C2, WI
Responsible scientist/administrator	Thinh Pham, Thijs Purnot, Elina Aittoniemi, Anne Silla, Guilhermina Torrao
Internal reviewer	Oliver Lah, Mirko Goletz, Jean-Charles Pandazis, George Panagakos, Subash Dhar

This document is issued within the frame and for the purpose of the SOLUTIONSplus project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 875041. This document reflects only the author's view and the Agency is not responsible for any use that may be made of the information it contains.

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List of Abbreviations

CE	Circular Economy
CO2	Carbon dioxide
CAPEX	Capital expenditure (per vehicle)
dB	Decibel
dB(A)	Decibels A-weighted
DLR	German Aerospace Center
DTU	Technical University of Denmark
ERTICO	European Road Transport Telematics Implementation Coordination
EV	electric vehicle
FIER	FIER Automotive company
FOT	Field Operational Test
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
IDIADA	Institut d'Investigació Aplicada de l'Automòbil (Institute for Applied Automotive Research)
IRR	Internal Rate of Return
kg	kilogram
KPI	Key performance indicator
km	kilometre
kWh	kilowatt-hour
LrD	average road traffic noise level per day
LrN	average road traffic noise level per night
MaaS	Mobility as a Service
MW	megawatt
NOx	Nitrogen oxides
NPV	Net present value
OPEX	Operating expenditure (for the deployed e-vehicle system)
OSM	OpenStreetMap
PM	Particulate Matter
PU	Public, fully open, e.g. web
p-km	passenger-kilometre

SDG	Social Development Goal
SOL+	SOLUTIONSplus
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
UNEP	United Nations Environment Program
vkm	vehicle-kilometre
VRU	vulnerable road user
VTT	Technical Research Centre of Finland Ltd
V2C2	Virtual Vehicle Research Center
WI	Wuppertal Instiute for Climate, Environment and Energy
WP	Work package

Executive summary

This deliverable presents the results achieved in the Evaluation framework, user needs and data requirements task in the SOLUTIONSplus project. This task focuses on developing a holistic assessment framework to support measuring the success of demonstration(s) and projects in fulfilling their objectives, and to identify impacts of various e-mobility solutions with different objectives, different technologies, different targeted users, and different sets of involved stakeholders for various applications.

The developed assessment framework provides an overview of different steps to conduct the impact assessment within the SOLUTIONSplus project . By applying the framework, the impact assessment process can be conducted in a coherent and harmonised way across the demonstration cities to ensure the fulfilment of the project objectives.

The assessment framework includes six main subsequent steps covering analysis of high-level user needs, identification of key performance indicators (KPIs), data collection, descriptive and analytical KPI assessment, KPI evaluation and results analysis.

As part of this deliverable, a reference KPI list is formulated with the aim to capture unique aspects of each demonstration city while simultaneously ensuring comprehensive assessment. This KPI list is added in Appendix 1.A and contains three sub-lists: 1) weighted KPI list including mandatory KPIs for all demos within the SOLUTIONSplus project but with different weighting factors for different demos, 2) common (non-weighted) KPI list aiming to complement the information collected via weighted KPIs to cover additional aspects of the demos, and 3) additional (non-weighted) KPI list covering proposed KPIs from demonstration cities; these are often specific to few cities and hence not mandatory for all demonstration cities. The methodology and process for identifying and prioritising KPIs, and to formulate the reference KPI list are also presented in this deliverable.

This deliverable further describes a method for processing and evaluating the KPIs covering two main steps. The first step is referred to as analytical and descriptive assessment of the KPIs. This analytical assessment produces the relevant KPI values for each demonstration city based on the data collected by the city teams and stored in the data repository. These KPI values are inputs for descriptive KPI assessment to further analyse the collected KPI data and complement it with findings from earlier studies and existing frameworks to investigate societal impacts by impact area, which will be carried out as expert assessment. The obtained KPI values are also used as inputs to the evaluation step to aggregate both values of different KPIs and stakeholders' views on relevance/importance of these KPIs for each demonstration city. The outcome of the evaluation step is a STAR rating of the KPIs expressed by one to five stars. The evaluation step is supported by an Evaluation tool. The developed evaluation method is especially useful for comparing and deciding on different e-mobility solutions for projects where the KPIs are different in nature and stakeholders have different needs and expectations. The evaluation tool can be used to assist with the evaluation of different scenarios and comparing potential e-mobility solutions across different elements for the specificity of the city where the potential solution has been tested.

The reference KPI list, the manual for the evaluation tool and the evaluation tool itself are provided as part of this deliverable.

1 Introduction

The SOLUTIONSplus project aims at setting up a global platform for shared, public and commercial e-mobility solutions. The developed platform is used to kick-start the transition toward low-carbon and sustainable mobility in urban areas through innovative and integrated mobility solutions. Within the project, relevant e-mobility solutions will be demonstrated in cities from Europe, Asia, Latin America and Africa, see Figure 1. The SOLUTIONSplus demonstration cities are Dar es Salaam, Kigali, Hamburg, Madrid, Hanoi, Pasig, Kathmandu, Quito and Montevideo.

Figure 1. Demonstration cities within SOLUTIONSplus project. Two cities, Madrid in Europe and Hanoi in Asia are given with their goals, applications and number of stakeholders as examples.

In these nine cities, e-mobility hubs for different types of e-vehicles (e-bikes, e-buses and e-minibuses, e-scooters,[1] e-mopeds, e-cargo bikes; approx. from 20 to 200 e-vehicles per city) are planned to support electrification of personal mobility, as well as first/last mile cargo delivery, and also modal interchanges, to connect public transport with other e-mobility modes. The implementation includes management and operating systems (for parking and charging, unified ticketing system, etc.). The aim is to assit local level policies, institutional settings, policy processes in the intention to enhance sustainable development in road transport. The focus is also on economic feasibility and thereby, creation of dedicated plans for financing, value networks and well-working business models. From users' perspective, accessibility and inclusion of different road users is also promoted.

The project workplan encompasses city level demonstrations to test different types of innovative and integrated e-mobility solutions. As shown in Figure 1 for Madrid and Hanoi, different cities will have different goals, applications and their corresponding stakeholders. Moreover, for an e-mobility solution, different stakeholders will also have different objectives. As an example, for a demonstration in Hanoi city with 50 e-mopeds for last-mile connection between a shopping mall and a bus stop, a service provider (e.g. public transport company) can have an objective of making high profits with these e-mopeds. The end users (e.g. passengers) may approach the e-mobility solution with target of travelling back home safely

[1] Electric step or kick scooters.

with the provided service. Besides, the local authorities (e.g. Department of Environment) strive to create a healthier living environment with these e-mopeds.

To assess the success and impacts of the demonstrated e-mobility solutions, a holistic assessment framework is needed to cope with different objectives, different technologies, different targeted users, and with different sets of involved stakeholders for various applications. This report describes the developed framework to evaluate the potential impacts of the demonstrated e-mobility solutions in the nine demonstration cities.

Figure 2 denotes strong interlinkages among WP1 (*Toolbox and Evaluation*) tasks and task 4.4 from WP4 (*Comparative demonstration actions*) within the SOLUTIONSplus project. As shown in Figure 2, the prioritisation and methodology for assessing KPIs were defined by the evaluation framework task, while the assessment tools come from the toolbox of Task 1.1 will be applied in the impact assessment. The actual assessment is based on data collected by the implementation support task (Task 4.4), and the data collection mechanisms are planned in the impact assessment task (Task 1.3).

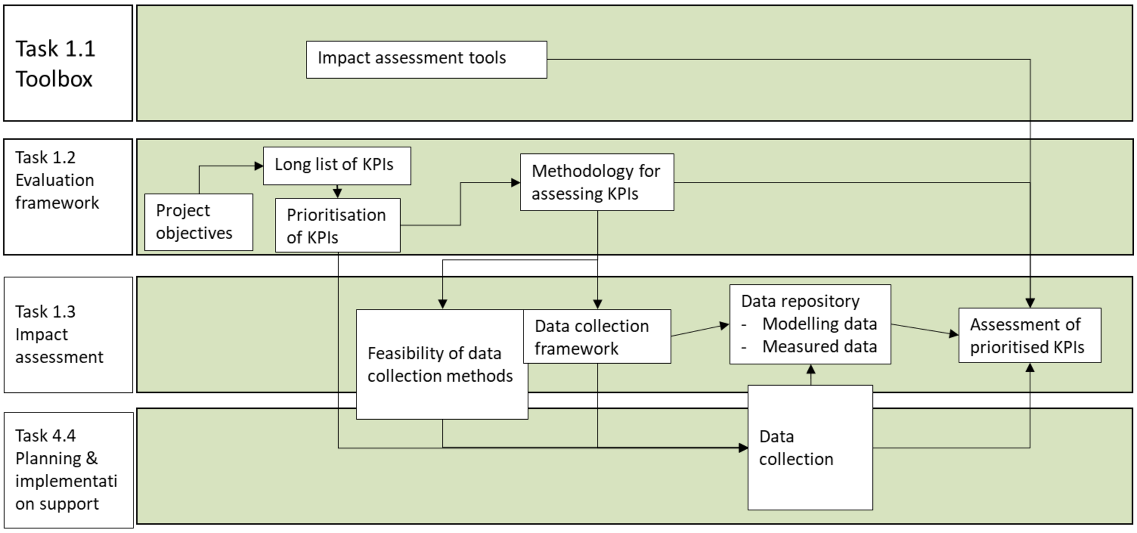

Figure 2. Interlinkages among WP1 tasks and task 4.4 from WP4.

This deliverable is organised as follows. Chapter 2 presents an overview of the developed holistic assessment framework together with descriptions of its main steps and supporting tools. Chapter 3 presents the approach to define the KPI list for the impact assessment to be used by the demonstration cities within the SOLUTIONSplus project. Chapter 4 describes the assessment and evaluation of KPIs. Finally, chapter 5 summarises the main conclusions of this deliverable and discusses the recommendations for future application and potential development of the presented assessment framework.

2 Assessment Framework

2.1 Approach

Within SOLUTIONSplus project, the approach for conducting impact assessment is described below,

- Step 1) Establish baseline: Defining baseline as status quo before implementation enables assessing only the impact of the implemented solution and excluding other factors. As a result, it simplifies the assessment and makes the impacts of the solution clear.

  In SOLUTIONSplus project, the baseline describes the situation without implementation of the e-mobility solutions. It will be defined for both demonstration and city level. The deliverable D1.6 Impact Assessment Result (Panagakos 2020) provides elaboration on the SOLUTIONSplus project baselines.

- Step 2) Ex-ante impact assessment: This step assesses the impacts that can be expected in each demonstration. It provides the expected change of the outcome of the planned SOLUTIONSplus demonstration activities in comparison to the baseline.
- Step 3) Ex-post impact assessment: This step exploits the KPI data collected (during)/after the implementation of e-mobility solutions to estimate the realised impacts of each demonstration (by comparing the values to the baseline), and then compares these realised impacts to the expected impacts defined during ex-ante assessment.
- Step 4) Up-scaled impact assessment: This step assesses potential impacts of scaled up projects. The city-specific scaled-up project will be designed together with the local stakeholders on the basis of the demonstration results (Panagakos 2020). The up-scaled impact assessment quantifies the expected impact of the scaled-up project for the target years 2025 and 2030 in comparison to the baseline scenario defined at city level.
- Step 5) Derive overarching conclusions: This step forms general overarching conclusions based on the individual results from all demonstration cities. The cross-cutting evaluation of selected impact areas to examine the scalability and transferability of the demonstrated technologies as well as the corresponding preconditions. For example regarding impact area mobility, what type of changes to mobility patterns of users can be expected (and thus changes to the cities' mobility system or wider infrastructure) in different types of cities, what factors affect this (impact paths), where are similarities and differences, can any general recommendations be made on achieving sustainable mobility?

Table 1 shows the types and scope of the aforementioned impact assessment.

Table 1. Types and scope of impact assessment.

	Baseline	Ex-ante assessment	Ex-post assessment	Up-scaled assessment
Demonstration level	X	X	X	
City level	X			X

2.2 Framework overview

The assessment framework is a structured guideline for the practical steps of impact assessment. Its purpose is to ensure that the impact assessment process is carried out in a coherent, harmonised way across the cities and to ensure that the objectives of the WP can be fulfilled. The process includes defining objectives and key performance indicators as well as methodologies for data collection and evaluation of the KPIs. However, as the project includes real-life demonstrations of different e-mobility solutions, flexibility is ensured with an iterative approach.

The different steps of the assessment framework will exploit several tools (e.g. KPI list, toolbox, evaluation tool) to support the data collection and analysis during the evaluation process. The different steps of the process cover analysis of high-level user needs, identification of relevant Key Performance Indicators (KPIs), as well as methodologies for data collection and actual KPI evaluation. The overview of the developed assessment framework is shown in Figure 3.

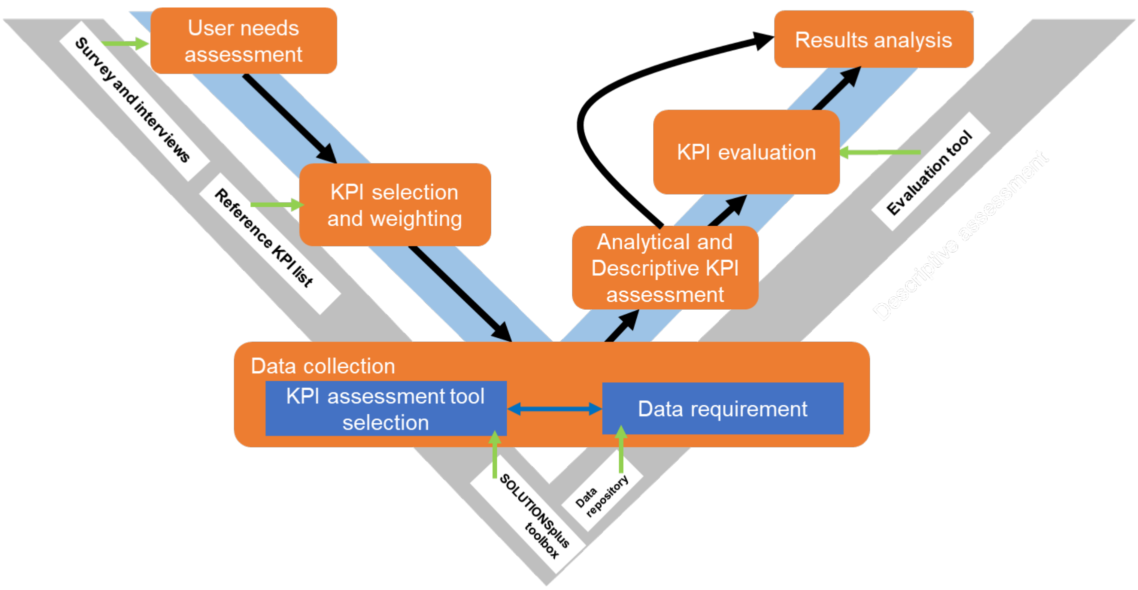

Figure 3.Overview of assessment framework.

The framework is presented in the form of a V diagram (inspired by FESTA 2018) with two V-cycles. The inner V-cycle defines the main steps when performing the assessment. These main steps are described in more detail below. The outer V-cycle denotes the main supporting tools required by the main steps in the inner V-cycle namely survey and expert interviews, reference KPI list, SOLUTIONSplus toolbox, data repository and evaluation tool.

As shown in Figure 3, the assessment framework includes six steps: 1) User needs assessment, 2) KPI selection and weighting, 3) Data collection, 4) Analytical and descriptive KPI assessment, 5) KPI evaluation and 6) Results analysis. Subsections 2.2.1–2.2.6 elaborate in detail the aforementioned six steps with regard to the goal of each step, the required input(s), expected output(s) and the required tool(s).

2.2.1 User needs assessment

Goal: The main goal in this step is to assess the needs and expectations of relevant stakeholders with regard to the e-mobility solutions demonstrated in each city. Data will be collected through an online survey and stakeholder interviews. The results from user needs assessment provide guidance for determining the overall suitability of the e-mobility solutions implemented in the project, and deliver a first approach related to fine-tuning the solutions (Goletz and Krajzewicz 2020). The user needs assessment takes place in each of the nine demonstration cities and will be carried out by the research partners of the respective cities according to the methodology defined in deliverable D1.3 User Needs Assessment (Goletz and Krajzewicz 2020).

Input(s) and expected outcome(s): The required inputs for performing this step include a list of relevant stakeholders for each respective city and the corresponding e-mobility solutions, the collected data from the user needs survey and stakeholder interviews. The expected outcome of this step is identification of needs, preferences and expectations of the stakeholders in each demonstration city.

Supporting tool(s): One of the main supporting tools in this step is the online survey and stakeholder interview guideline. A guideline to carry out the stakeholder interviews was provided as a supporting tool. The stakeholder interviews are needed for deeper discussion and interaction with stakeholders.

A more detailed description of this step regarding the chosen approach and supporting tools is presented in the deliverable D1.3 User Needs Assessment (Goletz and Krajzewicz 2020) of the SOLUTIONSplus project.

2.2.2 KPI selection and weighting

Goal: This step aims at selecting and weighting KPIs for each demonstration city to assess the various potential impacts of the demonstrated e-mobility solutions, starting from the demonstration level and ending at the up-scaled project.

Input(s) and expected outcome(s): The outcome from the user needs assessment step may be used as an input for the KPI selection step besides a reference KPI list defined by the e-mobility experts in SOLUTIONSplus project. The expected outcomes of this step are KPI lists and their corresponding weighting factors for each demonstration city.

Supporting tool(s): A reference KPI list defined by expert partners within the SOLUTIONSplus project has been used as a supporting tool. This list is used as a starting point to select the most relevant KPIs for each demonstration city.

The methodology for selecting the KPIs is presented in detail in Chapter 3.

2.2.3 Data collection

Goal: The Data collection step focuses on collecting and classifying the data needed for assessing the selected KPI values for each demonstration city. The collected data will be stored in the data repository developed in the SOLUTIONSplus project (Kalayci, Erlachner and Steiner 2020). Two mutually related sub-steps as presented below:

- *KPI assessment method selection*: for each selected KPI for a demo city, select the most suitable and realistic method (e.g. interview, survey, logged data or simulation / modelling) for assessment.
- *Data requirements and collection*: specify the required data for KPI assessment for application of the chosen method.

Input(s) and expected outcome(s): The main inputs of this step is the selected KPI list generated in the KPI selection step. This step will collect the data required for KPI evaluation and identify gaps in data. The main output are the values of all the selected KPIs.

Supporting tool(s): Different tools and methods are required for descriptive assessment of KPIs. Within SOLUTIONSplus project, two tools have been developed to support the implementation of this step, namely the SOLUTIONSplus toolbox and a data repository as presented below:

- *SOLUTIONSplus toolbox* is a structured toolbox accessible on the project website in a user-friendly manner. The toolbox will contain tools for assessing e-mobility solutions, capacity building material, summaries of business plans and models, summaries of innovations tested in the demonstration actions, operations and management tools for e-mobility solutions, information on financing and funding options, factsheets and policy briefs. The SOLUTIONSplus toolbox is presented in the deliverable D1.1 SOLUTIONSplus toolbox (Todorov, Anttila and Philatie 2020) of this project.

The data repository will be used to store the data collected during the demonstration actions. It will contain time-series data collected from sensors mounted to vehicles and charging points and data collected through questionnaires and interviews. The characteristics of the SOLUTIONSplus data, data structure, versioning, interfacing, data backup, security, privacy perspectives and the data repository architecture are given in more detail in the deliverable D1.5 Data repository (Kalayci, Erlachner and Steiner 2020).

2.2.4 Analytical and descriptive KPI assessment

Goal: This step performs two KPI assessment approaches namely analytical assessment and descriptive assessment. The former aims at generating numerical KPI values for the selected KPIs. The numerical KPI values are required as input to the evaluation tool in the KPI evaluation step. The KPI values are also used in the descriptive assessment to assess societal impacts such as accessibility, personal mobility, emissions and air quality, travel efficiency, road safety and well-being, which are forming an important part of the SOLUTIONSplus project objectives.

Input(s) and expected outcome(s): One of the main inputs for this step is the collected data from the data collection step. The expected outcomes are the numerical KPI values from the analytical assessment and social impacts (both direct and indirect) from descriptive assessment.

Supporting tool(s): This step requires the selected assessment tool(s) from the data collection step.

Chapter 4 describes in more details the methodology for the analytical and descriptive KPI assessment.

2.2.5 KPI evaluation

Goal: This step aims at translating the KPI values to a STAR rating system supported by the developed evaluation tool.

Input(s) and expected outcome(s): The main inputs of this step are the KPI value and the KPI weighting factors for each demonstration city. The expected output is the star rating for the selected KPIs.

Supporting tool(s): This step requires the evaluation tool, which is capable of converting and aggregating KPI values to the STAR rating system, to quantitatively evaluate the high level KPIs with the STAR rating system. The STAR rating evaluation tool is elaborated in section 4.44.2.

2.2.6 Results analysis

Goal: This step collates the analysis results from demonstration cities to identify trends, similarities and differences and form overall conclusions on the potential impacts of e-mobility.

Input(s) and expected outcome(s): This step requires the STAR rated KPIs from the KPI evaluation step as well as relevant outcomes from the ex-ante and ex-post assessment and the descriptive KPI assessment step (section 2.2.4).

The expected outcome within 2020 and early 2021 is the baseline and ex-ante assessment of impacts of the demonstration e-mobility solutions in nine demonstration cities and a synthesis report for all the cities. The baseline and ex-ante assessments and the city reports for nine demo cities are elaborated in the deliverable D1.6 Impact assessment results (Panagakos 2020).

3 Key Performance Indicators

3.1 Identification of KPIs

The planning of the assessment framework started with the definition of objectives for the assessment tasks, reflecting the main purpose and objectives of the SOLUTIONSplus project. According to the FESTA Handbook (FESTA 2018) a field study starts with this step along with further specifications of the planned measures, which in this project relates to implementation of the electric vehicles in the partner cities of the SOLUTIONSplus project. Despite being originally developed to provide guidance for field operational tests (FOT) of intelligent transport systems, parts of the FESTA Handbook can also be applied to demonstration projects. It provides valuable guidance on conducting experimental procedures and performing impact assessment among other evaluations.

The main impact areas to be covered by the key performance indicators (KPIs) were identified based on the objectives and the demonstration plans of the SOLUTIONSplus project. The four main areas are listed below:

1. *User acceptance and usage of e-vehicles*

   In order to maximise the intended benefits of e-vehicles and achieve successful implementation, e-vehicles should be deployed and used as widely as possible. In usage, the focus is on how much e-vehicles are used when making journeys and in the delivery of goods, and how well the e-vehicles are accepted by the potential users (including vulnerable user groups). Complementing aspects in usage include: how much shared services are used, and how e-vehicles are combined into the journey chain.

2. *Accessibility*

   Accessibility refers to how well the e-vehicle services are able to respond to the user demand of travelling or transporting goods. It addresses whether new trips are possible, whether the current everyday trips are made easier, and whether the quality of the trips is affected. Accessibility to transport options determines to which degree people are enabled to pursue employment, social interactions and leisure activities as well as access to necessary services such as health services. Personal mobility as part of accessibility is highly correlated with well-being contributing to individual Quality of Life, which is presented below. The relationship does not seem to be linear as personal transportation can have positive (e.g. comfort, increase social contacts, transfer to work) as well as negative effects (e.g. stress, tiredness) on well-being. Besides, it might affect well-being e.g. by increasing risk of accidents, air pollution and decreased use of active travel modes. Efficiency was included as part of accessibility as it describes how fluently the destinations can be reached.

3. *Environment*

   The impacts on the environment were considered as a separate impact area since the SOLUTIONSplus project specifically aims to contribute to a sustainable urban road transport system. Local air pollution emissions are targeted as well as carbon dioxide.[2] The focus was on urban road environment but there may also be more general impacts in the other built environment of the cities. Carbon dioxide emissions target the more global scale.

4. *Quality of Life*

The final aim was to improve the quality of life of people. The World Health Organization (WHO 1997) states that quality of life is individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. Quality of Life is accomplished as the outcome of social, physical, mental and economic well-being. Well-being is generally considered a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

These four aforementioned impact areas reflect the focuses of the SOLUTIONSplus initiative − to enhance sustainable e-mobility. Furthermore, these impact areas are related to each other with complex feedback loops. The field data collection and e-mobility solutions planned to be implemented in the demonstration cities define greatly the starting point of the impact assessment. The schematic picture of the impact path in the SOLUTIONSplus project is presented in *Figure 4*. The most important impact areas to be affected in the SOLUTIONSplus project are the user acceptance and usage of e-vehicles (area 1), and how the use is going to change mobility behaviour or transport of goods (as part of area 2). The other two impact areas (3 and 4) are in a certain way dependent on the first two, and many aspects cannot be directly measured due to the demo nature of the project. Consequently, impact assessment methods, such as expert evaluation and modelling or simulations, need to be applied for evaluating those.

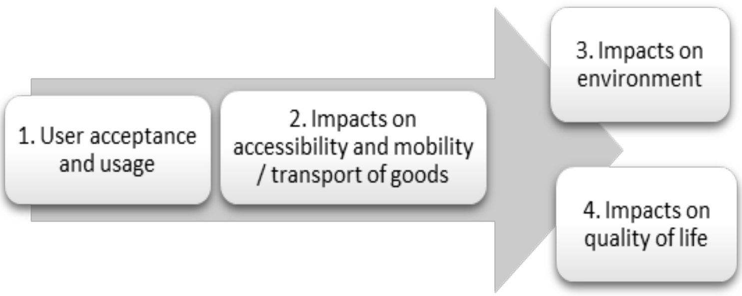

Figure 4. A schematic picture of impact path.

The formulation of research questions and KPIs utilised theories and frameworks available (e.g. FESTA, 2018) and experiences from previous projects (e.g. CIVITAS WIKI project (van Rooijen, Nesterova and Guikink 2013)). The identification of KPIs for the SOLUTIONSplus assessment process was inspired by the four aforementioned impact areas. First, these main impact areas were divided into smaller components to have a better understanding on the content of each impact area (Table 2). Next, the identification of relevant KPIs was inspired by considering possible effects that the demonstrations could have on these identified impact areas and their components. Therefore, the identification of KPIs focussed on KPIs producing

[2] Where applicable and feasible (i.e. given data limitations), quantification of potential air pollutant emissions load (i.e. mass) would be conducted.

useful information to reply to these research questions. The KPIs were drafted with an iterative approach.

Table 2. Main impact areas and their components which were used as a starting point to identify relevant KPIs for the SOLUTIONSplus project.

Will the demonstrations have an effect on…?	
User acceptance and usage of e-vehicles	User acceptance (awareness, user experience, intended use, willingness to pay)
	Usage (adequation of used e-vehicle, amount of travelling with e-vehicles, transport of goods in e-vehicles, cost of transport, (vulnerable) user groups)
Accessibility	Personal mobility (number of length of trips, use of travel modes, duration, quality of journey, multimodality)
	Transport of goods (number of length of trips, precision of estimated travel time)
Environment	Road environment (emissions, energy use, noise)
	Other infrastructure (energy grid)
	Land use (need for charging infrastructure)
Quality of Life	Social well-being (liveability, road safety)
	Economic well-being (jobs, economic benefits, costs)

3.2 Prioritisation of KPIs

The next step was to define the most important KPIs. This was done to limit the number of KPIs to be included in the assessment and to identify the most feasible KPIs related to the demonstrated e-mobility solutions.

This process consisted of the following tasks:

- Prioritisation of KPIs by each expert inside an organisation, within the partners and organisations involved in the assessment work. The prioritisation of KPIs was instructed to be made based on their relevance and level of importance in each impact area via three-step scale.
- Combined prioritisation of KPIs by each organisation. The scores given by individual experts inside one organisation were used in defining an overall prioritisation of KPIs. This prioritisation was done via internal discussions based on average values of scores given for each KPI. Compilation of prioritisations across partner organisations and producing the proposal on the most important KPIs to be evaluated as part of impact assessment. This step also included the final review of the KPI list to remove or combine potentially overlapping KPIs. The final proposal was then discussed in a meeting with other partners to reach a consensus of the most important KPIs.

3.3 Formulation of reference KPI list

In the next phase the KPI list was complemented with additional KPIs which were also identified relevant for individual demonstrations. Therefore, this allowed the final KPI list to capture unique aspects of each city while at the same time ensuring comprehensive assessment. These additional KPIs were mainly related to the features of some specific demonstrations (e.g. KPIs related to MaaS application) or more detailed technical or operational aspects of demo vehicles or charging infrastructure.

During the process of merging these two KPI lists, the categorisation of KPIs was also adapted. The original four categories ('User acceptance and usage of e-vehicles', 'Accessibility', 'Environment', and 'Quality of Life') were expanded into nine categories:

1. Financial costs/benefits: same KPIs as proposed in the area of 'User acceptance and usage of e-vehicles', some new KPIs.
2. Institutional/political: new descriptive KPIs related to 'Coherence with national plans and development goals', 'Alignment with international/national/city legislation & regulations', 'Ease of implementation'.
3. Climate related: same KPIs as proposed in the area of 'Environment'.
4. Environmental: same KPIs as proposed in the area of 'Environment'.
5. Social: same KPIs as proposed in the area of 'User acceptance and usage of e-vehicles', 'Accessibility' and 'Quality of Life'.
6. Economic: same KPIs as proposed in the area of 'Quality of Life' (economic wellbeing).
7. Demand: same KPIs as proposed in the area of 'User acceptance', new KPIs related to population and businesses served, and demand for MaaS app.
8. Supply: mostly new KPIs related to technical and operational aspects of demo vehicles or charging infrastructure.
9. Use: same KPIs as proposed in the areas of 'Usage and acceptance' and 'Accessibility'; new KPIs related to utilisation rate of EVs.

Next, this revised KPI list was discussed with the demonstration cities during the SOLUTIONSplus living lab activities in October 2020. The aim of these discussions was to collect the feedback of demonstration cities on the proposed KPI list and to hear their views on the most relevant KPIs regarding their demonstration activities. The discussion focussed on potential proposals on KPIs to be added to the KPI list, requests for clarifications, and the feasibility to collect the required information. All the received feedback was collected and reviewed and taken into account when the final KPI list was formulated during several online meetings among the main partners involved in the assessment process. The definitions of all KPIs can be found in appendix 2.

The final KPI list is organized into "levels", where each lower level is a decomposition of the upper level and reflects more detail. Level 1 KPIs describe the general categories that are relevant for the e-mobility assessment, the level 2 and 3 KPIs the (more) detailed indicators that are used for expressing the success of e-mobility for the application or area (e.g. city) that is under assessment.

Having different levels of KPI's enables homogenization and horizontal comparison between different demonstrators and cities. If at a lower level the KPIs are different between cities, higher level KPIs enable comparison on a higher level. Also the different levels are needed to be able to address and analyze different aspects and different research questions. A top down approach with weighting of KPIs also prevents biases, too many KPI's on the lowest level will influence the outcome of the analyses.

Besides the three levels of detail in the KPIs we also distinguish between mandatory (weighted) KPIs, common and additional KPIs. To summarize these three sets of KPIs:

1. List of weighted KPIs, that are mandatory for all demos and need to be collected in order to compare impacts and define the effects of the SOLUTIONSplus project. These KPIs will be included in the weighting process occurring in the later stages of the project (procedure and purpose of this weighting exercise will be explained in section 4.4 of this deliverable). . However, in case some KPIs are not applicable for a specific demo, their relevance can be estimated as zero during the weighting process. The list of Level 1, Level 2 and Level 3 weighted KPIs includes KPIs from six categories as shown in Table 3. Some KPIs include only Level 1 and Level 2. The units of all the Level 3 KPIs are shown in the appendix 1.A.1.
2. List of common (non-weighted) KPIs. These KPIs are important for the overall assessment of city demonstrations. These common KPIs aim to complement the information collected via weighted KPIs to cover additional aspects of the demonstrations. Hence, the collection of data for these KPIs is strongly recommended. The list of Level 1, Level 2 and Level 4 common (non-weighted) KPIs includes KPIs from six categories is shown in appendix 1.A.2.1. The last three categories of the common (non-weighted) KPIs are the same as in the weighted KPIs. Even though these Level 1 and Level 2 KPIs are mutual for both weighted and common (non-weighted) KPIs, the Level 3 and Level 4 KPIs are different. These common KPIs are also targeted to produce additional information to define the values for the weighted KPIs.
3. List of additional (non-weighted) KPIs. The KPIs in this list will be used, for example, for describing the baseline situation in each demonstration city, and for estimating the impacts of demonstrations during the descriptive KPI assessment (described further in section 4.2 of this deliverable). Many of these additional KPIs have been proposed by the demonstration cities and they are hence often specific to only one or few demonstration cities. Therefore, these KPIs were not considered as mandatory for all demonstration cities. Instead, from this list the demonstration cities can select the KPIs which they find most relevant for the assessment of their demonstration activities. The list of Level 1, Level 2 and Level 4 additional (non-weighted) KPIs include KPIs from four categories is shown in appendix 1.

Table 3. List of weighted KPIs (Level 1, Level 2 and Level 3). Some KPIs include only Level 1 and Level 2.

KPI – Level 1	**KPI – Level 2**	**KPI – Level 3**
Financial costs and revenues	Financial viability	NPV (Net present velue)
		IRR (Internal Rate of Return)
		Payback period
	Availability of financial resources	Ease of raising external funding
Institutional/ political	Coherence with national plans and development goals	
	Alignment with international/national/city legislation & regulations	
	Ease of implementation	
Climate related	Impact on GHG emissions	Amount of carbon avoided (% change compared to baseline)
Environmental	Impact on air pollutants	NOx emissions avoided

KPI – Level 1	**KPI – Level 2**	**KPI – Level 3**
		PM2.5 emissions avoided
	Impact on noise	Perception of the impact of the demo EVs on noise level
	Impact on environmental resources	Resources saved due to recycling
Social	Impact on accessibility	Access to jobs, opportunities and services (personal travel)
		Access to pickup/delivery locations (freight).
	Affordability of e-vehicle services	
	Impact on travel time	Change in travel times due to e-mobility services (personal travel)
		Change in travel times due to e-mobility services (freight)
	Impact on road safety	(Annual) Number of road accidents with fatalities/serious injuries
		(Annual) Number of road accidents with minor injuries/material damage
		(Annual) Number of traffic related near accidents/dangerous situations
	Impact on charging safety	(Annual) Number of charging related safety incidents
	Impact on security	(Annual) Number of vandalism/theft incidents
	Impact on well-being	Change in well-being due to changes in active travel
	Quality of e-mobility services	Suitability of e-vehicles in changing climate conditions
		User perception of comfort of e-vehicles
		Ease of driving e-vehicles - professional drivers
		Ease of driving e-vehicles - other users
		Ease of charging the e-vehicle
		Perception of safety
		Perception of personal security
		User perception of continuity of journey chains, incl. modal interchange from/to e-vehicles
Economic	Impact on national/local budget	Required public investment as % of relevant national/local budget
	Impact on external trade	Abated fossil fuel imports as % of total imports
		Abated other imports as % of total imports
	Impact on employment	Number of additional jobs
		Expected increase (%) in the average wage

4 Key Performance Indicator Assessment and Evaluation

4.1 Approach

According to the FESTA handbook (FESTA 2018), (key) performance indicators (KPIs) are quantitative or qualitative indicators, which are derived from one or several measures, agreed on beforehand and expressed as a percentage, index, rate or other value monitored at regular or irregular intervals and compared to one or more criteria. Performance indicators should be appropriate to the project objectives and scope, to help in evaluating the success of a project in fulfilling its objectives as well as the success of the implementation plan.

Impact assessment describes the process of evaluating these performance indicators in a qualitative and/or quantitative sense, including consideration of the context given by the specific circumstances of a project and reflection of potential other simultaneous trends.

Firstly, the KPIs will be assessed. The KPI assessment includes both analytical assessment (section 4.2) and descriptive assessment (section 4.3). The analytical assessment aims to achieve the KPI values based on the data collected by the city teams and stored in the data repository. The KPI values are required by the STAR rating evaluation tool for all defined weighted level 3 KPIs. The KPI values will also be used in the descriptive assessment.

In the SOLUTIONSplus project, the collection of KPI data is compulsory for the weighted KPIs and highly recommended for the common (non-weighted) KPIs. From the list of additional (non-weighted) KPIs the city teams can select the most relevant for their demonstration activities. The reference KPI list (annex A of this deliverable) includes examples of the units for each KPI. However, the cities have the flexibility to use other units according to the data format available. The KPI data collection will be supported by the surveys designed by the WP1 assessment partners e.g. to collect information on the perceptions and views of passengers, bus drivers and/or travellers on the effects of demonstrations, formulas to support the calculation of some KPIs (e.g. financial and environmental), and additional tools which can be found from the SOLUTIONSplus toolbox.

The descriptive assessment studies the potential impacts of SOLUTIONSplus solutions on the impact areas: user acceptance, environment, greenhouse gas (GHG) and other emissions, air quality, traffic safety, traffic efficiency, energy efficiency, personal mobility, well-being/quality of life, sustainability and electrical safety defined in the project SOLUTIONSplus objectives..

Based on the KPI assessment, KPI evaluation is performed**.** The KPI evaluation is based on a methodology that uses STAR rating . The KPI evaluation process can will be performed using a developed evaluation tool which will be explained in section 4.4. The evaluation tool has the purpose of aggregating both values of different KPIs and stakeholders' views on the relevance/importance of these KPIs for each city into a STAR rating expressed by one to five stars. The assessment of KPIs will include different assessment types, namely baseline, ex-ante assessment, ex-post assessment and assessment of a scaled-up project, see section 2.1 and deliverable D1.6 Impact assessment results (Panagakos 2020) for more detailed explanation. These different types of assessments will be performed on single demonstration component level, city level and with a wider scope (i.e. scaled-up project). It is expected that not all assessment types are relevant for all KPIs.

4.2 Analytical KPI assessment

The Analytical KPI assessment focuses on obtaining the numerical values for the weighted Level 3 KPIs presented in Chapter 3. While the focus of the descriptive assessment is on a selection of the presented KPIs (see section 4.3.2), the goal of the analytical KPI assessment is to address all the defined Level 3 KPIs. The results of the analytical assessment give input to the descriptive assessment (see section 4.3) and the evaluation method described in section 4.4.

The analytical assessment consists of the following steps:

1) Obtain Level 3 KPI values on demonstration level

In most cases the Level 3 KPI values cannot be directly obtained from the assessment in the demonstration projects. For those cases, the level 3 KPI values will be obtained by combining and aggregating (non-weighted) Level 4 KPI (see 0) values using data that is collected in the demonstration projects during the ex-ante and ex-post assessment. The level 4 KPI value that is needed for such aggregation is dependent on the solution that is demonstrated in the project. For example, the calculation of the Level 3 KPI 'Amount of carbon avoided' will be different for a project where a Diesel bus is replaced by an electric bus compared to a project where optimized charging strategies are applied to electric buses, even though both projects have the potential to reduce carbon emissions.

The tools developed as part of the SOLUTIONSplus toolbox will contribute to the process of aggregating Level 4 KPI data into Level 3 KPI values.

In other cases, for example for the Level 3 KPIs related to 'Quality of e-mobility services' (see section 3.3), the KPI values can directly be obtained from the data collected by means of surveys in the demonstration projects, thus combining level 4 KPI values is not needed.

The Level 3 KPI values that form the output of this first step can be used as input information to the descriptive KPI assessment described in section 4.2.

2) Upscaling to city level

One of the goals of the SOLUTIONSplus project is to achieve bankable up-scaled projects that can be implemented after the completion of this project. Therefore, city-specific up-scaled projects will be designed together with the local stakeholders on the basis of the demonstration results. For that matter, the level 3 KPI values that were determined on demonstration level have to be converted to the scale of the up-scaled project. For example; if the demonstration project consists of the deployment of 50 e-mopeds and the up-scaled project plans to implement 1000 e-mopeds, the level 3 KPI values gathered in the demonstration have to be up-scaled accordingly in order to reflect the expected impact of the up-scaled project. For the case of 'Amount of carbon avoided' this would result in a multiplication of the value obtained in the demonstration project with a factor of 20.

3) Comparing against baseline

The Level 3 KPIs are defined as the progress that can be made with the up-scaled project compared to the city level baseline. Therefore, for all Level 3 KPIs, the values obtained in the previous step will be compared against the city level baseline scenario and the KPI values will be expressed as the change compared to this baseline. This is defined as:

$$KPI\ value_{up-scaled} = KPI\ value_{up-scaled\ project} - KPI\ value_{up-scaled\ baseline}$$

The analytical assessment will also provide input to the descriptive assessment described in 4.3. This assessment will be done for both the demonstration project and the up-scaled project. Hence, for the descriptive assessment the Level 3 KPI values on demonstration level are required and are defined as the values obtained in the demonstration project compared against the baseline on demonstration level, following the equation below.

$$KPI\ value_{demonstration} = KPI\ value_{demonstration\ project} - KPI\ value_{demonstration\ baseline}$$

4.3 Descriptive KPI assessment

4.3.1 Overview

This section presents the methodology for the descriptive, impact assessment in SOLUTIONSplus which applies both qualitative and quantitative analysis. The focus of descriptive KPI assessment is on societal impacts such as accessibility, personal mobility, emissions and air quality, travel efficiency, road safety and well-being, which are forming an important part of the SOLUTIONSplus project objectives.

Potential impacts can be divided into direct and indirect impacts. In SOLUTIONSplus, direct impacts can be seen as those caused directly by technology, e.g. replacing internal combustion engine (ICE) vehicles with electric vehicles, while indirect impacts are formed through changes in personal mobility e.g. through introduction of a new travel mode. Due to the variety of solutions demonstrated in the SOLUTIONSplus project, both direct and indirect impacts may be expected.

Different methods will be used for estimating KPI values during analytical assessment, depending on the available data and the type of KPI. Many demand and supply related KPIs for example relate to the current population as well as to available mobility options, and they can be answered using national statistics and information from service providers or other stakeholders. KPIs related to user perception, such as perceived safety and comfort, can be answered using results from traveller surveys. Expert assessment is needed when forming conclusions of effects on the societal impact of e-mobility solutions, such as impacts on travel times, road safety and road transport emissions, which requires considering information from several KPIs and potentially other sources. Details on data collection methods are reported in the deliverable D1.6 Impact assessment result (Panagakos 2020).In addition to the data collected during the demonstrations, the descriptive assessment will exploit findings from earlier studies and existing frameworks for the identification of impacts of e-mobility solutions. The focus of descriptive assessment is more on high level assessment of societal impacts by impact areas instead of focussing on some spefific KPIs.

4.3.2 Relevant KPIs for descriptive assessment

As described in section 2.1, user acceptance of e-mobility solutions together with potential changes in personal mobility affect the scope, direction and magnitude of the impacts that can be expected. Therefore, these areas form the basis of the descriptive assessment. In the reference KPI list of the SOLUTIONSplus project, these are reflected mostly through the Level 1 KPIs on Demand, Supply and Use (Table 4). In addition to personal travel, these concepts are expanded to freight and deliveries.

As mentioned earlier, the focus of descriptive KPI assessment is on societal impacts, which form an important part of the SOLUTIONSplus project objectives. Hence, in addition to KPIs related to personal mobility, KPIs on emissions, air quality, accessibility, travel efficiency, road safety and well-being are of special importance. From the project objective perspective, some most important Level 1 and Level 2 KPIs to be considered in descriptive assessment are marked in bold in Table 4. The KPIs related to financial and economic aspects will be further analysed especially as part of WP5 of the SOLUTIONSplus project which focuses on the feasibility and financial aspects of the demonstrations and scaled-up projects. The KPIs on institutional and political aspects are descriptive in nature and the data collected on these KPIs will be documented together with the summary of all collected KPI values, mentioned in Section 4.1.

Table 4. List of weighted and common (non-weighted) KPIs. Some most important Level 2 KPIs to be considered in descriptive assessment are in bold).

KPI - Level 1	**KPI - Level 2**
Financial costs/revenues	Financial viability
	Availability of financial resources
Institutional/political	Coherence with national plans and development goals
	Alignment with international/national/city legislation & regulations
	Ease of implementation
Climate related	**Impact on GHG emissions**
Environmental	**Impact on air pollutants**
	Impact on noise
	Impact on environmental resources
Social	**Impact on accessibility**
	Affordability of e-vehicle services
	Impact on travel time
	Impact on traffic network efficiency
	Impact on road safety
	Impact on charging safety
	Impact on security
	Impact on wellbeing
	Quality of e-mobility services
Economic	Impact on national/local budget
	Impact on external trade
	Impact on employment
Demand	**Total travel time**
	Average distance travelled
	Awareness of e-mobility services
Supply	E-vehicles - operational
Use	**Modal split and multimodality**
	Average distance travelled in EV
	Market share of e-mobility
	Interaction

Table 4 includes KPIs from both the list of weighted and common (non-weighted) KPIs, previously presented in Table 3 and the annex A.2.1, respectively. As described in section 3, these Level 1 and Level 2 KPIs are described by one or several additional, lower level KPIs. These are more specific to individual demonstrations, and their relevance for the assessment will be considered by the city teams.

The success of any mobility solution depends on the user acceptance and potential users need to be aware of it as well as be willing to use it. User acceptance is a broad aspect, which includes topics such as awareness, willingness to use and pay, perceived comfort and journey quality and safety.

Mobility is usually defined as the potential for movement, where the realised or actual movement happens. As this is difficult to measure, it is often approximated through revealed mobility, which describes the actual trips taking place (Innamaa, et al. 2013). To structure the mobility concept and its parts, the mobility model can be used Figure 5. This model is based on scientific literature and expert interviews conducted to identify the relevant factors and variables, which relate to both potential and revealed mobility, and it has been applied in various projects as a framework for studying personal mobility patterns. This mobility model will be modified for use the demonstrations involving solutions dealing with the delivery of goods, to reflect the different objectives of freight transport.

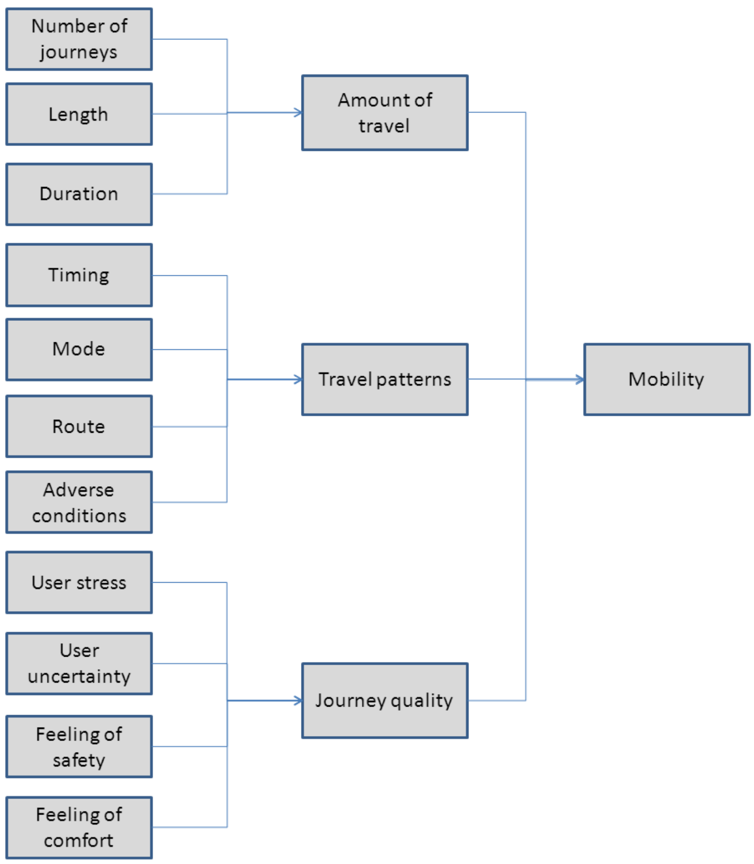

Figure 5. Mobility model for impact assessment extracted from (Innamaa, et al. 2013).

Road transport causes emissions both on the local and global scale. Regarding global CO_2 emissions, the carbon intensity of travel, related to the type and size of the vehicle and the amount of travel, is of most importance. Air pollution is additionally caused by road pavement and tyre wear. Beyond these direct sources, emissions are also caused during the entire vehicle life cycle as well as during the production process of fuel or electricity supply.

Social impact area also include: travel time, traffic network efficiency, road safety and well-being. Traffic efficiency is a measure of how efficiently in terms of travel time and delay people and goods are able to move through the transport network. The amount of travel activity, fleet vehicle size and average occupancy influence travel efficiency on a given network.

The road safety assessment follows the generally accepted theoretical background, where the number of accidents is related to the three dimensions: exposure, risk and consequences (Nilsson 2004). Thus, road safety can be influenced by a change in any of these three dimensions. Accident risk differs e.g. by travel mode, route and time of travel. Therefore, changes in personal mobility patterns can potentially affect road safety. As traffic accidents are relatively rare events, proxy measures such as traffic related near accidents or dangerous situations reported by passengers or drivers could also be considered in road safety assessment.

Well-being is a subjective measure of how people feel about their lives. It is related to transport in several ways. When available, accessible, inclusive and affordable, transportation enables fulfilling needs that enhance well-being of people. Health is also closely related to well-being, as the use of active travel modes can have beneficial impacts on health through increased physical activity (i.e. in case the amount of walking and cycling is increased). On the other hand, air pollution and noise caused by internal combustion engine vehicles and road traffic, in general, can be detrimental to health and quality of life.

4.4 Evaluation

This section focuses on evaluation of the weighted KPIs. The evaluation method is based on a multi-criteria decision analysis (MCDA) (Bruhn Barfod 2020) and is used for aggregating the KPI values resulting from the analytical assessment and presenting them as star ratings. These star ratings can be used for giving judgment to e-mobility solutions and evaluate if the performance of the assessed solutions is in balance with the required financial investments. The presented evaluation method will be applied for the up-scaled assessment, where different e-mobility solutions will be evaluated on city level.

4.4.1 Purpose of evaluation

The list of weighted KPIs presented in chapter 3 describes the main aspects that are relevant for the evaluation of e-mobility solutions and thereby provides a reference in the evaluation process. KPIs are however different in nature, as can be seen in the Level 1 KPIs. The Level 2 and Level 3 KPIs describe more detailed aspects needed to estimate the effects the specific solutions will have on the Level 1 KPIs.

Remark: The non-weighted KPIs described in chapter 3 are not directly used in the evaluation process. However, they are used as inputs to the weighted Level 3 KPIs, as described previously in the analytical assessment.

When evaluating the project, the following questions may arise: When is the project considered viable and worth investing money in? What should be achieved for the project to be considered a success? Who determines if a project is viable and/or successful? And how can one compare different technical solutions or applications that may seem feasible in a project? Evaluation can help in answering these questions and provide guidance in the decision making process.

To address these questions, an example is shown in Table 5, where the KPIs related to the environment are indicated. The Level 1 KPI 'Environmental' was decomposed into the Level 2 KPIs 'Impact on air pollutants', 'Impact on noise' and 'Impact on environmental resources'. These Level 2 KPIs are again decomposed into the Level 3 indicators as indicated in the table. These Level 3 KPIs are quantitative, meaning that they can be expressed in numerical values. In the assessment process, the Level 3 KPI values can be obtained from measurements, simulations, or other relevant means, such as references from the literature. Combining the obtained Level 3 KPI values into quantitative values for the Level 1 and Level 2 KPIs is not straight forward. The Level 3 KPIs have different natures and therefore may not be combined using mathematical tools or methods. The contribution of each Level 3 KPI value to the parent Level 2 KPI, depends on the importance (weight) given to it by the different stakeholders and is therefore subjective. The same holds for the Level 2 KPI values and their contribution to the Level 1 KPI values. Involving the different stakeholders in the decision making and gathering their feedback on the perceived importance of different KPIs is therefore essential in the evaluation process. While the weighting process will ultimately be subjective, the SOLUTIONSplus team recognizes the importance of aiming for highest levels of comparability between the results from the different cities. The organisations involved in Tasks 1.2 and 1.3 have held significant discussions with the relevant city teams in the consolidation of the KPIs, and plan to continue such discussions as the city teams facilitate the actual evaluation processes. Discussions are also to be held regarding recommended methodologies to be used for weighting purposes (e.g. Delphi method).

Table 5. KPIs related to environmental aspects for e-mobility solutions.

KPI - Level 1	KPI - Level 2	KPI - Level 3
Environmental	Impact on air pollutants	NOx emissions avoided
		PM2.5 emissions avoided
	Impact on noise	Perception of the impact of the demo EVs on noise level
	Impact on environmental resources	Resources saved due to recycling

The importance given to the different KPIs by the different stakeholders is reflected by the weighting factors used in the evaluation method. These weighting factors allow for the conversion of the Level 3 KPI values obtained in the analytical assessment into aggregated scores for the Level 1 and Level 2 KPIs. These aggregated scores are presented in the shape of a star rating, where "1 star" is the minimum and "5 stars" the maximum score that the KPIs can get. These scores indicate the achieved performance for the KPIs; the minimum star rating indicates low performance, the maximum score a high performance. As the star rating is a normalized way of presenting the KPI score, comparisons between different KPIs can be made.

Figure 6 gives a schematic representation of the use of weighting factors leading to aggregated star ratings, following the same example of environmental KPIs as depicted in Table 5. The aggregated star ratings for the KPIs that resulted from the weighting process can help in the decision-making; a project can be evaluated to see if its performance weighs up against the financial costs and therefore a viable project. Also, multiple scenarios can be compared in order to choose the most favourable one based on the weighting factors set by the stakeholders and the resulting aggregated scores that reflect the expected performance of e-mobility for the project.

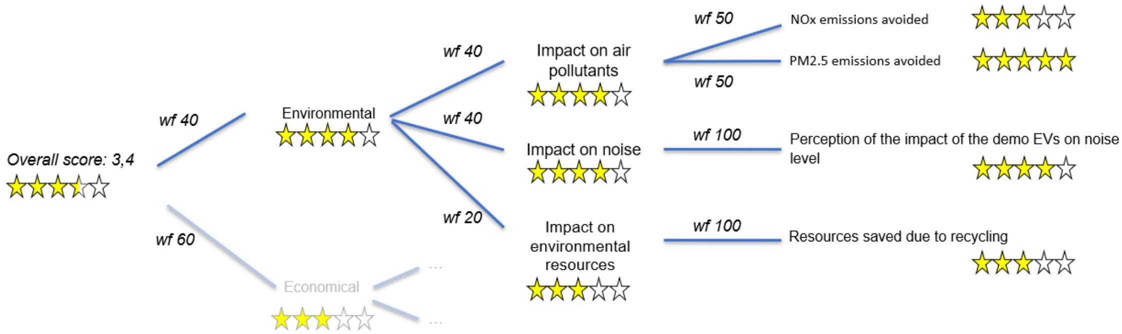

Figure 6. Illustration of the use of weighting factors (wf) *to calculate (aggregated) KPI star ratings. Example given is for the KPIs related to environmental impact. The depicted star ratings in this example are fictional and only used for illustrational purpose. The process starts with assigning weights to the right-most KPIs and proceeds from right to left, the overall score for environmental KPI being 3,4.*

4.4.2 Evaluation methodology

This section describes the evaluation method. The different steps in the method are illustrated in a schematic workflow in Figure 7.

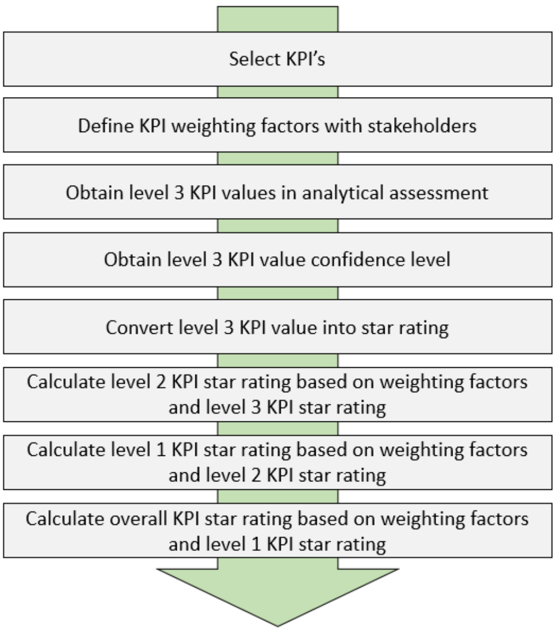

Figure 7. Schematic workflow showing the steps in the evaluation process.

1. Select weighted KPIs

The first step in the assessment process is to define the KPIs that will be used for measuring the performance of a demonstration or project. For SOLUTIONSplus, the KPIs relevant for e-mobility are described in chapter 3. It is important for the evaluation method and the calculation of the star rating that all relevant KPIs are defined on the different levels, as well as the links between the KPIs on the different levels.

For the SOLUTIONSplus project, only the weighted KPIs are taken into account in the evaluation since these are the KPIs expected to be relevant for all the demonstration cities taking part in the project.

2. Define KPI weighting factors with stakeholders

In order to deal with the importance assigned by different stakeholders to the different KPIs, weighting factors are used. These weighting factors are defined together with the stakeholders and the average value of a city's stakeholders' input is used in that city's evaluation process. Two templates were created to support choosing the weighting factors for each citybased on the feedback provided by selected stakeholders. The first template is used for setting the weighting factors for every Level 1, 2 and 3 KPI. The second template is used for aggregating the input from all stakeholders in a city and calculating the average weighting factors that will be used in each city's evaluation.

The weighting factors used in the evaluation method can be chosen between 0 and 100. The method for deciding on these weighting factors is the 'Swing weighting' method (Bruhn Barfod 2020), and its application for the SOLUTIONPLUS project is described in more detail in D1.6 Impact assessment results (Panagakos 2020). By using this methodology, the stakeholders assign the KPI they find most important a value of 100 using the Excel template distributed to the city teams. All other weighting factors among one KPI impact area are then set relative to the most important one. Thus, if a stakeholder finds a certain KPI half as important as the most important one, this KPI is assigned a weighting factor of 50. Once the weights have been set by the stakeholders, they are converted to normalized weights (meaning that the sum of all weights belonging to a set of KPIs at the same level is equal to 100), which can be used directly in the Evaluation tool.

3. Obtaining Level 3 KPI values in analytical assessment

The star ratings for the different levels of KPIs are based on the values obtained for the Level 3 KPIs, meaning that the evaluation of the KPIs starts with the lower level KPIs and data is aggregated to find the scores for the Level 1 and Level 2 KPIs. Therefore, analytical assessment (see 4.2) is needed for finding the values for the Level 3 KPIs.

4. Obtaining Level 3 KPI value confidence level

The process of searching for values for Level 3 KPIs in the analytical assessment (see 4.2) is not straightforward and it may be required to combine different sources of information to reach an acceptable estimate. In some cases, the Level 3 KPI values can be difficult to obtain, because, for example, the data coming from the measurements in a demonstration project is not complete or the period of data collection in the demonstration is not representative for the evaluation. In these cases, data from previous projects or other sources may be used, but this can lead to estimations for the Level 3 KPI values that do not describe the assessed solution accurately. Therefore, the evaluation method contains a confidence level, which expresses the estimated confidence on how accurate is the proposed value used for the Level

3 KPI . In case two demonstrations or upscaling scenarios have the same evaluation overall star rating, the confidence level can help in making a distinction between the two.

Note that the confidence level is subjective and not trivial to assess. In general, measurements are expected to give higher confidence than simulations or data from previous projects, but exceptions will likely be common.

In the evaluation process the confidence level estimations are only to be provided for the Level 3 KPIs by the assessor (together with the involved stakeholders supplying the KPI data during the assessment), since this is the KPI level where actual assessment data is used. Confidence levels for the Level 1 and Level 2 KPIs are calculated from the Level 3 KPI confidence levels and the weighting factors for the weighted KPIs. Discussions regarding the confidence level estimations will be tackled as part of future meetings with the city teams (and/or the relevant assessors) as part of the provision of guidance regarding the matter.

5. Convert level 3 KPI value into star rating

To calculate scores for the Level 1 and Level 2 KPI, aggregation of the Level 3 scores based on the weighting factors is needed. For this aggregation to work, all the Level 3 KPI values must be converted to the same scale. This is done by converting the Level 3 KPI value into a star rating for that KPI, where the maximum is 5 stars and the minimum is 1 star. For this conversion, the following information is needed:

- KPI_{min}, the KPI value that corresponds to the minimum star rating of 1. The minimum KPI value states 'the bare minimum value' that the stakeholders would like to achieve for the specific KPI. The minimum value is mainly based on previous experience in other assessment projects and/or targets set by the stakeholders of the demonstration project.
- KPI_{max}, the KPI value that corresponds to the maximum star rating of 5. The maximum KPI value represents 'the absolute best value' that the stakeholders see as suitable for the specific KPI. The value can be set based on expert knowledge and experience, or it can be based on legislation or standards. For CO2 emission for example, the maximum star rating could be based on the target values mentioned in the Paris climate agreement.

The process of obtaining these KPI minimum and maximum values is challenging. However, it reflects the complexity of evaluation where the performance of a solution or scenario in a project matches the performance expected by the stakeholders. For most of the KPI target values, expert knowledge is required in order to make proposals for these values. The knowledge and expertise of the partners in WP1 will assist with the proposition of KPI acceptable values. The proposed values will then be reviewed with the relevant stakeholders to gather their feedback on the proposed values. Finding the right stakeholder to review the proposed target value for each KPI is a challenging process, as it depends on the experience, interest and availability to participate in the discussions. Practical guidelines for organizing the process will be developed during the course of this project.

Once KPI values corresponding to the minimum and maximum star rating have been established, the Level 3 KPI value can be converted into a star rating with the equation below:

$$Star\ rating_{KPI\ level\ 3} = (5 - star\ rating_{min}) \times \frac{KPI_{value} - KPI_{min}}{KPI_{max} - KPI_{min}} + star\ rating_{min}$$

where $star\ rating_{min}$ is the minimum star rating of 1.

6. Calculate Level 2 KPI star rating based on weighting factors and Level 3 KPI star rating

After converting the Level 3 KPI values into normalized star ratings, the star ratings for the Level 2 KPIs can be calculated based on the respective Level 3 KPI star ratings and the weighting factors assigned to the Level 3 KPIs by the stakeholders. The star ratings for the Level 2 KPIs can be calculated using the equation below:

$$star\ rating_{KPI,level\ 2} = \frac{\sum_1^n star\ rating_{KPI\ level\ 3,\ i} * wf_{KPI\ level\ 3,\ i}}{100},$$

Where n is the number of Level 3 KPIs linked to the Level 2 KPI of interest, $star\ rating_{KPI\ level\ 3,\ i}$ the star rating for these Level 3 KPIs and $wf_{KPI\ level\ 3,\ i}$ the weighting factors for these Level 3 KPIs.

7. Calculate Level 1 KPI star rating based on weighting factors and Level 2 KPI star rating

Similar to the calculation of the Level 2 KPI star ratings, the Level 1 KPI star ratings can be calculated. For this, the Level 2 KPI star ratings are used together with the Level 2 KPI weighting factors, making use of the equation below:

$$star\ rating_{KPI,level\ 1} = \frac{\sum_1^n star\ rating_{KPI\ level\ 2,\ i} * wf_{KPI\ level\ 2,\ i}}{100},$$

Where n is the number of Level 2 KPIs linked to the Level 1 KPI of interest, $star\ rating_{KPI\ level\ 2,\ i}$ the star rating for these Level 2 KPIs and $wf_{KPI\ level\ 2,\ i}$ the weighting factors for these Level 2 KPIs.

8. Calculate overall KPI star rating based on weighting factors and Level 1 KPI star rating

Finally, the overall star rating for an assessment project can be calculated from the Level 1 KPI star ratings and the Level 1 KPI weighting factors by using the following equation:

$$star\ rating_{combined} = \frac{\sum_1^n star\ rating_{KPI\ level\ 1,\ i} * wf_{KPI\ level\ 1,\ i}}{100},$$

Where n is the number of Level 1 KPIs, $star\ rating_{KPI\ level\ 1,\ i}$ the star rating for these Level 1 KPIs and $wf_{KPI\ level\ 2,\ i}$ the corresponding Level 1 KPI weighting factors.

4.4.3 Evaluation tool

The evaluation tool contains the implementation of the evaluation methodology previously described. The tool implementation is done in the commonly used software Microsoft Excel, to make sure the Evaluation tool is available to a broad audience. For further improvement of the tool functionality, future releases of the tool can be done in other software packages.

The different functionalities of the Evaluation tool are spread across different tabs. This is shown in Figure 8, where the main tool structure is depicted together with the main functionalities of the different parts of the tool.

The Evaluation tool will be available for download from the Solutions+ toolbox on the project website (http://www.solutionsplus.eu/toolbox.html).

The tool does not require any specific training. Detailed instructions for using the Evaluation tool can be found in the tool manual documented in appendix 1.B.

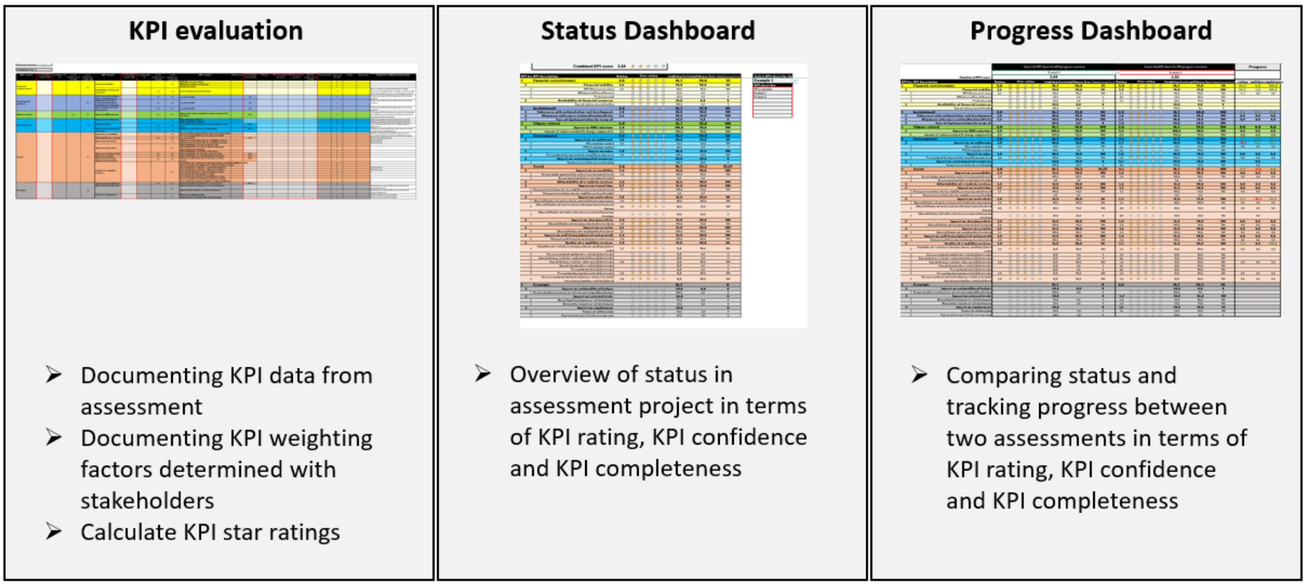

Figure 8. Evaluation tool lay-out with a summary of the main functionalities.

4.4.4 Application of the Evaluation method: Example

In Figure 9 an example is given of how the star rating system can be used for comparing different e-mobility up-scaled scenarios. In these fictional scenarios, the impact of different e-mobility solutions on city level are visualised by means of the star rating for the different Level 1 KPIs that were chosen for the SOLUTIONSPLUS project. In this example, the star rating is lower in scenario 1 for some of the Level 1 KPIs, for example, the economic impact. The combined star rating for scenario 1 is however higher than for scenario 2. Thus in this example scenario 1 would be favourable for the specific needs and objectives of the involved stakeholders. Comparisons can be made for any kind of scenario, as long as the Level 3 KPI data has been made available in the ex-ante and ex-post assessment for the applications that are taken into account in the scenario (in this example, e-scooters, e-busses and e-taxis).

KPI level 1	Scenario 1 500 e-scooters 100 e-busses	Scenario 2 1000 e-scooters 50 e-busses 50 e-taxis
Financial	★★★★☆	★★☆☆☆
Political	★★★★☆	★★★☆☆
Climate related	★★★☆☆	★★★★☆
Environmental	★★★★☆	★★★☆☆
Social	★★★★☆	★★★☆☆
Economical	★★★☆☆	★★★★☆
Combined rating	★★★★☆	★★★☆☆

Figure 9. Illustration of the use of the star rating for scenario comparison. Note that the depicted scenarios are fictional and only serve illustrational purpose.

5 Conclusions and future work

Conclusions

This deliverable presents the assessment framework for performing different types of assessment within the SOLUTIONplus project, namely baseline, ex-ante, ex-post and up-scaling. The assessment framework includes six subsequent steps from User needs assessment, KPI selection, Data collection, Descriptive and analytical KPI assessment, KPI evaluation to results analysis. The assessment framework is formulated in a form of a double V cycle diagram where the inner cycle shows the relation between its six aforementioned main steps. The outer cycle provides an overview of the supporting tool(s), developed within the SOLUTIONSplus project, for each main step.

The initial KPI list was identified addressing four main impact areas, i) user acceptance and usage, ii) accessibility, iii) environment and iv) quality of life. This initial KPI list was then revised to select the most important and feasible KPIs related to the SOLUTIONSplus project objectives and to the demonstrated e-mobility solutions. Finally, the revised KPI list was discussed with the demonstration cities during the SOLUTIONSplus living lab activities in October 2020. Feedback of the demonstration cities was taken into account to achieve a final KPI list (also called reference KPI list) being capable of capturing unique aspects of each city while at the same time ensuring comprehensive assessment.

The reference KPI list consists of three main parts. One is the weighted KPIs with three KPI levels. These weighted KPIs are mandatory for all demonstration cities. In addition, the groups of the common (non-weighted) KPIs and additional (non-weighted) KPIs with four KPI levels were defined. The collection of information on common (non-weighted) KPIs is highly recommended for all demonstration cities whereas the selection of additional (non-weighted) KPIs can be different according to the demonstrations planned for each city.

Within this deliverable, the method for evaluating the KPIs is also elaborated. It contains two steps, The first one is a descriptive and analytical assessment. The second one is a STAR rating evaluation of the KPIs supported by a developed evaluation tool within task 1.2. The main purpose of the STAR rating evaluation tool is to aggregate both values of different KPIs and stakeholders' views on the relevance/importance of these KPIs for each demonstration city. The outcome of the second step is STAR rating of the KPIs expressed by one to five stars. The evaluation tool can be used to assist with the evaluation of different scenarios and comparing potential e-mobility solutions across different elements for the specificity of the city where the potential solution has been tested.

Future work

During the coming years within the SOLUTIONSplus project, the assessment framework together with its guidance for selecting the assessment methods with their requirements (e.g. data requirements) for the reference KPI list will be updated. In addition, based on the lessons learned from the actual application of the framework when performing the baseline, ex-ante and ex-post assessments at nine demonstration cities in the SOLUTIONplus project, the assessment framework will be adjusted if needed and further practical guidelines for obtaining the required input information together with the stakeholders will be developed. For example, the determination of the minimum and maximum targeted KPI requires practical guidance to obtain these values.

The developed reference KPI list includes an extensive list of KPIs covering different impact areas as well as technical and operational aspects of e-mobility solutions. This list could be exploited and used as inspiration also in future projects and demonstration activities aiming to assess the impacts of e-mobility solutions implemented in different environments and countries.

6 References

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Appendix 1 (A) KPI list and (B) Evaluation tool manual

A Reference KPIs list

A.1 Weighted KPIs

KPI - Level 1	KPI - Level 2	KPI - Level 3	Unit of KPI level 3
Financial costs/revenues	Financial viability	NPV (Net present velue)	Euros
		IRR (Internal Rate of Return)	Euros
		Payback period	Years
	Availability of financial resources	Ease of raising external funding	(Likert scale)
Institutional/ political	**Coherence with national plans and development goals**		(Likert scale)
	Alignment with supra-national/national/city legislation & regulations		(Likert scale)
	Ease of implementation (in terms of administrative barriers)		(Likert scale)
Climate related	Impact on GHG emissions	Amount of carbon avoided (% change compared to baseline)	% and kg
Environmental	Impact on air pollutants	NOx emissions avoided	% and kg
		PM2.5 emissions avoided	% and kg
	Impact on noise	Perception of the impact of the demo EVs on noise level	(Likert scale)
	Impact on environmental resources	Resources saved due to recycling	kg
Social	Impact on accessibility	Access to jobs, opportunities and services (personal travel)	(Likert scale)
		Access to pickup/delivery locations (freight).	(Likert scale)
	Affordability of e-vehicle services		

KPI - Level 1	KPI - Level 2	KPI - Level 3	Unit of KPI level 3
	Impact on travel time	Change in travel times due to e-mobility services (personal travel)	% (and h?)
		Change in travel times due to e-mobility services (freight)	% (and h?)
	Impact on road safety	(Annual) Number of road accidents with fatalities/serious injuries	(no unit)
		(Annual) Number of road accidents with minor injuries/material damage	(no unit)
		(Annual) Number of traffic related near accidents/dangerous situations	(no unit)
	Impact on charging safety	(Annual) Number of charging related safety incidents	(no unit)
	Impact on security	(Annual) Number of vandalism/theft incidents	(no unit)
	Impact on well-being (physical and mental)	Change in well-being due to changes in active travel	(Likert scale)
	Quality of e-mobility services	Suitability of e-vehicles in changing climate conditions	(Likert scale)
		User perception of comfort of e-vehicles	(Likert scale)
		Ease of driving e-vehicles - professional drivers	(Likert scale)
		Ease of driving e-vehicles - other users	(Likert scale)
		Ease of charging the e-vehicle	(Likert scale)
		Perception of safety	(Likert scale)
		Perception of personal security	(Likert scale)
		User perception of continuity of journey chains, incl. modal interchange from/to e-vehicles	(Likert scale)
Economic	Impact on national/local budget	Required public investment as % of relevant national/local budget	(%)
	Impact on external trade	Abated fossil fuel imports as % of total imports	(%)
		Abated other imports as % of total imports	(%)
	Impact on employment	Number of additional jobs	(no unit)
		Expected increase (%) in the average wage	(%)

A.2 Non-weighted KPIs

A.2.1 *Common non-weighted KPIs*

KPI - Level 1	KPI - Level 2	KPI - Level 4
Demand	Total travel time	Total time spent travelling per day per person [min per day]
	Average distance travelled	Average distance travelled by type of vehicle
	Awareness of e-mobility services	Awareness of e-vehicles as an option to make the journey [expressed on a Likert scale, e.g. 1–9, low–high]
Supply	E-vehicles - operational	Average driving speed
Use	Modal split and multimodality	Share of travel modes (modal split)
		Number of multimodal trips including use of e-vehicles [% of all trips]
		Number of first/last mile trips with e-vehicles (personal transport)
		Number of first/last mile trips with e-vehicles (freight)
	Average distance travelled in EV	Average distance traveled with e-vehicles per day [km]
	Market share of e-mobility	Number and type of trips made with an e-vehicle [% of all trips]
	Market share of e-mobility	Number and type of trips made with an e-vehicle [% of all trips]
	Interaction	Interaction with other road users [expressed on a Likert scale, e.g. 1–9, failure–perfect]
Climate related	Impact on GHG emissions	Carbon footprint (gCO2/p-km)
Social	Affordability of e-vehicle services	Ticket price (freight: Cost of transport)
	Impact on road safety	Number of road accidents involving VRUs (vulnerable road users)
		Number of traffic related near accidents/dangerous situations involving VRUs
	Impact on traffic network efficiency	Impact on congestion
	Quality of e-mobility services	Perception of traffic efficiency (congestion)
	Impact on well-being (physical)	Change in exposure to emissions
Economic	Impact on employment	Change in the required person work-years
		Number of new businesses

A.2.2 ***Other additional non-weighted KPIs***

KPI - Level 1	KPI - Level 2	KPI - Level 4
Demand	Population served	Population of the demo city region
		Population of the demo area
		Population of each neighbourhood of shared e-scooter point
	Population density	Average population density in the city region
	Businesses served	Businesses in the demo area by economic activity
		% of businesses served by the SOL+ demo in the demo area by economic activity
		% of businesses using last-mile schemes (by all transport modes)
	Transport work (passenger-km, etc.)	Total PKM performed by all transport modes in the city region
	Average utilisation of vehicles	Average utilization of public/private vehicles
	Awareness of e-mobility services	Local User perception of changing from current modes of transportation to e-vehicles (resistance of change)
		Local User awareness of potential social, health, environmental and financial benefits from e-vehicles/last-mile schemes (awareness of benefits)
	Demand for MaaS app	Total unique users of the MaaS app
		Total direction inquiries using the MaaS app
		Total bookings done using the MaaS app
		Total (%) trips paid using the MaaS app
		Total PKM facilitated through the MaaS app
		Total trips shifted from private modes to public transport through the MaaS app
	Willingness to pay for the e-mobility services	Willingness to pay for the e-vehicle services [monetary value/p-km or per trip/month]
Supply	Existing fleets	Number of vehicles by type
		Number of vehicles designed in the context of SOL+ sold
		Vehicle productivity (km/vehicle/day)
	Existing transport infrastructure	Number of km by type
	E-vehicles - technical	Energy efficiency [kWh/p-km] (Energy consumption of a vehicle [liters/100km or miles per gallon or electric equivalent])
		Annual energy consumption of a vehicle [kWh/year]
		Maximum passenger capacity per type
		Maximum loading capacity per type
		Maximum climb rate
		Maximum torque
		Maximum speed
		Range of temperature for operability
		Maximum and minimum values of the state of charge

KPI - Level 1	KPI - Level 2	KPI - Level 4
		Charging power for single opportunity charging
		Expected life of vehicles
		Expected life of batteries
	E-vehicles - operational	Vehicle-hours performed during demo
		Average charging time
		E-vehicle operating staff (drivers etc.)
		Average range between charging intervals
		Average state of charge between charging intervals
		Time for opportunity charging
		Number of breakdowns/failures - vehicles
		Number of scheduled repairs - vehicles
		Number of unscheduled repairs - vehicles
		Failures per operational hour - vehicles
		Material damage to freight
	E-vehicles - financial	(CAPEX) Capital cost per vehicle [infrastructure, monetary value]
		Purchase cost of batteries
		(OPEX) Operating cost for the deployed e-vehicle system [per vehicle-hour or per vehicle-km or mile or per trip, monetary value]
		Fees for battery rental/leasing
		Cost saving for drivers
		Impact on fares
		Costs of scheduled maintenance- vehicles
		Costs of unscheduled maintenance - vehicles
		Total cost of ownership - vehicle
		Total revenue kilometers
		Total revenue hours
		Time saved by staff due to charging solution (against existing solution)
		Cost of vehicle downtime
		Revenue hours lost due to charging
		Potential revenue/unit
	Power demand for e-mobility	Total power demand from grid for e-mobility [MW]
		Power consumption of e-vehicles
	Availability of electricity	Production capacity & import/export possibilities
	Energy mix of electricity production	Average production by type of fuel
		Marginal production by type of fuel
	Charging infrastructure - technical	Number of required chargers for e-mobility
		Number of available charging points
		Number of fast charging points
		Number of battery swapping stations
		Location of charging stations
		Number of public charging points installed
		Ground surface required for charging e-vehicles [m2]
		Charging power for overnight charging
		Number of users of the public charging facilities

KPI - Level 1	KPI - Level 2	KPI - Level 4
	Charging infrastructure - operational	Average charging time/user
		Charging behaviour (simultaneous vs. one at a time)
		Number of charging cycles per day
		Number of breakdowns/failures - charging solution
		Timing of charging (time of day; effect on power requirements)
		Number of scheduled repairs - charging solution
		Number of unscheduled repairs - charging solution
		Failure/operational hour - charging solution
	Charging infrastructure - financial	Required public/private investment in charging facilities
		Total cost of ownership - charging solution
		Operational costs - charging solution
		Maintenance costs - charging solution
	Transport organisation & governance	Effectiveness of transport organisation & governance (Likert scale)
	Availability of human resources (operation, maintenance, etc.)	Number of skilled personnel for EV operation & maintenance
Use	Transport work in EV (passenger-km, etc.)	Total person-kilometers performed with EV
		Total vehicle kilometers performed with EV (passengers)
	Transport work with EV (freight)	Total freight km performed with EV
		Total vehicle kilometers performed with EV (freight)
	Average distance travelled in EV	Total kilometres or miles travelled with e-vehicles per week in a region
	Utilisation of EV	Average occupancy (pax/trip)
		Average load (kg/trip or /day)
		Number of trips / delivery vehicle
		Number of deliveries / day by type of economic activity
		Number of orders / week / business by type of activity
		% of deliveries by EVs
		% of trips by EVs
		Load capacitiy utilisation
		Utilisation time (frequency of deliveries / peaks)
	Market share of e-mobility	Number of person trips conducted by the e-vehicles
		Number of freight trips conducted by the e-vehicles
		Person km travelled with an e-vehicle [% of all p-km]
		Number [or%?] of people served (within a catchment area)
		Nr of unique users
Environmental	Impact on environmental resources - Resources saved due to recycling (kg)	% of non-operational batteries recovered through Extended Producer Responsibility schemes
		% of batteries used in second life appliances
		% of batteries recycled either locally or abroad

B **Evaluation tool manual**

The overall methodology for the evaluation tool was described in section 4.4. This chapter gives the working instructions that provide some guidance in the practical application of the evaluation tool in an assessment project. The first section will describe the process of entering data from the assessment in the evaluation tool. This data forms the basis of the star rating methodology and contains the KPI data and weighting factors that were described earlier in this document (see section 4.4.2).

The second section will give an overview of the status dashboard, which shows the calculated star ratings for the KPIs. Finally, the third section will describe the use of the progress dashboard which allows the user to compare between two status snapshots in a project.

An overview of the different components of the Evaluation tool is depicted in Figure 10.

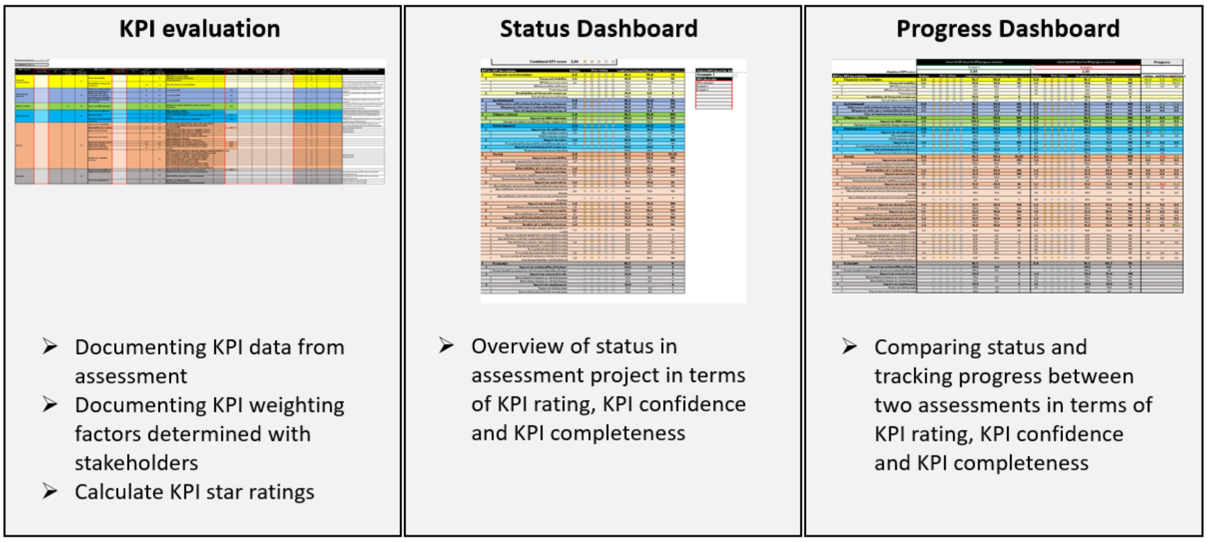

Figure 10. The different components of the Evaluation tool; The KPI evaluation sheet (see B.1), The Status Dashboard (see B.2) and the Progress Dashboard (see B.3)

B.1 Using the KPI evaluation data sheets

Within the SOLUTIONSPLUS project, if multiple assessments will be executed at different points in time during the project, for every assessment separately a KPI sheet is to be filled in.

The KPI sheets are used for entering the specific KPI data for the calculation of the star rating scores. The KPI data can be obtained from different sources, for example measurements in a demonstration project or from a simulation tool. For each KPI, specific data values are required to be filled in in order to be able to calculate the star rating specific for that KPI, in combination with the weighting factors that are also to be entered in the KPI sheet for every KPI. The KPI data values are only to be filled in for the level 3 KPIs; the level 1 and level 2 KPIs will be calculated based on the level 3 data values and the KPI weighting factors.

The next sections will describe the different columns of the evaluation sheet in detail.

B.1.1 *Combined star rating*

The combined star rating in *cell C3* will be the final result for the KPI evaluation process and is based on the KPI data that is filled in by the user (see B.1.15 - B.1.18) and the weighting factors that are applied to all the KPIs (seeB.1.3, B.1.8 and B.1.14). If there is KPI data filled in, an overall rating between 1 and 5 (or zero and 5, see B.1.25) is displayed, which gives a combined score for all the KPIs that are used in the evaluation project.

B.1.2 ***KPI – level 1***

in *column B* in the sheet "KPI Evaluation" in the evaluation tool the level 1 KPIs are listed according to how they were defined in the SOLUTIONSPLUS project. These are high level KPIs and display the 6 most relevant aspects of e-mobility. For the SOLUTIONSPLUS project, the level 1 KPIs are not to be modified by the user.

Note: this column is not to be modified by the user

B.1.3 ***Level 1 weighting factor***

in *column C* in the sheet "KPI Evaluation" in the evaluation tool the weighting factors for the level 1 KPIs are to be filled in by the user. These weighting factors indicate the importance that was given to each level 1 KPI by the different stakeholders. These weighting factors can be obtained following the methodology described in (Panagakos 2020) and the accompanying weighting factor templates. The level 1 KPI weighting factors are used for combining the level 1 KPI ratings (see B.1.4) into a combined project star rating (see **Error! Reference source not found.**).

Note: this column requires user input

B.1.4 ***Level 1 Rating***

in *column D* in the sheet "KPI Evaluation" in the evaluation tool the star rating for the level 1 KPIs is displayed. This star rating is based on the level 3 KPI data filled in by the user (see B.1.15 - B.1.18), the level 2 weighting factors (see B.1.8) and the level 3 weighting factors (see B.1.14). The level 1 rating is a score between 1 and 5 (or zero and 5, see B.1.25) and displays how well the project is doing with respect to the specific level 1 KPI. Calculation method of level 1 KPI rating is depicted in section 4.2.

Note: this column is not to be modified by the user

B.1.5 ***Level 1 Confidence level***

in *column E* in the sheet "KPI Evaluation" in the evaluation tool the level 1 KPI confidence level is displayed. This confidence levels gives an indication of the certainty that the level 1 KPI rating (see B.1.4) is correct. The level 1 confidence level is calculated from the level 3 KPI confidence levels (see B.1.18), the level 2 KPI weighting factors (see B.1.8) and the level 3 KPI weighting factors (see B.1.14).

Note: this column is not to be modified by the user

B.1.6 ***Level 1 Completeness level***

in *column F* in the sheet "KPI Evaluation" in the evaluation tool the level 1 completeness level is displayed. The completeness level indicates the completeness of filling in the required level 3 KPI data (see B.1.15 - B.1.18) that is needed for calculating the level 1 KPI rating (see B.1.4). A high completeness level means that there that the level 1 KPI rating is based on more data than a low completeness level.

Note: this column is not to be modified by the user

minimum star rating setting	1

Combined star rating

KPI - Level 1	Level 1 weighting factor [0 - 100]	Level 1 Rating [0 - 5]	Level 1 Confidence level [0 - 100]	Level 1 Completeness level [0 - 100]	KPI - Level 2	Level 2 weighting factor [0 - 100]	Level 2 Rating [0 - 5]	Level 2 Confidence level [0 - 100]	Level 2 Completeness level [0 - 100]
Financial costs/revenues				0,0	Financial viability				0,0
					Availability of financial resources			0,0	0,0
Institutional/ political				0,0	Coherence with national plans and development goals			0,0	0,0
					Alignment with supra-national/national/city legislation & regulations			0,0	0,0
					Ease of implementation (in terms of administrative barriers)			0,0	0,0
Climate related			0,0	0,0	Impact on GHG emissions			0,0	0,0
Environmental				0,0	Impact on air pollutants				0,0
					Impact on noise			0,0	0,0
					Impact on environmental resources			0,0	0,0
Social				0,0	Impact on accessibility				0,0
					Affordability of e-vehicle services			0,0	0,0
					Impact on travel time				0,0
					Impact on road safety				0,0
					Impact on charging safety			0,0	0,0
					Impact on security			0,0	0,0
					Impact on well-being (physical and mental)			0,0	0,0

Figure 11. Snapshot of the left side of the KPI evaluation sheet, containing the level 1 and level 2 KPI data. For detailed descriptions of each column, see section B.1.2- B.1.11

KPI - Level 3	KPI level 3 unit	Level 3 weighting factor [0 - 100]	KPI value	KPI value minimum star rating	KPI value maximum star rating	KPI value confidence level [0 - 100]	KPI rating [1 - 5]	completeness [0 - 100]	Method	Assigned tool	Comments / additional information
NPV (Net present velue)								0			
IRR (Internal Rate of Return)								0			
Payback period								0			
Ease of raising external funding								0			*Direct rating based on information about available government and donor funds, credit lines, etc. to be used for the scaled-up project in case external funding is required.*
see level 2 KPI		NA						0			*Written description of the situation; no numerical values required*
see level 2 KPI		NA						0			*Written description of the situation; no numerical values required*
see level 2 KPI		NA						0			*Written description of the situation; no numerical values required*
Amount of carbon avoided (% change compared to baseline)		100,0						0			*Calculation of CO2 emissions in terms of LCA. If not possible, then WTW perspective, which is the minimum requirement for comparing alternative fuels.*
NOx emissions avoided								0			*Volume of emissions avoided in comparison to baseline*
PM2.5 emissions avoided								0			*Volume of emissions avoided in comparison to baseline*
Perception of the impact of the demo EVs on noise level		100,0						0			*Perception of people living in the neighbourhood, user, drivers etc.)*
Resources saved due to recycling (kg)		100,0						0			*This does not include fossil fuels. It only concerns vehicles and their parts including batteries.*
Access to jobs, opportunities and services (personal travel)								0			*Enables reaching new destinations and services, user*
Access to pickup/delivery locations (freight)								0			*perception. Quntitative indicator by DLR; if not feasible, direct*
see level 2 KPI		NA						0			*Direct rating of L2 indicator*
Change in travel times due to e-mobility services (personal travel)	%							0			*Only if relevant*
Change in travel times due to e-mobility services (freight)								0			*Only if relevant*
(Annual) Number of road accidents with fatalities/serious injuries								0			
(Annual) Number of road accidents with minor injuries/material damage								0			
(Annual) Number of traffic related near accidents/dangerous situations								0			
(Annual) Number of charging related safety incidents		100,0						0			
(Annual) Number of vandalism/theft incidents		100,0						0			
Change in well-being due to changes in active travel		100,0						0			
Suitability of e-vehicles in changing climate conditions [Likert scale]								0			
User perception of comfort of e-vehicles [Likert scale]								0			
Ease of driving e-vehicles - professional drivers [Likert scale]								0			*Only if relevant*
Ease of driving e-vehicles - other users [Likert scale]								0			*Only if relevant*
Ease of charging the e-vehicle [Likert scale]								0			

Figure 12. Snapshot of the right side of the KPI evaluation sheet, containing the level 3 KPI data. For detailed descriptions of each column, see sections B.1.12 - B.1.23

B.1.7 ***KPI – level 2***

in *column G* in the sheet "KPI Evaluation" in the evaluation tool the level 2 KPIs are listed according to how they were defined in the SOLUTIONSPLUS project. These are sub-categories for the level 1 KPIs and give more detail into how the level 1 KPIs can be measured . For the SOLUTIONSPLUS project, the level 2 KPIs are not to be modified by the user.

Note: this column is not to be modified by the user

B.1.8 ***Level 2 weighting factor***

in *column H* in the sheet "KPI Evaluation" in the evaluation tool the weighting factors for the level 2 KPIs are to be filled in by the user. These weighting factors indicate the importance that was given to each level 2 KPI with regard to a level 1 KPI by the different stakeholders. These weighting factors can be obtained following the methodology described in (Panagakos 2020) and the accompanying weighting factor templates. The level 2 KPI weighting factors are used for combining the level 2 KPI ratings (see B.1.9) into the level 1 KPI ratings (see B.1.4).

Note: this column requires user input

B.1.9 ***Level 2 Rating***

in *column I* in the sheet "KPI Evaluation" in the evaluation tool the star rating for the level 2 KPIs is displayed. This star rating is based on the level 3 KPI data filled in by the user (see B.1.15 - B.1.18) and the level 3 weighting factors (see B.1.14). The level 2 rating is a score between 1 and 5 (or zero and 5, see B.1.25) and displays how well the project is doing with respect to the specific level 2 KPI. Calculation method of level 1 KPI rating is depicted in section 4.2.

Note: this column is not to be modified by the user

B.1.10 ***Level 2 Confidence level***

in *column J* in the sheet "KPI Evaluation" in the evaluation tool the level 2 KPI confidence level is displayed. This confidence levels gives an indication of the certainty that the level 2 KPI rating (see B.1.4) is correct. The level 2 confidence level is calculated from the level 3 KPI confidence levels (see B.1.18) and the level 3 KPI weighting factors (see B.1.14).

Note: this column is not to be modified by the user

B.1.11 ***Level 2 Completeness level***

in *column J* in the sheet "KPI Evaluation" in the evaluation tool the level 2 completeness level is displayed. The completeness level indicates the completeness of filling in the required level 3 KPI data (see B.1.15 - B.1.18) that is needed for calculating the level 2 KPI rating (see B.1.4). A high completeness level means that there that the level 2 KPI rating is based on more data than a low completeness level.

Note: this column is not to be modified by the user

B.1.12 ***KPI - Level 3***

in *column L* in the sheet "KPI Evaluation" in the evaluation tool the level 3 KPIs are listed according to how they were defined in the SOLUTIONSPLUS project. These are sub-categories for the level 2 KPIs and give the practical data that is required for calculating the level 2 KPIs.

The level 3 KPIs are measurable indicators and therefore all have a defined unit (see B.1.13). For the SOLUTIONSPLUS project, the level 3 KPIs are not to be modified by the user.

Note: this column is not to be modified by the user

B.1.13 ***KPI level 3 unit***

in *column M* in the sheet "KPI Evaluation" in the evaluation tool the level 3 KPI units are listed. The level 3 KPIs (see B.1.12) are all defined as measurable indicators, of which the unit is depicted in this column, see A.1.

Note: this column is not to be modified by the user

B.1.14 ***KPI level 3 weighting factor***

in *column N* in the sheet "KPI Evaluation" in the evaluation tool the weighting factors for the level 3 KPIs are to be filled in by the user. These weighting factors indicate the importance that was given to each level 3 KPI with regard to a level 2 KPI by the different stakeholders. These weighting factors can be obtained following the methodology described in (Panagakos 2020) and the accompanying weighting factor templates. The level 3 KPI weighting factors are used for combining the level 3 KPI ratings (see B.1.19) into the level 2 KPI ratings (see B.1.9).

Note: this column requires user input

B.1.15 ***KPI value***

The level 3 KPI values that are to be entered in *column O* in the sheet "KPI Evaluation" in the evaluation tool. The KPI value that is to be entered has the unit that is mentioned in the unit column (*Column M*). The KPI values are used for calculating the KPI and Research Question star ratings, and are therefore an important piece of information in the assessment process.

Note: this column requires user input

B.1.16 ***KPI value minimum star rating***

The KPI value that corresponds to the minimum star rating (see B.1.25) can be filled in for each level 3 KPI in *column P* in the 'KPI Evaluation' sheet in the evaluation tool. Based on the KPI value that corresponds to the minimum star rating and the KPI value that corresponds to the maximum star rating of 5 stars (see B.1.17), the KPI value entered in *column O* (see B.1.15) can be converted into a star rating for that specific level 3 KPI. Obtaining this KPI value for the minimum star rating is not a trivial process and needs input from the different stakeholders involved in the assessment. The minimum KPI value states 'the bare minimum value' that the stakeholders would like to achieve for the specific KPI.

Note: this column requires user input

B.1.17 ***KPI value maximum star rating***

The KPI value that corresponds to the maximum star rating (5 stars) can be filled in for each level 3 KPI in *column Q* in the 'KPI Evaluation' sheet in the evaluation tool. Based on the KPI value that corresponds to the minimum star rating (see B.1.16) and the KPI value that corresponds to the maximum star rating of 5 stars, the KPI value entered in *column O* (see B.1.15) can be converted into a star rating for that specific level 3 KPI. Obtaining this KPI value for the maximum star rating is not a trivial process and needs input from the different stakeholders involved in the assessment. The maximum KPI value represents 'the absolute best value' that the stakeholders see as suitable for the specific KPI.

Note: this column requires user input

B.1.18 ***KPI value confidence level***

The KPI confidence level can be entered in *column R* on the 'KPI Evaluation' sheet in the evaluation tool. The confidence level gives an indication of the confidence that the involved stakeholders have in the value that was given to the KPI (see B.1.15). The confidence level will be dependent on the data source for the KPI value that was entered. For example, a direct measurement of the specific KPI in a demonstration project is likely to result in a higher confidence level than obtaining the KPI value from a simulation model. The confidence level is only to be filled in for the level 3 KPIs. The confidence level for the level 1 and level 2 KPIs is calculated from the level 3 KPI confidence values, taking the level 3 KPI weighting factors into account.

Note: this column requires user input

B.1.19 ***KPI rating***

Based on the KPI value (B.1.15), the KPI value corresponding to the minimum star rating (B.1.16) and the KPI value corresponding to the maximum star rating of 5 stars (B.1.17), the KPI star rating in *column S* on the 'KPI Evaluation' sheet in the evaluation tool is calculated by linearly interpolating the KPI value between the minimum and maximum KPI value and projecting it to the star rating range, e.g. from 1 to 5 [stars] (see the equation below). The KPI rating is thus automatically calculated based on the KPI values and not to be entered or modified by the user. The level 3 KPI ratings will be converted into star ratings for the level 1 and level 2 KPIs based on the KPI weighting factors.

$$KPI_{rating} = (5-1) \times \frac{KPI_{value} - KPI_{min}}{KPI_{max} - KPI_{min}} + 1$$

Note: this column is not be modified by the user

B.1.20 ***Completeness level***

The completeness level in *column T* on the 'KPI Evaluation' sheet in the evaluation tool gives an indication of the completeness of the KPI data that is to be provided by the user. If the KPI data is complete (see B.1.15, B.1.16 and B.1.17) and a KPI rating can be calculated (see B.1.19), the KPI completeness level is set to 100. If the KPI data is not yet complete and the KPI rating cannot be calculated, the completeness level is set to zero. In case the KPI weighting factor (B.1.14) is set to zero, indicating that the specific KPI is not relevant in the assessment, the KPI completeness level is left blank and it will not be taken into account in the aggregated completeness level for the level 1 and level 2 KPIs. The KPI completeness level is automatically calculated based on the entered KPI data and is thus not to be filled in or modified by the user.

Note: this column is not be modified by the user

B.1.21 ***Method***

The 'Method' in *column U* on the 'KPI Evaluation' sheet in the evaluation tool can optionally be used by the user to indicate what method will be used for obtaining the KPI value (see B.1.15). This can be specifically useful when the specific tool for assessing the KPI value is not yet known or available and the user wants to indicate what generic method may be applicable for obtaining the KPI value. Examples of methods for obtaining a KPI value are simulation, survey, interview and measurement.

Note: this column can optionally be used by the user

B.1.22 ***Assigned tool***

In *column V* on the 'KPI Evaluation' sheet in the evaluation tool the user can optionally link to the specific tool that will be used for assessing the KPI value. Examples of such tools are simulation tools or survey forms. Also a measurement report or a specification sheet or reports from previous projects can be useful to fill in, if applicable. For the SOLUTIONSPLUS project, a wide variety of tools will be made available in the developed 'toolbox' in task 1.1 , see http://www.solutionsplus.eu/toolbox.html.

Note: this column can optionally be used by the user

B.1.23 ***Comments***

In the 'Comments' column in *column W* in the 'KPI Evaluation' sheet in the evaluation tool by default remarks about the specific KPIs are depicted, where relevant. The user is however free to modify, delete or add own comments where necessary or helpful in describing the details of the specific assessment project in which the evaluation tool is applied.

Note: this column can optionally be used or modified by the user

B.1.24 ***Adding a KPI sheet***

By default, the Evaluation tool has one sheet for entering the required KPI data for the assessment the user wants to perform. In case multiple assessments are performed during the project, KPI sheets can be added to the evaluation tool for each assessment separately. For example, in the SOLUTIONSPLUS project assessment on city level is done at the beginning of the project (the baseline scenario where no e-mobility solutions will be introduced) and at the end of the project (Up-scaled assessment, where different developed e-mobility solutions can be combined in order to illustrate the impact for a city).

Adding a KPI evaluation sheet can be done by creating a copy of the existing 'KPI evaluation' sheet in the evaluation tool:

- Right-click the existing sheet 'KPI evaluation' and select 'move or copy' in the pop-up menu
- In the 'Move and copy' window, tick the box 'create a copy'
- Select the position of the copied sheet in the document (free to choose by the user)
- Click 'OK' in the "Move and copy' window
- Rename the newly added sheet to any name preferred by the user.

Once the new KPI evaluation sheets have been added and renamed (if desired), add the new sheets to the list of KPI sheets in the Status Dashboard sheet (see B.2), such that they become available for both the Status Dashboard and the Progress Dashboard (see B.3)

B.1.25 ***Minimum star rating setting***

In the calculation of the level KPI star rating (see B.1.19), the minimum star rating is used together with the KPI value corresponding to this minimum star rating (see B.1.16) and the KPI value corresponding to the maximum star rating (see B.1.17) in order to translate the KPI value (see B.1.15) into a star rating value. The minimum star rating is set to 1 by default, but can be edited by the user in *cell C1* to a value that is favoured by the user, preferably in consultation with the stakeholder involved in the assessment process.

In case multiple assessments are executed and documented in the same evaluation tool document (see B.1.24), make sure that all the KPI evaluation sheets use the same value for the minimum star rating, as using different values per KPI sheet leads to misleading results when comparing between assessments on the Status Dashboard (B.2) or the Progress Dashboard (see B.3)

B.2 Using the Status Dashboard

The Status Dashboard displays the aggregated star rating scores that are calculated from the KPI data that was filled in by the user in the 'KPI Evaluation' sheet (see B.1) and thereby gives an overview of the status for all the level 1, level 2 and level 3 KPIs. The status dashboard is only intended for status visualization purposes and is therefore not to be edited by the user (expect the selection of the KPI evaluation sheet that is to be visualized, see B.2.8 and B.2.9). Figure 13 shows a snapshot of the status dashboard as used in the evaluation tool.

Combined KPI score 2,64

KPI level	KPI description	Rating	Star rating	Weighting factor	Confidence level	Completeness level
1	Financial costs/revenues	2,6		16,7	50,0	35
2	Financial viability	2,6		70,0	50,0	50
3	NPV (Net present velue)	2,6		50,0	50,0	100
3	IRR (Internal Rate of Return)			30,0	0,0	0
3	Payback period			20,0	0,0	0
2	Availability of financial resources			30,0	0,0	0
	Ease of raising external funding			100,0	0,0	0
1	Institutional/	2,8		16,7	35,0	80
2	Coherence with national plans and development goals	3,0		40,0	50,0	100
2	Alignment with supra-national/national/city legislation & regulations	2,6		40,0	20,0	100
2	Ease of implementation (in terms of administrative barriers)			20,0	0,0	0
1	Climate related	2,0		16,7	50,0	100
2	Impact on GHG emissions	2,0		100,0	50,0	100
3	Amount of carbon avoided (% change compared to baseline)	2,0		100,0	50,0	100
1	Environmental	3,0		16,7	30,0	64
2	Impact on air pollutants	3,0		40,0	30,0	60
3	NOx emissions avoided	3,0		60,0	30,0	100
3	PM2.5 emissions avoided			40,0	0,0	0
2	Impact on noise	3,0		40,0	30,0	100
3	Perception of the impact of the demo EVs on noise level	3,0		100,0	30,0	100
2	Impact on environmental resources			20,0	20,0	0
3	Resources saved due to recycling (kg)			100,0	20,0	0
1	Social	3,0		16,7	59,3	91,25
2	Impact on accessibility	3,4		12,5	50,0	100
3	Access to jobs, opportunities and services (personal travel)	3,4		100,0	50,0	100
3	Access to pickup/delivery locations (freight)			0,0	0,0	
2	Affordability of e-vehicle services	3,4		12,5	50,0	100
2	Impact on travel time	1,7		12,5	60,0	100
3	Change in travel times due to e-mobility services (personal travel)	1,7		100,0	60,0	100
3	Change in travel times due to e-mobility services (freight)			0,0	0,0	
2	Impact on road safety	3,5		12,5	85,0	80
3	(Annual) Number of road accidents with fatalities/serious injuries	3,0		40,0	100,0	100
3	(Annual) Number of road accidents with minor injuries/material damage	4,0		40,0	70,0	100
3	(Annual) Number of traffic related near accidents/dangerous situations			20,0	20,0	0

Select KPI sheet for dashboard
Example 1
KPI sheet list
KPI evaluation
Example 1
Example 2

Figure 13. The Status dashboard in the evaluation tool, which gives an overview of the status and star rating for all the KPIs

The different components of the status dashboard are described in the following sections.

B.2.1 *KPI level*

The KPI level column on the status dashboard indicates the level of the KPI in the KPI tree, level 1 being the highest and level 3 the lowest. Level 1 KPIs describe the general categories that are relevant for the e-mobility assessment, the level 2 and 3 KPIs the (more) detailed indicators that are used for expressing the success of e-mobility for the application or area (e.g. city) that is under assessment.

Note: this column is not be modified by the user

B.2.2 ***KPI description***

The KPI description column on the status dashboard gives a description of the KPIs as they were selected and defined for the SOLUTIONSPLUS project. The KPIs and thereby also the description of the KPIs is the same as in the KPI evaluation sheets (see B.1.2, B.1.7 and B.1.12). For the SOLUTIONSPLUS project the KPIs are common for all users and therefore not to be modified by the user.

Note: this column is not be modified by the user

B.2.3 ***Rating***

The Rating column on the Status Dashboard displays the KPI ratings that was calculated from the KPI data that was entered by the user in the KPI evaluation sheets (see B.1.4, B.1.9 and B.1.19). The rating is given on a scale between 1 – 5 (the lower rating of 1 can be edited by the user, see B.1.25).

Note: this column is not be modified by the user

B.2.4 ***Star rating***

The star rating column on the Status Dashboard gives a visual representation of the KPI rating (see B.2.3). The number of yellow-coloured star indicate the rating, on a scale between 1 and 5 (the lower rating of 1 can be edited by the user, see B.1.25) and in steps of 0.5.

Note: this column is not be modified by the user

B.2.5 ***Weighting factor***

The weighting factor column on the status dashboard indicate the weight and thereby the priority that was given to the different KPIs based on the stakeholders input (the weighting factor methodology is explained in more detail in the deliverable D1.6 Impact assessment result (Panagakos 2020). The KPI weighting factors are to be provided by the user on the KPI evaluation sheet (see B.1.3, B.1.8 and B.1.14).

Note: this column is not be modified by the user

B.2.6 ***Confidence level***

The Confidence level on the status dashboard shows the aggregated confidence level for the KPIs. The confidence level is an indication of how sure the stakeholders which provided the KPI values are about the correctness of the KPI values. The confidence level for the different KPI levels is calculated from the KPI level 3 confidence (see B.1.18) and the weighting factors for the different KPI levels (see B.1.3, B.1.8 and B.1.14).

Note: this column is not be modified by the user

B.2.7 ***Completeness level***

The completeness level column on the Status Dashboard indicates the completeness of the data that is needed for calculating the star ratings for every KPI. For the level 3 KPIs the completeness level is directly based on completeness of the KPI data filled in by the user (see B.1.20), for the level 1 and level 2 KPIs the completeness levels of the different level 3 KPIs are aggregated based on the weighting factors that were assigned to the different KPIs (see B.1.3, B.1.8 and B.1.14).

Note: this column is not be modified by the user

B.2.8 *Selecting KPI evaluation sheet for dashboard view*

The drop down menu in *cell M4* can be used for changing the KPI evaluation sheet that the user wants to see visualized on the Status Dashboard. Clicking on *cell M4* shows the drop-down menu and allows the user to select the desired KPI evaluation sheet. By default the KPI evaluation sheet 'Example 1' is selected.

Note: this is a user-selectable menu

B.2.9 *Adding KPI sheets to dashboard view*

By default the Evaluation tools consists of 3 KPI evaluation data sheets, the sheet 'KPI evaluation' that the user can use for entering KPI data from the assessment (see B.1) and two examples sheets (see B.4). In case the user added more KPI data sheets to the evaluation tool (see B.1.24), these sheets have to added manually by the users to the KPI sheet list on the Status Dashboard sheet.

B.3 Using the Progress Dashboard

The Progress Dashboard allows the user to compare between the status of two different assessments. This is relevant when in a project multiple assessments are conducted. In the SOLUTIONSPLUS project the up-scaled assessment planned for the end of the project can be compared to the baseline assessment executed at the starting phase of the project, if desired. The progress dashboard is only applicable in case at least two KPI evaluation data sheets are available in the evaluation tool (see B.2.9). By default, the 'Example 1' and 'Example 2' data sheets are selected to be shown on the progress dashboard.

A snapshot of the Progress Dashboard is depicted in Figure 14. The content of the Progress Dashboard is very similar to the content of the Status Dashboard, only doubled in order to make the comparison between assessments possible. For a detailed description of the different columns of the Progress Dashboard, see the description of the Status Dashboard in B.2.

		Select 1st KPI sheet for KPI progress overview				Select 2nd KPI sheet for KPI progress overview				Progress [%]		
		Example 1				Example 2						
	Combined KPI score	2,64				2,92				10,6		
KPI level	KPI description	Rating	Weighting factor	Confidence level	Completeness leve	Rating	Weighting factor	Confidence level	Completeness leve	rating	confidence	completeness
1	Financial costs/revenues	2,6	16,7	50,0	35	3,9	16,7	51,0	70	50,8	2,0	100,0
2	Financial viability	2,6	70,0	50,0	50	3,9	70,0	51,0	100	50,8	2,0	100,0
3	NPV (Net present velue)	2,6	50,0	50,0	100	3,8	50,0	50,0	100	46,2	0,0	0,0
3	IRR (Internal Rate of Return)		30,0	0,0	0	4,2	30,0	40,0	100			
3	Payback period		20,0	0,0	0	3,8	20,0	70,0	100			
2	Availability of financial resources		30,0	0,0	0		30,0	0,0	0			
	Ease of raising external funding		100,0	0,0	0		100,0	0,0	0			
1	Institutional/	2,8	16,7	35,0	80	2,9	16,7	40,0	100	4,3	14,3	25,0
2	Coherence with national plans and development goals	3,0	40,0	50,0	100	3,0	40,0	50,0	100	0,0	0,0	0,0
2	Alignment with supra-national/national/city legislation &	2,6	40,0	20,0	100	2,6	40,0	20,0	100	0,0	0,0	0,0
2	Ease of implementation (in terms of administrative barriers)		20,0	0,0	0	3,4	20,0	60,0	100			
1	Climate related	2,0	16,7	50,0	100	2,0	16,7	50,0	100	0,0	0,0	0,0
2	Impact on GHG emissions	2,0	100,0	50,0	100	2,0	100,0	50,0	100	0,0	0,0	0,0
3	Amount of carbon avoided (% change compared to baseline)	2,0	100,0	50,0	100	2,0	100,0	50,0	100	0,0	0,0	0,0
1	Environmental	3,0	16,7	30,0	64	3,1	16,7	31,2	100	3,7	4,0	56,3
2	Impact on air pollutants	3,0	40,0	30,0	60	2,7	40,0	38,0	100	-10,7	26,7	66,7
3	NOx emissions avoided	3,0	60,0	30,0	100	3,0	60,0	30,0	100	0,0	0,0	0,0
3	PM2.5 emissions avoided		40,0	0,0	0	2,2	40,0	50,0	100			
2	Impact on noise	3,0	40,0	30,0	100	3,0	40,0	30,0	100	0,0	0,0	0,0
3	Perception of the impact of the demo EVs on noise level	3,0	100,0	30,0	100	3,0	100,0	30,0	100	0,0	0,0	0,0
2	Impact on environmental resources		20,0	20,0	0	4,2	20,0	20,0	100		0,0	
3	Resources saved due to recycling (kg)		100,0	20,0	0	4,2	100,0	20,0	100		0,0	
1	Social	3,0	16,7	59,3	91,25	3,1	16,7	57,8	100	3,3	-2,6	9,6
2	Impact on accessibility	3,4	12,5	50,0	100	3,4	12,5	50,0	100	0,0	0,0	0,0
3	Access to jobs, opportunities and services (personal travel)	3,4	100,0	50,0	100	3,4	100,0	50,0	100	0,0	0,0	0,0
3	Access to pickup/delivery locations (freight)		0,0	0,0			0,0	0,0				
2	Affordability of e-vehicle services	3,4	12,5	50,0	100	3,4	12,5	50,0	100	0,0	0,0	0,0
2	Impact on travel time	1,7	12,5	60,0	100	1,7	12,5	60,0	100	0,0	0,0	0,0
3	Change in travel times due to e-mobility services (personal	1,7	100,0	60,0	100	1,7	100,0	60,0	100	0,0	0,0	0,0
3	Change in travel times due to e-mobility services (freight)		0,0	0,0			0,0	0,0				
2	Impact on road safety	3,5	12,5	85,0	80	3,7	12,5	72,0	100	5,7	-15,3	25,0
3	(Annual) Number of road accidents with fatalities/serious	3,0	40,0	100,0	100	3,0	40,0	100,0	100	0,0	0,0	0,0
3	(Annual) Number of road accidents with minor injuries/material damage	4,0	40,0	70,0	100	4,0	40,0	70,0	100	0,0	0,0	0,0
3	(Annual) Number of traffic related near accidents/dangerous situations		20,0	20,0	0	4,5	20,0	20,0	100		0,0	
2	Impact on charging safety	3,4	12,5	80,0	100	3,4	12,5	80,0	100	0,0	0,0	0,0
3	(Annual) Number of charging related safety incidents	3,4	100,0	80,0	100	3,4	100,0	80,0	100	0,0	0,0	0,0

Figure 14. Snapshot of the Progress Dashboard in the Evaluation tool, which allows you to compare the status of two different assessments and track the status progress

The following sections describe the use of the Progress Dashboard.

B.3.1 *Selecting KPI sheets for comparing*

On the Progress Dashboard, *cell C2* and *cell L2* contain drop-down menus where the user can select the KPI evaluations sheets between which the comparison in status is made. Click on *cell C2* to show the drop-down menu and select the desired KPI evaluation sheet to be displayed on the left side of the Progress dashboard. Clicking on *cell L2* shows the drop-down menu and allows selection of the desired KPI evaluation sheet to be displayed on the right side of the Progress dashboard. The KPI evaluation sheet on the left side of the Progress dashboard is considered the baseline assessment against which the KPI evaluation sheet selected on the right side is compared. Note that KPI evaluation sheets can only be selected from the drop-down menus from *cell C2* and cell L2 when they have been added to the list of KPI evaluation sheets on the Status Dashboard (see B.2.9).

B.3.2 *Status progress*

The progress columns on the right side of the Progress dashboard show the percentual change in the star rating between the assessment documented in the KPI evaluation sheet selected on the left side of the Progress dashboard (see B.3.1) and the assessment captured in the KPI evaluation sheet selected on the right side of the dashboard. The percentual progress is illustrated in a similar way for the KPI confidence level and the KPI completeness level.

Positive progress values (displayed in green) indicate that the star rating/confidence/completeness level of the assessment selected on the **right** is **higher** than for the assessment selected on the right.

Negative progress values (displayed in red) indicate that the star rating/confidence/completeness level of the assessment selected on the **right** is **lower** than for the assessment selected on the right.

B.4 Example KPI evaluation sheets

The Evaluation tool contains two Example sheets showing what the KPI evaluation data could look like for an assessment.

The ‘Example 1‘ sheet illustrates what the assessment at the beginning of a project could look like, when typically the KPI data is not yet complete.

The ‘Example 2‘ sheet illustrates what the assessment at a later stage in a project could look like, when the KPI data is expected to be more complete.

Note that both sheets are only examples to help in displaying the Evaluation tool functionality and the KPI values used on the sheets are fictional. The example sheets are also used to show the functionality of the Status dashboard (see B.2) and the Progress Dashboard (see B.3).

Appendix 2 KPI Definition

Contents

A. Financial indicators

1.1 A.1 Financial viability

1.1.1 A.1.1 NPV (Net Present Value)

Reflecting the present worth of an investment, NPV is defined as the sum of all future cash flows discounted at a periodic rate of return to account for the time value of money. A positive NPV indicates that the projected earnings generated by the project exceeds the anticipated costs and the project can be accepted. The NPV of the up-scaled project will be calculated via a specialized software, including the UNEP e-MOB, which offers this possibility. A value function will be needed to transform the NPV (expressed in monetary terms) into a star value as required by the evaluation framework.

1.1.2 A.1.2 IRR (Internal Rate of Return)

IRR denotes the rate of return that sets the net present value of the future cash flows of a project equal to zero. An IRR higher than the opportunity cost of the project owner indicates a profitability that exceeds the expected one from other activities and suggests the undertaking of the project. The higher a project's IRR is, the more desirable its undertaking becomes. The IRR of the up-scaled project will be calculated via a specialized software. A value function will be needed to transform the IRR (expressed in %) into a star value as required by the evaluation framework.

1.1.3 A.1.3 Payback period

It denotes the time (in years) required to recover the funds expended in an investment or to reach the break-even point. It does not take into account the time value of money, a fact that makes it easy to apply and understand. The lower a project's payback period is, the more desirable its undertaking becomes. The payback period of the up-scaled project will be calculated via a specialized software. A value function will be needed to transform the payback period (expressed in years) into a star value as required by the evaluation framework.

1.2 A.2 Availability of financial resources

1.2.1 A.2.1 Ease of raising external funding

This KPI complements the ones on financial viability and plays an important role in occasions where the up-scaled project is not sustainable financially but still generates social benefits exceeding its social costs.

Question	**How easy it is to raise external funds to implement the project?** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	Evaluation by project experts followed by validation by local stakeholders
Notes	The evaluation combines your assessment on three separate dimensions: A. The availability of government/regional/city funds for supporting the project B. The intention of international donors to get involved in funding e-mobility projects of the suggested nature C. The preparedness of commercial banks to support projects concerning e-mobility in the project city through preferential interest rates
Evaluation	1. The answer to all three dimensions (A and B and C) is negative 2. The answer to either A or B is positive, while C is negative 3. The answer to both A and B is positive, while C is negative 4. The answer to both A and B is negative, while C is positive

	5. The answer to C and one or both of A and B is positive

A 5-point scale is used for scoring. The score enters directly the evaluation framework.

B. Institutional/political indicators

1.3 B.1 Coherence with national plans and development goals

Question	**How does the scaled up project align with national or city level plans and policies?** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	Evaluation by project experts followed by validation by local stakeholders
Notes	The evaluation combines your assessment on four separate policy categories: A. Alignment with **transport policy** at national or city level (e.g., National Transport Plan, City Master Plans, etc.) B. Alignment with **energy policy** at national level (e.g., Energy Performance / Efficiency Standards, etc.) C. Alignment with **environment policy** at national or city level (e.g., emission standards, waste and recycling policies, etc.) D. Alignment with **overarching policies** at national level (e.g., National Development Plans, Climate Action Plans, NDCs, etc.)
Evaluation	1. The alignment with categories A, B, C and D is negative 2. The alignment with one of the four categories A, B, C and D is positive but negative with remaining three dimensions 3. The alignment is positive with any two categories (category A, B, C & D) 4. The alignment is positive with any three categories (category A, B, C & D) 5. The alignment is positive with all categories (category A, B, C & D)

A 5-point scale is used for scoring. The score enters directly the evaluation framework.

1.4 B.2 Alignment with supra-national/national/city legislation & regulations

This KPI intends to capture the alignment or compliance of the proposed project and its components with relevant legislation and regulations. As seen below, it is ideal that the process is embedded into local discussions, and consultations with experts.

Question: **What is the level of compliance of the project to the applicable regulations and laws?**

Procedure: The assessment entails the following steps:

1. Identification of relevant regulations that would need to be complied with by the (up-scaled) project concept and its components based on the categories below (list down all relevant/applicable regulations as identified during the consultation meetings and conversations with experts/suppliers/authorities). Please note that the identification of such would entail a multi-scalar approach, as there might be supra-national, national, sub-national, and local regulations that might apply to the project and its elements.

- **Vehicle standards and regulations** – including applicable homologation regulations (if applicable)
- **Charging equipment and infrastructure** – including relevant standards for charging equipment and infrastructure
- **Business regulations** – would encompass regulations applicable to the set-up and the process of providing the services (e.g. competition regulations; regulations pertaining to the legal requirements for emergent business models
- **Traffic regulations** – e.g. eligibility of the project vehicles to operate in the proposed area/ types of roads
- **Charging operations** – e.g. regulations pertaining to the operations/provision of charging services
- User / consumer protection regulations – e.g. for shared schemes – data protection, fair pricing regulations
- **Environmental regulations** – e.g. end-of-life regulations (battery recycling, etc.).

2. The alignment/compliance of the project concept to the identified regulations and laws will be assessed based on the following levels of compliance:

    - **Full compliance:** It can be ascertained that the relevant project element/s is/are fully compliant with the regulation.
    - **Presence of uncertainty:** Situations wherein it cannot fully be ascertained whether the relevant element/s of the proposed project is either fully compliant to, or appropriately covered by existing regulations, or in cases where potential significant regulatory hurdles are foreseen (e.g. impending changes in regulations).
    - **Non-compliance:** It can be ascertained that the relevant project element/s would not comply with the applicable regulation/s.

3. Assign a score to the project concept based on the 5-point scale provided below:

	Description
1	It is certain that the proposed project would **not comply** with at least 1 applicable regulation
2	There have been identified **at least 3 instances of uncertainties** in relation to the compliance of the proposed project with the applicable regulations
3	There have been identified **2 instances of uncertainties** in relation to the compliance of the proposed project with the applicable regulations
4	There has been identified **1 instance of uncertainty** in relation to the compliance of the proposed project with the applicable regulations
5	The proposed project **complies** with all applicable regulations identified above

The score enters directly the evaluation framework.

1.5 B.3 Ease of implementation (in terms of administrative barriers)

Question	**How easy it is to implement the project from an institutional/political point of view?** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:

Procedure	Evaluation by project experts followed by validation by local stakeholders
Notes	The evaluation combines your assessment on three separate dimensions: A. The project requires administrative interventions of limited scope from the relevant political and institutional bodies, e.g. activities for passing a new law that will make the uptake of an e-mobility solution possible B. The political and institutional bodies needed for supporting the implementation of the project are in place C. The existing national/city political and institutional bodies are (likely to be) supportive of the necessary actions required for the project implementation
Evaluation	1. The answer to all three dimensions (A and B and C) is negative 2. The answer to either A or B is positive, while C is negative 3. The answer to both A and B is positive, while C is negative 4. The answer to both A and B is negative, while C is positive 5. The answer to C and one or both of A and B is positive

A 5-point scale is used for scoring. The score enters directly the evaluation framework.

C. Climate-related indicators

1.6 C.1 Impact on GHG emissions

This KPI is defined as the percentage change in the absolute mass of GHG emissions resulting from the new e-mobility solution under consideration in comparison to the baseline scenario. In line with the e-MOB definition, it concerns **well-to-wheel CO_2 emissions** accumulated over the entire assessment period (2019 to 2030). Although the use of the e-MOB model is advisable for compatibility purposes, other calculators can be used if necessary. A value function will be needed to transform the percentage change of CO_2 emissions into a star value as required by the evaluation framework.

D. Environmental indicators

1.7 D.1 Impact on air pollutants

1.7.1 *D.1.1 NOx emissions abated*

This KPI is defined as the percentage change in the absolute mass of NOx emissions resulting from the new e-mobility solution under consideration in comparison to the baseline scenario. In line with the e-MOB definition, it concerns **tank-to-wheel NOx emissions** accumulated over the entire assessment period (2019 to 2030). Although the use of the e-MOB model is advisable for compatibility purposes, other calculators can be used if necessary. A value function will be needed to transform the percentage change of NOx emissions into a star value as required by the evaluation framework.

1.7.2 *D.1.2 PM emissions abated*

This KPI is defined as the percentage change in the absolute mass of PM emissions resulting from the new e-mobility solution under consideration in comparison to the baseline scenario. In line with the e-MOB definition, it concerns **tank-to-wheel PM emissions** accumulated over the entire assessment period (2019 to 2030). Although the use of the e-MOB model is advisable for compatibility purposes, other calculators can be used if necessary. A value function will be needed to transform the percentage change of PM emissions into a star value as required by the evaluation framework.

1.8 D.2 Impact on noise

Noise exposure does not only depend on its magnitude, but also of its intensity, frequency, duration, variability and time of occurrence. It is therefore advised to measure the subjective perception of the respondent in question (using categorical scales: e.g., noisy <-> quiet, annoying <-> not annoying, disagreeable <-> agreeable). Nevertheless, this perception should additionally be related/validated with acoustic measures (e.g., average day (LrD) and nighttime (LrN) road traffic noise levels in dB or dB(A)).

As shown in the table below, a dual approach is proposed consisting of two evaluation schemes of increasing complexity. The first and simpler one focuses on the noise performance of the specific type of EV introduced (NEW) in comparison to the baseline solution (OLD), which has to be defined a priori. It consists of two equally weighted parts; a subjective one (marked as Evaluation 1.1) and an objective one (marked as Evaluation 1.2). Evaluation 1.1 reflects the perceptions of the users/drivers of the EVs, while Evaluation 1.2 is based on average noise measurements inside or on the vehicle. A 5-point scale is used for both parts and the final score is the arithmetic mean of the two partial scores. The final score enters directly the evaluation framework. No value function is required for this evaluation scheme. However, the relative weights of the two parts (50/50) and the numerical values determining the scoring scale need to be validated by the local stakeholders.

Question	**What is the project's impact on road noise exposure?**				
Evaluation 1.1* **(subjective)** Perceived road noise exposure (user/driver)	1 Significantly noisier	2 Slightly noisier	3 No difference	4 Slightly quieter	5 Significantly quieter
Evaluation 1.2* **(objective)** Changes in average noise levels in db(A) (NEW vs. OLD)	> +2.5 db(A)	Up to +2.5 db(A)	+/- 0.5 dB(A)	Up to -2.5 db(A)	< -2.5 db(A)

*Perceived road noise exposure and average noise levels are first surveyed/measured inside/on the vehicle. This "frog perspective" gives us autarkic results that do not depend on the level of implementation (i.e., demo vs. up-scaled solution). In other words, these results suffice in case the second evaluation cannot be conducted due to any reasons (data-related, logistics, etc.).

1.9 D.3 Impact on environmental resources

Circular Economy (CE) is defined as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations". The CE is based on three shared principles, which can be summarized as follows: (i) design out waste and pollution, (ii) keep products and materials in use, and (iii) regenerate natural systems[3].

<table>
<tr><td>Question</td><td>Does the project enhance/promote circular economy in the project city?
Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:</td></tr>
<tr><td>Procedure</td><td>Evaluation by project experts followed by validation by local stakeholders</td></tr>
<tr><td>Notes</td><td>The evaluation combines your assessment on three separate dimensions:
A. Useful application of materials through:
• recycling – i.e., processing materials to obtain the same (high grade) or lower (low grade) quality, and/or
• recovering – i.e., incineration of material with energy recovery
B. Smarter vehicle use and manufacturing through:
• rethinking – i.e., making vehicle use more intensive (e.g., by sharing arrangements), and/or
• reducing – i.e., increasing efficiency in vehicle manufacturing or use by consuming fewer natural resources and materials
C. Expanded lifespan of vehicles and their parts through:
• reusing – i.e., using of a discarded vehicle that is still in good condition and fulfils its original function by another operator/user, and/or
• repairing – i.e., maintaining/repairing defective parts so that the vehicle can be used with its original function, and/or
• remanufacturing – i.e., using parts of discarded products in a new vehicle with the same or different function</td></tr>
<tr><td>Evaluation</td><td>1. The answer to all three dimensions (A and B and C) is negative
2. The only positive answer concerns dimension A
3. The only positive answer concerns dimension B
4. The only positive answer concerns dimension C or the answer to C is negative but both A and B receive positive answers
5. The answer to C and one or both of A and B is positive</td></tr>
</table>

A 5-point scale is used for scoring. The score enters directly the evaluation framework.

[3] Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., Kendall, A. (2019). A taxonomy of circular economy indicators. Journal of Cleaner Production, Volume 207, pp. 542-559.

E. Social indicators

1.10 E.1 Impact on accessibility

1.10.1 E.1.1 Access to jobs, opportunities and services (personal travel)

The indicator assesses the impact of the e-mobility solutions on accessibility. The SDG 11.2 indicator will be used for this purpose. It is defined as the proportion of the population that has convenient access to public transport (by sex, age and persons with disabilities). The KPI value will be estimated as the difference in the SDG 11.2 indicator values with and without the proposed scaled-up project. The SDG 11.2 indicator values will be calculated with support from DLR, using openly available data on population and street network. The DLR open-source tool *UrMoAc* will be used for calculating the accessibility values.[4]

Remark: If there are no further stops added in a city, there will be no impact on this indicator. Solutions such as e-bikes will be considered to increase accessibility through rental stations. Same holds for 3-wheelers & motorbikes.

Required data inputs

- Population distribution in the city (Source: DLR World Settlement Footprint)
- Street network for walking (OSM-OpenStreetMap)
- Public transit stops (locations, ideally including different entrances)

Every city has one percentage value describing the current state of reaching the indicator goal.

City	SDG 11.2 value, official value from UN Habitat[5]	SDG 11.2 value, SOL+ Scenario	Difference
Hanoi	n/a		
Pasig	n/a		
Kathmandu	n/a		
Dar es Salaam	n/a		
Kigali	50.33 %		
Quito	88.53%		
Montevideo	n/a		
Hamburg	90.5%	91.5% (example)	+1% (example)
Madrid	98.44%		

A value function will be needed to transform the KPI value obtained in the way described above into a star value as required by the evaluation framework.

[4] GitHub - DLR-VF/UrMoAC: A tool for computing accessibility measures, supporting aggregation, variable limits, and intermodality.

[5] Available Online, last accessed: May 19th, 2021: https://data.unhabitat.org/datasets/11-2-1-percentage-access-to-public-transport/

1.10.2 E.1.2 Access to pick-up/delivery locations (freight)

In cities where the e-Mobility solutions that are implemented also affect goods transport and freight, a qualitative judgement including experts from the field (min: n = 10) will be carried out. This judgement will mainly reflect the perspective of the users of the new e-cargo solutions (e.g., parcel delivery services) and will focus on aspects concerning the pick-up/delivery operations (e.g., parking possibilities, time restrictions, etc.). The views of other impacted stakeholders (e.g., shopkeepers, pedestrians, etc.) can also contribute to the assessment.

Question	**What is the impact of the e-mobility solutions on improving the pick-up/delivery operations of freight and goods transport?**				
Qualitative judgement by experts	1 Degradation	2 Slight decline	3 No difference	4 Slight improvement	5 Major improvement

A 5-point scale is used for scoring. The score enters directly the evaluation framework.

1.11 E.2 Affordability of e-mobility services

Question: **What is the expected level of change in the average price of the e-mobility services that the potential target users have to pay?**

Proposed unit: Percentage change in price/passenger-kilometer (%Δ/pkm) or price/ton-kilometer (%Δ/tkm).[6] The prices are to be quoted in local currencies.

Description:

This KPI intends to capture the potential impact of the proposed project concept in terms of the costs to the target users against the baseline scenario wherein the proposed project will not take place. It is important to ask "what would the users utilize (e.g. in terms of modes, or vehicles) in conducting the same transportation activity (either passenger or goods transport, depending on the project concept) if the project is not put in place. The baseline average costs can be based on different options such as: the most dominant existing alternative or; mix of alternatives based on surveys of users;[7] or based on the modal characteristics of a "typical route" in a city. The selection of the approach would vary depending on the project design, its boundaries, as well as resources for gathering data. This depends on the availability of data, and the applicability of the options to the specific project concept.[8]

Procedure:

1. Define the boundaries of the analysis (i.e., select the part of the network or a 'typical route' that will be examined)

[6] Essentially, one can think of this in terms of price paid by the intended user/s per unit of transportation activity, on average. For example, a user of an e-bike sharing scheme would pay #EUR per pkm, if s/he will not use the e-bike sharing system, s/he would have used a motorcycle, which would cost #EUR per pkm. The % difference would be accounted for.

[7] In case detailed user surveys are to be conducted in the demo phase, it is highly recommended that users be asked a question such as "what mode would you normally use in conducting this trip (i.e. if they had just used an e-mobility service provided by the demo)"? Average costs per pkm or tkm can be computed based on the % shares.

[8] The average cost calculation should also take into account the appropriate fee structures based on the local context (e.g. graduated fee structures based on distance, fixed + variable costs, etc…). Average trip lengths can be used as a basis for calculating the average costs and comparing them (e.g., how much a 5 km trip would cost in the project scenario and the base scenario).

2. Determine the average price/pkm or price/tkm of e-mobility service/s to be provided to the targeted users within the selected boundaries under the proposed project.
3. Determine the average price/pkm or price/tkm for the baseline scenario. The baseline price can be based on the average price/pkm or price/tkm for the mode that would most likely be used in the absence of the project.
4. Calculate the percentage difference between the average prices of Steps 2 & 3.

A value function will be needed to transform the KPI value obtained in the way described above into a star value as required by the evaluation framework.

1.12 E.3 Impact on travel time

1.12.1 E.3.1 Change in travel times due to e-mobility services (personal travel)

Proposed unit: **Percentage change in average travel time (expressed in minutes) between the up-scaled and baseline scenarios calculated on a predefined 'typical route' in the city**

Procedure:

1. Define the 'typical route' or the boundaries of the analysis
2. Define the transport solution that would be used under the baseline scenario for the same transport defined in Step 1 (it can be the dominant alternative or a mix of alternatives as explained in Section E.2)
3. Measure total travel time on the predefined route under the baseline scenario [min]. To improve accuracy, the estimate can be the arithmetic mean of multiple measurements on the same route by the same modes/vehicles
4. Measure the travel time and calculate the travel time per vehicle kilometer for the new e-mobility solution assessed during the demonstration activities in the city [min/v-km]
5. Use the travel time per transport mode [min/v-km] of Step 4 to calculate the travel time for the predetermined route in the up-scaled scenario [min]
6. Calculate the percentage difference in travel time between the up-scaled and baseline scenarios

A value function will be needed to transform the KPI value obtained in the way described above into a star value as required by the evaluation framework.

1.12.2 E.3.2 Change in travel times due to e-mobility services (freight)

Proposed unit: **Percentage change in average travel time for freight transport (expressed in minutes) between the up-scaled and baseline scenarios calculated on a predefined 'typical route' in the city**

Procedure:

1. Define the 'typical route' or the boundaries of the analysis
2. Define the transport solution that would be used under the baseline scenario for the same transport defined in Step 1 (it can be the dominant alternative or a mix of alternatives as explained in Section E.2)
3. Measure total travel time for freight transport on the predefined route under the baseline scenario [min]. To improve accuracy, the estimate can be the arithmetic mean of multiple measurements on the same route by the same modes/vehicles

4. Measure the travel time and calculate the travel time per vehicle kilometer for the new freight transport e-mobility solution assessed during the demonstration activities in the city [min/v-km]
5. Use the travel time per freight transport mode [min/v-km] of Step 4 to calculate the travel time for the predetermined route in the up-scaled scenario [min]
6. Calculate the percentage difference in freight travel time between the up-scaled and baseline scenarios

A value function will be needed to transform the KPI value obtained in the way described above into a star value as required by the evaluation framework.

1.13 E.4 Impact on road safety

The impact on road safety will be assessed in terms of changes in accident frequency and severity. Preferably, data will be collected in the area where the demo(s) are implemented or at the city level. Two different approaches of increasing complexity will be used for road safety assessment. The first and simpler one is based on the three safety-related KPIs that enter the evaluation framework. Their definition and estimation methods will be presented in the three subsequent headings in line with the other indicators of the evaluation framework. The second approach is a more elaborate one and comprises the descriptive evaluation. Two additional indicators are used for this purpose. Their definition and estimation is presented in Section E.4.4 below.

1.13.1 E.4.1 Road accidents with fatalities/serious injuries

Definition: **Annual number of accidents where someone was killed or seriously injured as a result of a road accident involving motor vehicle(s)**

Question	**Please estimate the potential impact of the proposed up-scaled project in terms of <u>number of road accidents with fatalities/serious injuries</u> in the area (compared to the situation before the implementation)** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	The target audience consists of professional groups such as road safety experts (e.g., from road safety authorities or from cities/municipalities), people involved in emergency operations (e.g., ambulance drivers, medical staff), experts on traffic operations from the city/municipality (e.g., police officers, traffic management, traffic planning), and other professionals responsible for the demo area services and/or operations related to road infrastructure
Evaluation	1. Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of road accidents with fatalities/serious injuries) 2. Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of road accidents with fatalities/serious injuries) 3. Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of road accidents with fatalities/serious injuries) 4. No change in road safety situation in the area/city 5. Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of road accidents with fatalities/serious injuries)

	6. Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of road accidents with fatalities/serious injuries) 7. Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of road accidents with fatalities/serious injuries)

A 7-point scale is used for scoring. A value function will be needed to transform scores into the 5-point scale of the evaluation framework.

1.13.2 E.4.2 Road accidents with minor injuries/material damage

Definition: **Annual number of accidents involving persons who sustained a minor injury or resulted in property loss (e.g., vehicle damage) as a result of a road accident involving motor vehicle(s)**

Question	**Please estimate the potential impact of the proposed up-scaled project in terms of the <u>number of road accidents with minor injuries/material damage</u> in the area (compared to the situation before the implementation).** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	The target audience consists of professional groups such as road safety experts (e.g., from road safety authorities or from cities/municipalities), people involved in emergency operations (e.g., ambulance drivers, medical staff), experts on traffic operations from the city/municipality (e.g., police officers, traffic management, traffic planning), and other professionals responsible for the demo area services and/or operations related to road infrastructure
Evaluation	1. Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of road accidents with minor injuries/material damage) 2. Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of road accidents with minor injuries/material damage) 3. Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of road accidents with minor injuries/material damage) 4. No change in road safety situation in the area/city 5. Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of road accidents with minor injuries/material damage) 6. Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of road accidents with minor injuries/material damage) 7. Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of road accidents with minor injuries/material damage)

A 7-point scale is used for scoring. A value function will be needed to transform scores into the 5-point scale of the evaluation framework.

1.13.3 E.4.3 Road accidents involving vulnerable road users (VRUs)

Initially, the third safety-related KPI of the evaluation framework concerned the frequency of traffic related near accidents/dangerous situations. Although this is a subject that deserves due consideration, the lack of sufficient data lead to the decision of replacing it with another important issue, the safety of vulnerable road users (VRUs). Nevertheless, the frequency of traffic related near accidents/dangerous situations remains a topic of interest and is considered in the descriptive evaluation of Section E.4.4.

Definition: **Annual number of accidents involving any pedestrians, cyclists or riders of powered-two-wheelers (or powered-three-wheelers when relevant), who were slightly or severely injured or killed as a result of a road accident involving motor vehicle(s) or not (occupants of vehicles may or may not be injured, but at least one VRU was injured/killed).**

Question	**Please estimate the potential impact of the proposed up-scaled project in terms of the <u>number of road accidents involving VRUs</u> in the area (compared to the situation before the implementation).** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	The target audience consists of professional groups such as road safety experts (e.g., from road safety authorities or from cities/municipalities), people involved in emergency operations (e.g., ambulance drivers, medical staff), experts on traffic operations from the city/municipality (e.g., police officers, traffic management, traffic planning), and other professionals responsible for the demo area services and/or operations related to road infrastructure
Evaluation	1. Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of road accidents involving VRUs) 2. Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of road accidents involving VRUs) 3. Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of road accidents involving VRUs) 4. No change in road safety situation in the area/city 5. Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of road accidents involving VRUs) 6. Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of road accidents involving VRUs) 7. Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of road accidents involving VRUs)

A 7-point scale is used for scoring. A value function will be needed to transform scores into the 5-point scale of the evaluation framework.

1.13.4 E.4.4 Additional indicators entering the descriptive evaluation

The descriptive evaluation complements the safety assessment of the evaluation framework by gathering viewpoints on two additional indicators through professional groups and also through registered users.

<u>A. Traffic related near accidents/dangerous situations</u>

Definition: **Annual number of traffic related near accidents or dangerous situations. These are unplanned events that have the potential to cause a road accident, but the situation did not yet result in casualties or material damage.**

Question	**Please estimate the potential impact of the proposed up-scaled project in terms of the <u>number of near accidents and dangerous situations</u> in the area (compared to the situation before the implementation).** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:

Procedure	The target audience consists of professional groups such as road safety experts (e.g., from road safety authorities or from cities/municipalities), people involved in emergency operations (e.g., ambulance drivers, medical staff), experts on traffic operations from the city/municipality (e.g., police officers, traffic management, traffic planning), and other professionals responsible for the demo area services and/or operations related to road infrastructure
Evaluation	1. Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of near accidents and dangerous situations) 2. Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of near accidents and dangerous situations) 3. Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of near accidents and dangerous situations) 4. No change in road safety situation in the area/city 5. Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of near accidents and dangerous situations) 6. Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of near accidents and dangerous situations) 7. Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of near accidents and dangerous situations)

No value function is required for this indicator as the score enters directly the descriptive evaluation.

B. Traffic related near accidents/dangerous situations involving VRUs

Definition: **Annual number of traffic related near accidents or dangerous situations involving VRUs, (VRUs & motor vehicle(s) or only VRUs). These are unplanned events that have the potential to cause a road accident, but the situation did not yet result in casualties or material damage.**

Question	**Please estimate the potential impact of the proposed up-scaled project in terms of the number of near accidents and dangerous situations involving VRUs in the area (compared to the situation before the implementation).** Indicate your views by selecting one of the ratings defined in the 'Evaluation box' below:
Procedure	The target audience consists of professional groups such as road safety experts (e.g., from road safety authorities or from cities/municipalities), people involved in emergency operations (e.g., ambulance drivers, medical staff), experts on traffic operations from the city/municipality (e.g., police officers, traffic management, traffic planning), and other professionals responsible for the demo area services and/or operations related to road infrastructure
Evaluation	1. Significant negative effect on the road safety situation in the area/city (i.e., significant increase in number of near accidents and dangerous situations involving VRUs) 2. Negative effect on the road safety situation in the area/city (i.e., moderate increase in number of near accidents and dangerous situations involving VRUs) 3. Slight negative effect on road safety situation in the area/city (i.e., slight increase in number of near accidents and dangerous situations involving VRUs) 4. No change in road safety situation in the area/city

	5. Slight positive effect on the road safety situation in the area/city (i.e., slight decrease in number of near accidents and dangerous situations involving VRUs) 6. Positive effect on the road safety situation in the area/city (i.e., moderate decrease in number of near accidents and dangerous situations involving VRUs) 7. Significant positive effect in the road safety situation in the area/city (i.e., significant decrease in number of near accidents and dangerous situations involving VRUs)

No value function is required for this indicator as the score enters directly the descriptive evaluation.

Furthermore, coverage is expanded to include the perspective of registered users of the e-mobility solutions, preferably drivers of e-vehicles and/or riders of e-bikes or 3 wheelers. As such, the same **five questions** asked to a target audience of professional groups (those of Sections E.4.1 to E.4.4) are also **posed to an audience of registered users** of e-mobility solutions. It is worth noting that considering the perspective of registered users herewith does not overlap with the road-safety related KPI on quality of services (Section E.8, Feature #6), as the descriptive evaluation is not part of the attribute weighting structure.

Unlike the evaluation framework, which relies on the preferences and priorities of the local stakeholders that participate in the weighting of attributes and scoring of the alternative up-scaled projects, the descriptive evaluation integrates not only perspectives of professional groups but also registered users for the safety impact assessment, which is conducted by the city team. In fact, this approach, taking into account possible safety-related incidents observed during demonstration, is recommended for the ex-post assessment of the demonstration components.

1.14 E.5 Impact on charging safety

Ensuring charging safety is a key element in the pursuit of e-mobility solutions. Consideration towards the type of charging technology and infrastructure to be utilized must be noted when assessing risks associated with charging (i.e. conductive, inductive, battery swapping), and whether communication and charging coordination are featured in the system. The assessment should also take into consideration the mitigation measures and good practices that have already been embedded to address the risks.
The KPI on charging safety is hinged on the assessment of the risks (and essentially, the project's risk performance) relating to the following categories of hazards (adopted from Wang et al., 2019):[9]

- Electrical shock to users and personnel: Charging facilities can cause electrical hazards, which can include potential electrical shock to customers (if applicable to the design of the project), as well as electrical shock and arc flash hazards to workers. Here are some examples of instances, which can lead to electrical shock: potential failure of ground fault circuit-interrupting breaker, potential failure of charging circuit-interrupting devices due to environmental factors or due to vandalism activities like copper theft (Wang et a., 2019). Electric shock hazards greatly depend on the characteristics of the charger. Protection against electric shock can be achieved through basic protection (e.g. preventing persons from being in contact with the energized components or parts), and fault protection

[9] Hazards refer to potential sources that may cause harm. Risks relate to the combination of the probability of occurrence of harm and the severity of that harm.

(protection in the event of failure of the basic insulation via disconnection of the supply). The reliability of the charging components with electrical safety protection features should be monitored and assessed through periodic safety inspections.

- Fire hazards: Fire hazards caused by charging of EVs may also affect personnel safety, as well as result in damage to property. Lithium-based batteries, for example, can self-ignite due to manufacturing errors, short-circuiting, exposure to extreme heat, or damage to the battery cell.[10] The pursuit of fast charging (and discharging) combined with the high driving performance of EVs is also documented to have a negative effect on fire risk (Sun et al., 2020). Fires due to charging may result from instances related to the following: overcharging, short circuiting, overheating of the charging environment, ignition of flammable materials, cable overload, faulty or insecure charging stations and cables, improper installation, improper charging practices, failure of the onboard charging equipment, and failure of the charging system in general. Protection towards external forces that may result in fires should also be taken into consideration (e.g. arson, burning in the vicinity, among others).
- Power grid instability: The potential impacts of the high penetration of uncontrolled charging can result in negative impacts to the power system due to potentially significant increases in peak demand; voltage deviation from acceptable limits; phase unbalance due to single-phase chargers; harmonics distortion; overloading of power system equipment; increase of power losses (Habib et al., 2014). The main key variables are: penetration level (i.e. the amount of EVs to be introduced into the system); the EV battery charger (i.e. fast chargers expected to increase peak demand than slow chargers); time of charging (i.e. EVs charging at the same time; interference with the peak demand time); location; battery capacity (i.e. high capacity batteries will draw larger amounts of energy); battery state-of-charge;; state of the distribution system (e.g. structure, equipment loading conditions, voltage level, and profile, load profile, etc…) (Nour et al., 2020).

Procedure:
The assessment of this KPI requires that the analyst scores the three categories in terms of severity and probability of occurrence. Only experts with good technical knowledge are involved in the assessment. The guidance for scoring the potential scale/severity of impacts is provided in the table below:

	Potential Severity/Scale of Impact[11]
0	If no adverse impact expected
1	If minor adverse impact expected
2	If low adverse impact expected
3	If moderate adverse impact expected
4	If high adverse impact expected

For the designed charging system solution, the risk probability (likelihood of occurrence) is characterized as:

[10] https://www.terrellhogan.com/electric-vehicle-battery-fire-risks/

[11] Ideally to be assessed with local experts, and should consider the scale (e.g. potential number of affected people), and severity of impacts.

	Likelihood of Occurrence[12]
0	If likelihood of occurrence is very low (less than once per 10 years)
1	If likelihood of occurrence is low (less than once per 5 years)
2	If likelihood of occurrence is moderate (once per year)
3	If likelihood of occurrence is high (once per month)
4	If likelihood of occurrence is very high (once per week or more frequently)

The scores for each of the hazard categories would be inputted in the tool as shown in the table below:

Hazards Categories	Impact (consequences)	Probability (likelihood)	Risk Score (Impact* Probability)
Electrical shock			
Fire hazards			
Power grid instability			
Sum			

It is conceivable that the experts who will undertake the assessment of charging safety might select to include in the analysis a more detailed breakdown of hazards under each of the categories mentioned above. In this case, the hazard category in the above tool should be replaced by the corresponding set of constituent sub-hazards, each one of which will have to be assessed separately as all other hazards.

A value function will be needed to transform scores into the 5-point scale of the evaluation framework.

1.15 E.6 Impact on security

Public transport security refers to measures taken by a transport system to keep its passengers, employees and freight safe, to protect the operator's infrastructure and equipment, and to make sure that other violations do not occur. In order to identify and address potential security risks, this KPI applies the risk assessment methodology to four dimensions, herewith referred to as Security Performance Standard (PS):

- PS1: Infrastructure and operation
- PS2: Vehicles
- PS3: Transport of goods
- PS4: Transport of persons

Project concept / e-solution(s) risk assessment considers risk impact and risk probability as presented below.

The **risk impact** refers to the consequences/impact in case some unexpected security related event happens. The following scale is used:

	Risk impact
0	If no adverse impact expected
1	If minor adverse impact expected

[12] The assessment of the likelihood of occurrence should take into consideration the safety measures that are embedded in the project.

2	If low adverse impact expected
3	If moderate adverse impact expected
4	If high adverse impact expected

For the designed e-mobility solution, the **risk probability** (likelihood of occurrence) is scored on the following scale:

	Risk probability
0	If likelihood of occurrence is very low (less than once per 10 years)
1	If likelihood of occurrence is low (less than once per 5 years)
2	If likelihood of occurrence is moderate (once per year)
3	If likelihood of occurrence is high (once per month)
4	If likelihood of occurrence is very high (once per week or more frequently)

To assess the potential impacts of the proposed up-scaled project in terms of impact on security, the scores on risk impact and risk probability for every PS category are entered in the table below and the overall security performance rating is calculated as the sum the partial scores of all PS categories.

Security Performance Standard	Guiding aspect	Risk Impact (consequences)	Risk Probability (likelihood)	Security Performance Score
Instructions		*Choose from: No impact [0] to Very high impact [4]*	*Choose from: Very low probability [0] to Very high probability [4]*	*Risk Impact X Risk Probability*
PS1: Infrastructure and operation	*Infrastructure and operation security score*			
PS2: Vehicles	*Vehicles security score*			
PS3: Transport of goods	*Transport of goods security score*			
PS4: Transport of persons	*Transport of people security score*			
Overall Security Performance				Σ

The perspectives of **all stakeholders** (e.g. operators, government, transport service providers) should be considered in the security risk assessment through meetings (online or local), workshops, or other events organized and facilitated by the city teams. End users (e.g., passengers of EVs) should be excluded, however, to avoid overlap with the personal security related KPI on quality of services (Section E.8, Feature #7).

It is conceivable that the stakeholders participating in the security risk assessment might select to include in the analysis a more detailed breakdown of hazards under each of the PS categories mentioned above. In this case, the PS category in the above table should be replaced by the corresponding set of constituent sub-hazards, each one of which will have to be assessed separately as all other PS/hazards.

A value function will be needed to transform the overall security performance ratings calculated as described above into the 5-point scale of the evaluation framework.

1.16 E.7 Impact on well-being due to active traveling

The basis for this KPI is the number of active kilometers associated with a specific up-scaled scenario. The active kilometers associated with the corresponding baseline solution are used for benchmarking. Due to the fact that there exist different modes of active traveling, a homogenization process is required. The amount of calories burned per kilometer of each transport mode is used for transforming active traveling distances into walking-equivalent kilometers, which serve as the homogenized unit. The conversion is based on the arithmetic mean of the calories burnt per kilometer by a 60kg 1,65m female and a 75kg 1,75m male person, as provided by the Activity Based Calorie Burn Calculator | SHAPESENSE.COM:

- Walking: 50.0 calories/km (based on 5km/h walking pace, 0% inclination)
- Cycling: 22.0 calories/km (based on 18km/h cycling pace)
- Driving moped/motorcycle: 4.5 calories/km (based on 35km/h average speed)
- Driving car: 3.0 calories/km (based on 50km/h average speed)

The formula, then, for calculating active traveling activity (in walking-equivalent km) is:

*Active kilometers = kilometers walking + 22/50 * kilometers cycling + 4.5/50 * kilometers moped/motorcycle + 3/50* kilometers car*

Procedure:

1. Define the ‘typical route’ or the boundaries of the analysis
2. Define the transport solution that would be used under the baseline scenario for the same transport defined in Step 1 (it can be the dominant alternative or a mix of alternatives as explained in Section E.2)
3. Determine the number of kilometers per active transport mode for the baseline scenario
4. Calculate the total number of walking-equivalent kilometers for the baseline scenario using the formula provided above
5. Based on information collected during the demonstration actions, determine the number of kilometers per active transport associated with the up-scaled scenario
6. Calculate the total number of walking-equivalent kilometers for the up-scaled scenario using the formula provided above
7. Calculate the difference in walking-equivalent kilometers between the up-scaled and the baseline scenarios.

A value function will be needed to transform the active traveling activity calculated as described above into the 5-point scale of the evaluation framework.

1.17 E.8 Quality of e-mobility services

Note	In this part of the questionnaire, we would like to have your opinion on how the suggested new e-mobility solution (indicated below as ‘NEW’) compares to the preferred one that you used before for the same transport (indicated below as ‘OLD’) in relation to the eight different quality features shown below. Before doing so, please indicate in the next box the OLD solution that you were using previously.

OLD solution	*Please briefly describe here the OLD solution (e.g. own car, diesel bus, safa tempo powered by gas, etc.)*
Procedure	Direct rating by end users through survey/questionnaire, with the exception of Feature #3, which will be assessed on the basis of feedback received from professional drivers
Feature #1 Suitability for adverse weather conditions	1. The OLD solution is much better than the NEW one 2. The OLD solution is better than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is better than the OLD one 5. The NEW solution is much better than the OLD one
Feature #2 Comfort in travel	1. The OLD solution is much more comfortable than the NEW one 2. The OLD solution is more comfortable than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is more comfortable than the OLD one 5. The NEW solution is much more comfortable than the OLD one
Feature #3 Ease of driving (by professional drivers)	1. The OLD solution is much easier to drive than the NEW one 2. The OLD solution is easier to drive than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is easier to drive than the OLD one 5. The NEW solution is much easier to drive than the OLD one
Feature #4 Ease of driving (by other users)	1. The OLD solution is much easier to drive than the NEW one 2. The OLD solution is easier to drive than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is easier to drive than the OLD one 5. The NEW solution is much easier to drive than the OLD one
Feature #5 Ease of charging/refueling	1. The OLD solution is much easier to charge/refuel than the NEW one 2. The OLD solution is easier to charge/refuel than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is easier to charge/refuel than the OLD one 5. The NEW solution is much easier to charge/refuel than the OLD one
Feature #6 Safety	1. The OLD solution is much safer than the NEW one 2. The OLD solution is safer than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is safer than the OLD one 5. The NEW solution is much safer than the OLD one
Feature #7	1. The OLD solution is much more secure than the NEW one 2. The OLD solution is more secure than the NEW one

Personal security (in terms of unlawful behaviors)	3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is more secure than the OLD one 5. The NEW solution is much more secure than the OLD one
Feature #8 Continuity of journey chains, including transshipment to other modes	1. The OLD solution is much better than the NEW one 2. The OLD solution is better than the NEW one 3. I don't see a difference between the two solutions in relation to this feature 4. The NEW solution is better than the OLD one 5. The NEW solution is much better than the OLD one

A 5-point scale is used for scoring all features. These scores will enter directly the evaluation framework.

F. Wider economic indicators

1.18 F.1 Impact on national/local budget

In public transport (e.g., buses) costs are often borne by the government. Therefore, any costs (capital and operational) in excess of current expenditures put an additional burden on the government finances. To the contrary, a positive impact on budget is expected in the case of for lower than current expenditures on public transport. Public investments are also needed for the provision of charging infrastructures and these can put an additional burden on public finances.

Proposed unit: **Percentage change in the relevant public (national/local) budget due to the up-scaled project**

Procedure:

1. Define the baseline scenario to be used for benchmarking purposes
2. Calculate the annual public budget flows (expenditures and revenues) associated with the up-scaled project over its life. The e-MOB model or another specialized software can be used for this purpose.
3. Calculate the annual public budget flows (expenditures and revenues) associated with the baseline scenario over the same period.
4. Calculate the annual differences in budget flows and the average net annual flow. For cities that can use the UNEP e-MOB calculator, this figure can be obtained as the difference in the annual total cost of ownership between the up-scaled and baseline scenarios
5. Express the net annual flow as a percentage of the average public (national/local) budget calculated over the last three years (2017-2019).

The assessment should be performed by experts using information on capital expenditures and operating expenses over the project period. The results should be validated by local teams/stakeholders.

A value function will be needed to transform the percentage change in public budget as calculated above into the 5-point scale of the evaluation framework.

1.19 F.2 Impact on external trade

1.19.1 F.2.1 Fossil fuel imports abated

Electric vehicles are expected to reduce demand for fossil fuels, which is of particular importance given that all countries within the project are net importers of oil. Therefore, any reduction in demand would reduce fossil fuel imports at the margin.

Proposed unit: **Percentage change in fossil fuel imports**

Procedure:

1. Define the baseline scenario to be used for benchmarking purposes
2. Calculate the vehicle-kilometers (vkm) for all modes using fossil fuels within the baseline scenario over project duration. The e-MOB model or another specialized software can be used for this purpose
3. Transform the baseline vkm to equivalent fuel consumption through the average energy intensity (liters of fuel per vkm) of each vehicle type in the fleet
4. Calculate the vehicle-kilometers (vkm) for all modes using fossil fuels within the up-scaled project over the same period. Use the same calculator as in Step 2
5. Transform the up-scaled project vkm to equivalent fuel consumption through the average energy intensity (liters of fuel per vkm) of each vehicle type in the fleet including those introduced by the project
6. Calculate the difference between the two estimates and express it as a percentage of the baseline fuel demand. For cities that can use the UNEP e-MOB calculator, the difference between the up-scaled and baseline scenarios is calculated directly by the model

The assessment should be performed by experts using information on vehicle kilometers for different modes. The results should be validated by local teams/stakeholders.

A value function will be needed to transform the percentage change in fossil fuel imports as calculated above into the 5-point scale of the evaluation framework. It is worth noting that in this case the proposed unit of the KPI (%) masks the effect of the project on the absolute import value, which can be very important in specific economic environments. The local stakeholders should consider this aspect when defining the value function.

1.19.2 F.2.2 Other imports affected

Electric vehicles are expected to substitute ICE vehicles in some cases (e.g., replacing a diesel bus with electric bus) and in others cases they are simply added to the fleet (e.g., e scooters for last mile). The overall impact on imports can be negative or positive depending on the nature of the project and the baseline scenario used for benchmarking. Note that fuel imports are excluded from this analysis as they are dealt with in Section F.2.1.

Proposed unit: C**hange in imports of vehicles/parts**

Procedure:

1. Define the baseline scenario to be used for benchmarking purposes
2. Calculate the number of EVs to be introduced into the system due to the up-scaled project by type of vehicle
3. Estimate the value of the corresponding imports also accounting for the required maintenance during the useful life of the vehicles. The estimate should pay attention and exclude all inputs in products/services provided by local suppliers

4. Calculate the number and type of vehicles (EVs or ICE ones) that would have been used under the baseline scenario to provide the transport services foreseen by the up-scaled project
5. Estimate the corresponding value of imports as in Step 3
6. Calculate the difference between the two estimates

The assessment should be performed by experts using market information on various vehicle types. The results should be validated by local teams/stakeholders.
A value function will be needed to transform the change in import value as calculated above into the 5-point scale of the evaluation framework.

1.20 F.3 Impact on employment

1.20.1 F.3.1 Job creation

This KPI is defined as the absolute number of net additional jobs (N_{NET}) expected to be generated by the assessed new e-mobility solution in comparison to the baseline scenario. N_{NET} is calculated as the difference between the jobs expected to be added (N_{ADD}) due to the new solution over the assessment period (2019 to 2030) and those expected to be lost (N_{LOST}) during the same period ($N_{NET} = N_{ADD} – N_{LOST}$). It is expected that the calculation will be based on the number of EVs entering the market and the estimated effects on the labor market as experienced through past projects in the demo city or elsewhere in the world. A value function will be needed to transform the number of additional jobs into a star value as required by the evaluation framework.

1.20.2 F.3.2 Expected impact on technical skills requirements

Originally, this KPI was designed to capture possible effects on the wages in the urban transport sector and related occupations. However, after consultation with stakeholders, it was decided instead to approach this topic through the requirements on technical skills that the up-scaled project imposes. It is expected that these requirements will be reflected in the wages anyway.
According to the literature, the specialties relating to EVs concern: (i) EV technicians involved in the construction and mainly maintenance of the vehicles, (ii) EV design engineers involved in the design or remodeling of vehicles, and (iii) IT analysts or other Industry 4.0 experts involved in developing and maintaining transport related software applications (e.g., MaaS apps).
As in Section E.7, a homogenization process is required. The average monthly salaries of these specialties in Switzerland, as provided by https://www.paylab.com/ch/salaryinfo, was used for this purpose. They appear in the table below:

	Low (10%)	High (90%)	Mean	Conversion factor
Auto electrician, car industry	2.784	5.848	4.316	1,0
Design engineer, car industry	3.988	7.302	5.645	1,3
IT analyst	4.826	10.761	7.794	1,8

Proposed unit: **Number of skilled positions required**
Procedure:

1. Define the baseline scenario to be used for benchmarking purposes

2. Estimate the number of net positions in the following specialties that the up-scaled project is expected to require in comparison to the baseline scenario:

    A. EV technicians
    B. EV design engineers
    C. IT analysts or other Industry 4.0 experts

3. Transform these into EV technician equivalent positions (N_{teq}) through the formula:

$$N_{teq} = 1.0\ A + 1.3\ B + 1.8\ C$$

Note that the definition of N_{teq} can be brought closer to the demonstration city realities by introducing conversion factors that reflect the local salaries. In fact, the data source cited above provides information for all countries around the world. It is also worth noting that the skill requirements of this indicator can be seen as overlapping with the job creation KPI of Section F.3.1. on the assumption that the skill requirements are met with appropriate hiring. This overlap, however, is only partial as the unskilled labor of Section F.3.1. does not enter N_{teq}. Furthermore, N_{teq} provides the connection with the WP2 of SOLUTIONSplus that deals with the training needs associated with the project interventions.

A value function will be needed to transform the number of skilled positions as calculated above into the 5-point scale of the evaluation framework.