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Data Collection and Reporting Guidelines for European electro-mobility projects

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Abstract

Analysis of the data collected from electro-mobility projects has shown that only in very limited cases, the data reported were of enough quality and/or comprehensive enough to allow a meaningful and complete analysis. Various types of data are sometimes missing, making it almost impossible to analyse them correctly. The objective of this report is to provide guidance to publicly funded European Electro-mobility Projects on what and how to monitor and report. Detailed description of the necessary monitored elements and those which are considered as optional due to the complexity or expense involved in collecting them, is included, as well some ideas on quality control and on data collection. An extensive stakeholder consultation has taken place before the release of this report.

Acknowledgements to the GeM project

This document is based largely on the Green eMotion internal report "Demo Regions Reporting Guidelines" but has been modified to reflect the authors experience with analysis of data from similar projects.

Green eMotion (http://www.greenemotion-project.eu/) is a large-scale European electro-mobility demonstration project funded by the European Commission, launched within the European Union's Green Cars Initiative. It brings together 43 partners from industry, energy sector, electric vehicle manufacturers, municipalities as well as universities and research institutions. The aim is to develop and to demonstrate a commonly accepted and user-friendly framework consisting of interoperable and scalable technical solutions in connection with a sustainable business platform. Smart grid developments, innovative ICT solutions, different types of electric vehicles and urban mobility concepts will all be taken into account. The four-year project started in March 2011 and is expected to end in February 2015.

List of Contributors

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Contents

1. Introduction

In order to achieve the GHG targets of the EU, the transport sector has to cut by 20% by 2030 compared to 2008 its GHG emissions. Furthermore, significant efforts is needed in order to achieve the targets set by the Transport White Paper, i.e. a 50% reduction of conventionally fuelled vehicles in cities by 2030, a total ban by 2050 and CO_2-free city logistics in major urban centers by 2030. In order to achieve these targets it is clear that a large shift to electro-mobility has to take place.

The Commission in its H2020 work-programme 2014-2015 has dedicated almost 140 Million Euro to projects related to electro-mobility (see the Green Vehicles call at http://ec.europa.eu/programmes/horizon2020/en/news/green-vehicles-2014) under the “Smart, green and integrated transport” challenge. Some of these projects will involve deployment of electrical vehicles in the European territory and their monitoring.

Currently more than 320 R,D&D projects are funded by the EU and Member States. Their total budgets add up to approximately 1.9 billion Euros. These projects are listed in the EV-Radar tool, which was developed by the JRC. The EV-Radar is an interactive e-mobility project visualization tool, which collects and portrays in an interactive way R&D and demonstration efforts for electro-mobility in Europe. Its latest version can be accessed under http://iet.jrc.ec.europa.eu/ev-radar/

Analysis of the data collected from earlier projects, has shown that only in very limited cases, the data reported were of enough quality and/or comprehensive enough to allow a meaningful and complete analysis. Various types of data, such as coordinates, data on charging points, state-of-charge of the battery, are sometimes missing, making it almost impossible to analyse them correctly.

The objective of this report is to provide guidance to publicly funded European Electro-mobility Projects on what and how to monitor and report. Privately funded projects may also choose to follow this guide as more data on e-mobility will help the analysis in support to this sector. Detailed description of the necessary monitored elements and those which are considered as optional due to the complexity or expense involved in collecting them, is included, as well some ideas on quality control and on data collection. An extensive stakeholder consultation has taken place before the release of this report.

2. Elements Monitored and Data coding

2.1. Projects

Due to the huge amount of data that may be collected by each Project, there is a need to use key codes and identification numbers in order to have all the data well structured, easily manipulated and human-readable.

Since many Projects throughout Europe operate independently, some measures need to be taken in order to assure the coherence and clarity of data. For example, if Projects A and B incorporate a new vehicle to their monitored fleets, the identification numbers given to these vehicles must be related with the name of the Project. That means that codes like “EV001” might cause problems when data from different Projects have to be stored together. Therefore, each project should define a **Project Code**, which should be used as a prefix for all data records of the Project.

The Project Code shall be used in the identification numbers of the monitored charging points, electric vehicles, users, and so on. Each Project should also use codes to identify uniquely the Cities, Regions or Countries that the Project is monitoring.

For example, we have a project with the code name EMPRO (Electro-Mobility PROject). The first table that has to be filled-in should include the details of the Project (Table 1).

Table 1: Example of a Project

Project Code	Project name	Short Description
EMPRO	Electro-Mobility PROject	Project that will monitor electric vehicles and charging stations: • in Spain • in the region of Lombardia (Italy) and • the city of Thessaloniki (Greece). **Programme funding**: EU, National, Regional **Start date**: 01/01/2016 **End Date**: 31/12/2019 **Webpage**: http://www.em-project.eu

There should also be a table that will include the details of the territorial units that are being monitored along with the Partners being involved. In Table 2 an example with the areas being monitored by the EMPRO Project example is presented. The Territorial

Code should be according to the NUTS geocoding standard[1]. Furthermore, the version of the NUTS should also be reported in the main text (e.g. NUTS 2010).

Table 2: Example of areas being monitored

Territorial Code	Territorial Name	NUTS level	Partners
ES	Spain	0	IREC
ITC4	Lombardia	2	Regione Lombardia
EL122	Thessaloniki	3	Municipality of Thessaloniki

The example Project "EMPRO" will be used along the rest of the document.

Important notes

- The tables that are presented in this document are indicative and they do not describe the actual database architecture. For example, for some values a need for an extra database table may appear (e.g. in the case of multiple values of a field).
- In the figures throughout this document, the recording of data doesn't necessarily mean that they should be stored locally or that first they should be sent to a server where they will be stored. The key event is to "keep" the data and the actual implementation is system architecture dependant.

2.2. Electric Vehicles, Charging Points and Users

The previously introduced Project and Territorial identifiers shall be used for the identification of all the monitored elements in a Project. The result will be a sort of *name plate* that will identify each single element. Apart from that, one other aim of this identifier is to provide enough information about what type of element this is and to which Project it belongs.

The collection of the data should have at least three different categories of elements: *electric vehicles*, *charging points* and *users*. Each of these three different categories will be differentiated through identification codes by means of an acronym or an abbreviation.

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[1] Eurostat: http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_CLS_DLD&StrNom=NUTS_33&StrLanguageCode=EN

The identification codes for each element in a Project will be composed of four parts:

1. The Project Code followed by an underscore "_"
2. The Territorial Code followed by an underscore "_"
3. The prefix of the type of element:
    a. Electric Vehicle .... **EV**
    b. Charging point .... **CP**
    c. User .... **USR**
4. A serial number consisted of digits which will be assigned to every new element.

In Table 3 some examples are presented in order to show the final format of the identifiers for the elements that belong to the example Project "EMPRO". This fictitious Project has:

- 4 electric vehicles and 2 charging points which are being monitored in Spain,
- 2 electric vehicles in the region of Lombardy and
- 3 charging points in the city of Thessaloniki with 1 electric vehicle.

Table 3: Example of the elements of the Project

Territorial Area	Electric Vehicles	Charging points	Users
ES	EMPRO_ES_EV1 EMPRO_ES_EV2 EMPRO_ES_EV3 EMPRO_ES_EV4	EMPRO_ES_CP1 EMPRO_ES_CP2	EMPRO_ES_USR1 EMPRO_ES_USR2
ITC4	EMPRO_ ITC4_EV1 EMPRO_ ITC4_EV2		EMPRO_ITC4_USR1 EMPRO_ITC4_USR2
EL122	EMPRO_EL122 _EV1	EMPRO_EL122_CP1 EMPRO_EL122_CP2 EMPRO_EL122_CP3	EMPRO_EL122 _USR3

In Table 3 it is apparent that a Project needs at least one monitored electric vehicle for each Territorial area. Monitored charging points are also really important but on their absence the energy demand of the vehicles should be extracted from the state of charge of the battery.

2.3. Brief Description of the monitored elements

Electric Vehicles

In the Data Collection, only electric vehicles[2] equipped with data loggers or OEM's data acquisition systems should be included. These vehicles can be passenger cars, transporters, buses, motorcycles and any other kind of electric vehicle such as electric bicycles. For this purpose a variable describing the type of vehicle being monitored

[2] Electric vehicles for this purpose exclude pure hybrid vehicles, i.e. vehicles that do not get electricity from the grid.

should be included. Furthermore, it is really important to define the type of use of the electric vehicle (private use, business use, captive fleet, renting etc.) and the type of owner (private owner, private company, public company or municipality).

Charging points

There are two specific cases in the monitoring process of the charging points (Figure 1):

a) There are charging points or charging stations with as many power meters as sockets or connectors, in this case each socket or connector will be considered an independent charging point and it will be registered with its own charging point ID. That means that for case a) there will be two static registers for this charging point and each dynamic register will be for one specific socket identified by its own charging point ID.

b) The other case considers charging points with multiple sockets but with only one power meter. In this case it is impossible to distinguish the socket that is registered. This charging station will only have one ID and all the sockets will be considered identical.

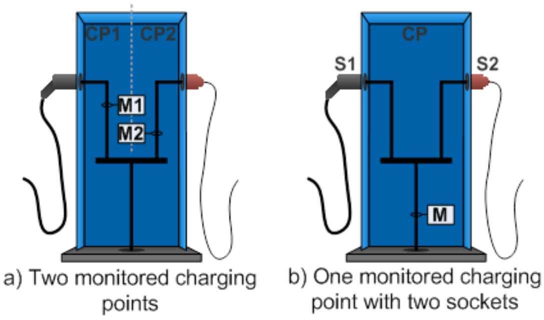

Figure 1: Different types of charging points

Users

"Users" is defined as the user of the vehicle at the time of the recording, which can be different from the owner of the vehicle. The recording of user data should be anonymous due to privacy issues but should include only general information such as gender and age.

3. Data templates

Data templates should be created with the aim of not only structuring and homogenizing the format in which data from all the different sources will be delivered but also facilitating the filling process.

The data that have to be recorded can be divided in two groups:

1. **Static data**: These data refer to list of elements that are being monitored by the Project. This is actually all the static information and details regarding the fleet (e.g. vehicle type, use, owner etc) and/or the charging points (e.g. geographic coordinates, charging type, number of outlets etc) being monitored.
2. **Dynamic data**: They include all the data being recorded from the loggers of the electric vehicles and the charging points. It should be noted that especially for the logging of the driving routes of the electric vehicles there should be a periodicity of logging which would allow meaningful interpretation of the results. It is suggested that the logging takes place every time the State of Charge of the battery changes (either reduced due to vehicle usage or increased due to charging/regeneration) by **1%** and at least either every **300 seconds** or **2 km** (whichever takes place first), but a frequency of 1 sec is prefered.

Both the static and dynamic data should be stored in files according to the JSON[3] format. Also a JSON schema should be created in order to define the structure of the data. In the following chapters there are suggested samples of these files for each type of data. JSON format is suggested in order to guarantee the correct and accurate content and structure of the recorded data. Furthermore, it facilitates the interoperability and seamless communication between different systems.

In this report there are two kinds of distinguishable elements: **minimum data** **and** **extra data**. It is considered by the authors that for each European project in the field of electromobility at least the minimum data should be collected. The extra data provide a more depth of information and will facilitate the further analysis, giving extra value to the projects, but are not obligatory.

3.1. Data quality control process

As with all data collection projects, an appropriate data quality control should be done to ensure that all data requirements are met. In general, all JSON files that contain the collected data should be parsed and checked for format and content errors.

The quality control process used should be also described in detail (steps followed, tools used etc.) and should include at least the following steps:

- Continuous variables format check (values within the ranges, percentages, units…)
- Discrete variables categories double check (spelling errors, non-valid categories, …)

[3] http://www.json.org/

- Detection and correction of outliers
- Gap filling
- Detection and correction of negative values

Figure 2 presents a suggested workflow of the process.

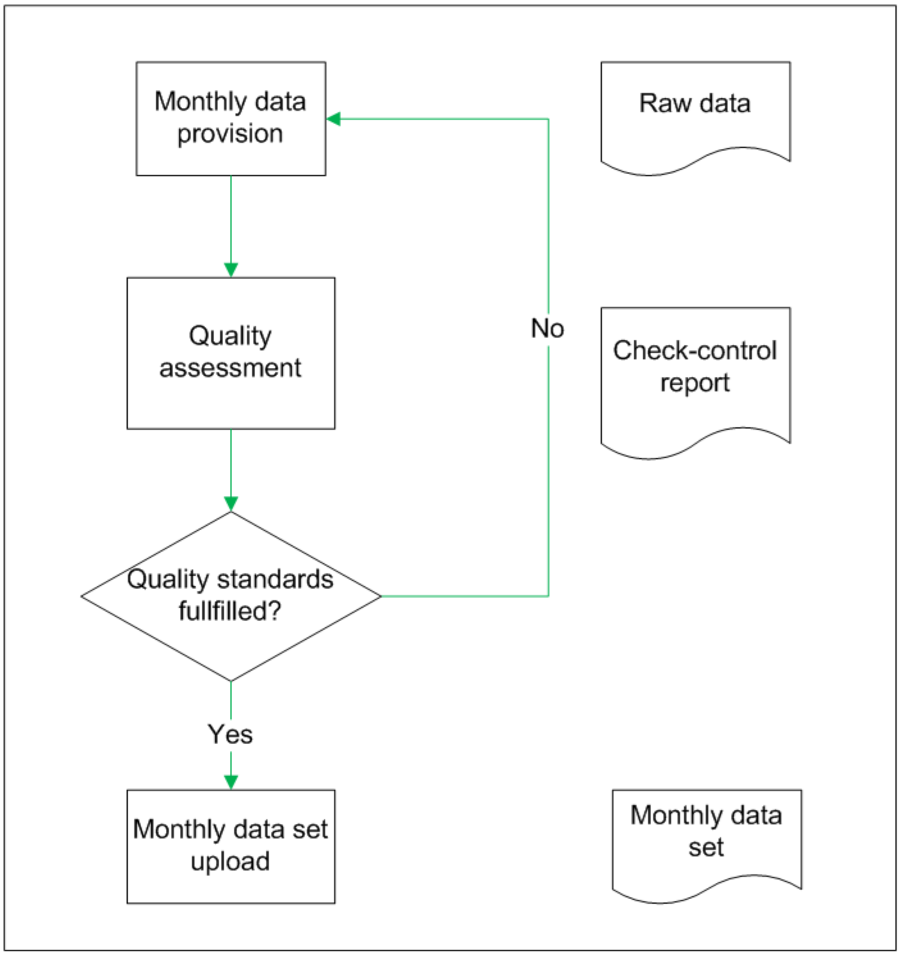

Figure 2: Suggested data quality control process workflow

3.2. Filling procedure

The five templates that have to be filled are the following:

STA_EV	**Static data** of the **Electric Vehicles**
STA_CP	**Static data** of the **Charging Points**
STA_USR	**Static data** of the **Users**

DYN_EV	**Dynamic data** of the **Electric Vehicles**
DYN_CP	**Dynamic data** of the **Charging Points**

The next pages contain more detailed information of each of the variables included in the files introduced above and also detailed explanations and details of the list of possible values that each variable could have.

3.3. Data protection

All data related with the drivers' activities should be treated according to the Regulation (EC) No 45/2001[4] of the European Parliament and of the Council (or any update of this regulation). Specifically the data collected by the relevant projects have to be:

- processed fairly and lawfully;
- collected for specified, explicit and legitimate purposes and not further processed in a way incompatible with those purposes;
- adequate, relevant and not excessive in relation to the purposes for which they are collected and/or further processed;
- accurate and, where necessary, kept up to date (all reasonable steps should be taken to ensure that data which are inaccurate or incomplete in relation to the purposes for which they are collected or for which they are further processed, are erased or rectified);
- kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data are collected or for which they are further processed.

Furthermore, the users that participate in a project have to give their consent for the monitoring of their activities when using the electric vehicles that are part of the project. Additionally, all data collection and reporting procedures should also be in line with any relevant national law.

[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:008:0001:0022:en:PDF

4. DATA FROM CHARGING SYSTEM DOMAIN

4.1. General Information

DOCUMENT TYPE: Text

DATA TO BE INCLUDED (per Project):

Table 4: Charging System Domain information

Data name	Indicator description	Static/ Dynamic
Charging Stations description	Charging Stations description Report (services, employees, assets, asset owner, charging manager etc.)	Static
System Management	Descriptive Report: Summarize how the charging station is managed (maintenance, queries, insurance, responsibilities...).	Static
Authentication techniques	Report on the authentication techniques, if installed. If existing, specify the type of authentication card and if it is user or vehicle-based.	Static
Value-added services	Report on value-added services (e.g. weather data, diagnostics, list of value-added services provided)	Static

4.2. Charging Point: static data

STA_CP:	**Static data** of the **Charging Points**

DOCUMENT TYPE: Static table of contents

Table 5: MINIMUM DATA TO BE INCLUDED (per charging point)

Code	Data name	Data type	List of values / Format
CP_TC	**Territorial Code**	String	(see Table 2)
CP_ID	**Charging point ID**	String	(see Table 3)
CP_DATE_0	**Enlist date**	Date	*DD/MM/YYYY*
CP_DATE_F	**Leave date**	Date	*DD/MM/YYYY*
CP_Manuf	**Charging point manufacturer**	String	
CP_Model	**Charging point model**	String	
CP_Year	**Charging point year of manufacturing**	Integer	*YYYY*
CP_Supplier	**Electricity supplier**	String	
CP_GPS_lat	**Charging point latitude**	Floating point	*degrees*
CP_GPS_lon	**Charging point longitude**	Floating point	*degrees*
CP_Location_Type	**Charging point location type**	String	street/ public access parking/ office parking/ household/ service area/ others
CP_Availab	**Charging point % uptime availability**	Floating point	Number between 0 and 100
CP_V2G_availab	**V2G availability**	String	yes/ no/ not applicable
CP_Authent	**Authentication availability**	String	none/ vehicle/ user/ both
CP_Battery	**Battery charger**	String	yes/no
CP_ChMode	**Charging mode**	String	IEC62196-Mode 1/ IEC62196-Mode 2/ IEC62196-Mode 3/ IEC62196-Mode 4
CP_Prot1	**Communication protocols EV-CP**	String	none/ SAE J2293/ IEC 61851/

			CHADEMO/ multiple/ others
CP_Prot2	**Communication protocols CP-EVSE**	String	none/ gprs/ ethernet/ wi-fi/ RS485/ CAN/ PLC/ multiple/ others
CP_Prot3	**Communication protocols EVSE-CH**	String	none/ gprs/ ethernet/ wi-fi/ RS485/ CAN/ PLC/ multiple/ others
CP_InpPow	**Input Power Supply**	String	single-phase/ three-phase/ three-phase+neutral/ DC
CP_InpNomV	**Input Nominal Voltage (Volts)**	Floating point	
CP_InpNomC	**Input Nominal Current (Amps)**	Floating point	
CP_InpNomP	**Input Nominal Power (kW)**	Floating point	
CP_Outlet	**Socket or connector output**	String	socket/ connector
CP_n_outlet	**Number of outlets**	Integer	
CP_TypeOut	**Type of socket/s or connector/s**	String	AC Type 1/ AC Type 2/ AC Type 3/ DC CHAdeMO/ DC CCS/ DC Type2 (such as TESLA)/ Industrial plug/ European standard plug (incl. Shuko, British, Swiss, etc)/ multiple/ others
CP_OutPow	**Output Power Supply**	String	single-phase/ three-phase/ three-phase+neutral/ DC
CP_OutNomV	**Output Nominal Voltage (Volts)**	Floating point	

CP_OutNomC	**Output Nominal Current (Amps)**	Floating point	
CP_OutNomP	**Output Nominal Power (kW)**	Floating point	

Suggested Frequency of data collection: on change
Suggested Periodicity of data reporting: on change

Variable specifications:

- **Enlist/Leave date:** *date in which the charging point joined or left the Project.*
- **Charging point manufacturer:** *name of the charging point manufacturer.*
- **Charging point model:** *name of the charging point model.*
- **Charging point year of manufacturing:** *year in which the charging point is manufactured.*
- **Electricity supplier:** *the supplier that provides the electricity to the charging point.*
- **Charging point latitude:** *GPS latitude coordinates expressed in degrees (e.g. 41.414588)*
- **Charging point longitude:** *GPS longitude coordinates expressed in degrees (e.g. 2.220395)*
- **Charging point location type:** *type of location of the charging point:*
  - street → *charge point located in the street.*
  - public access parking → *charge point located in a private parking with public access.*
  - office parking → *charge point located in a parking of a private company.*
  - household → *charge point located in a parking of a house or building.*
  - *service area* → *charge point located in gas station or a parking area of a shopping mall, restaurant, super-markets etc.*
  - others → *charge point located in any location not included in the previous cases.*
- **Charging point % uptime availability:** *percent of the time during the monitored period with the charging point being available. A charging point can be available when either it operates or it is in stand-by mode.*
- **V2G availability:** *availability of vehicle-to-grid (V2G) services defined as the capacity for transferring power from the vehicle to the grid.*
- **Authentication availability:** *authentication system of the vehicle or user by the charging point:*
  - none → *neither the vehicle nor the user can be authenticated.*
  - vehicle → *only the vehicle can be authenticated.*
  - user → *only the user can be authenticated.*
  - both → *both the vehicle and the user can be authenticated.*
- **Battery charger:** *availability of an off-board battery charger.*
  - yes → *the supply network A.C. power is converted in an off-board charging station to D.C.*
  - no → *the supply network A.C. power is converted in an on-board charging station to D.C.*
- **Charging mode:** *the standard leverages the charging modes as defined in IEC61851-1*
  - IEC62196-Mode 1 → *slow charging from a household-type socket-outlet.*
  - IEC62196-Mode 2 → *slow charging from a household-type socket-outlet with an in-cable protection device.*
  - IEC62196-Mode 3 → *slow or fast charging using a specific EV socket-outlet with control and protection function installed.*
  - IEC62196-Mode 4 → *fast charging using an external charger.*
- **Communication protocols EV-CP:** *communication protocol between EV and the charging point:*
  - none → *there is not any communication protocol between EV and charging point.*
  - SAE J2293 → *Standard on "Energy transfer system for electrical vehicles" that establishes requirements for Electric Vehicles (EV) and the off-board Electric Vehicle Supply Equipment (EVSE) used to transfer electrical energy to an EV from an Electric Utility Power System (Utility) in North America*
  - IEC 61851 → *Standard on "Electric vehicle conductive charging system" that applies to on-board and off-board equipment for charging electric road vehicles at standard AC supply voltages up to 1000V and at DC voltages up to 1500V.*

- CHADEMO → *Global industry standard that states both a quick charging method for EV delivering up to 62.5kW on direct current and the connectors for this purpose.*
- multiple → *the charging point has multiple outputs with different protocols.*
- others → *none of the previous cases.*

- **Communication protocols CP-EVSE:** *communication physical layer between the charging spot and the charging spot operator or energy meter:*
  - none → *there is not any communication protocol between charging spot and the charging spot operator or energy meter.*
  - gprs → *general packet radio service.*
  - ethernet → *computer networking technologies for local area networks (LANs).*
  - wi-fi → *mechanism for wirelessly connecting electronic devices.*
  - RS485 → *multipoint differential communications system*
  - CAN → *multi-master broadcast serial, differential bus*
  - PLC → *Power Line Communications*
  - multiple → *the charging point has multiple outputs with different protocols.*
  - others → *none of the previous cases.*
- **Communication protocols EVSE-CH:** *communication protocol between the charging spot operator and the energy retailer, distribution system operator etc (for the specification of the possible values see* communication protocols EV-CP*).*
- **Input power supply:** *type of power supply of the charging station*
  - single-phase → *the charging station is connected to the distribution circuit by means of a single-phase connection.*
  - three-phase → *the charging station is connected to the distribution circuit by means of a three-phase without neutral connection.*
  - three-phase+neutral → *the charging station is connected to the distribution circuit by means of a three-phase with neutral connection.*
  - DC → *the charging station is connected to the distribution circuit by means of a direct current connection.*
- **Input nominal voltage (Volts):** *input nominal voltage of the charging point.*
- **Input nominal current (Amps):** *nominal current of the charging point power input.*
- **Input nominal power (kW):** *nominal power of the charging point power input.*
- **Socket or connector:** *specify if the output is a socket or a connector:*
  - socket → *power outlet on a charging point where EV's plug are connected.*
  - connector → *wire and connector that goes out from the charging point to the EV socket.*
- **Number of outlets:** *number of outlets of the charging point (for a detailed explanation see Figure 1).*
- **Type of socket or connector:** *type of the socket or connector.*
- **Output power supply:**
  - single-phase → *the electric power transmission to the EV is done through a single-phase (phase + neutral) connection.*
  - three-phase → *the electric power transmission to the EV is done through a three-phase without neutral connection.*
  - three-phase+neutral → *the electric power transmission to the EV is done through a a three-phase with neutral connection.*
  - DC → *the electric power transmission to the EV is done through a direct current connection.*
- **Output nominal voltage (Volts):** *nominal value of the charging point output voltage.*
- **Output nominal current (Amps):** *nominal value of the charging point output current.*
- **Output nominal power (kW):** *nominal value of the charging point power outlet.*

FILE:

In the following table a JSON example file is included. The file should contain as many records as the number of charging points that are registered.

```json
[
    {
        "CP_TC": "ES",
        "CP_ID": "EMPRO_ES_CP1",
        "CP_DATE_0": "01/01/2011",
        "CP_DATE_F": "31/12/2011",
        "CP_Manuf": "ManufacturerX",
        "CP_Model": "ModelX",
        "CP_Year": 2011,
        "CP_Supplier": "CompanyX",
        "CP_GPS_lat": 41.414588,
        "CP_GPS_lon": 2.220395,
        "CP_Location_Type": "street",
        "CP_Availab": 100,
        "CP_V2G_availab": "no",
        "CP_Authent": "both",
        "CP_Battery": "yes",
        "CP_ChMode": "IEC62196-Mode 1",
        "CP_Prot1": "others",
        "CP_Prot2": "gprs",
        "CP_Prot3": "ethernet",
        "CP_InpPow": "single-phase",
        "CP_InpNomV": 230,
        "CP_InpNomC": 16,
        "CP_InpNomP": 3.7,
        "CP_Outlet": "connector",
        "CP_n_outlet": 1,
        "CP_TypeOut": "others",
        "CP_OutPow": "single-phase",
        "CP_OutNomV": 230,
        "CP_OutNomC": 16,
        "CP_OutNomP": 3.7
    },
    {
        "CP_TC": "ES",
        "CP_ID": "EMPRO_ES_CP2",
        "CP_DATE_0": "01/03/2011",
        "CP_DATE_F": "31/12/2011",
        "CP_Manuf": "ManufacturerY",
        "CP_Model": "ModelY",
        "CP_Year": 2010,
        "CP_Supplier": "CompanyX",
        "CP_GPS_lat": 40.414588,
        "CP_GPS_lon": 3.220395,
        "CP_Location_Type": "public parking",
        "CP_Availab": 100,
        "CP_V2G_availab": "no",
        "CP_Authent": "both",
        "CP_Battery": "yes",
        "CP_ChMode": "IEC62196-Mode 1",
        "CP_Prot1": "others",
        "CP_Prot2": "gprs",
        "CP_Prot3": "ethernet",
        "CP_InpPow": "single-phase",
        "CP_InpNomV": 230,
        "CP_InpNomC": 16,
        "CP_InpNomP": 3.7,
        "CP_Outlet": "connector",
        "CP_n_outlet": 1,
        "CP_TypeOut": "others",
        "CP_OutPow": "single-phase",
```

```
        "CP_OutNomV": 230,
        "CP_OutNomC": 16,
        "CP_OutNomP": 3.7
    }
]
```

Comments and recommendations

- There must be one data register for each charging point with power meter. For those charging points with multiple outputs, there would be as many registers as outputs with individual power meters. Otherwise, this charging point would be enlisted as a unique element with multiple power outlets. In case the different outputs of a charging point have different communication protocols, it must be indicated with the value “multiple”. (Figure 1)
- According to the terminology agreed in the CEN CENELEC Focus Group, the field “Socket or connector output” should be one of these 2 possible components for a charging spot: socket or connector.

4.3. Charging Point: dynamic data

DYN_CP:	**Dynamic data** from the **Charging Point** and charge of an EV

DOCUMENT TYPE: Dynamic table of contents

Table 6: MINIMUM DATA TO BE INCLUDED (per charging event)

Code	Data name	Data type	List of values / Format
DCP_TC	**Territorial Code**	String	(see Table 2)
DCP_DATE_0	**Initial Date**	Date	*DD/MM/YYYY*
DCP_TIME_0	**Initial Time**	Time	*HH:MM:SS*
DCP_DATE_F	**Final Date**	Date	*DD/MM/YYYY*
DCP_TIME_F	**Final Time**	Time	*HH:MM:SS*
DCP_CP_ID	**Charge point ID**	String	(see Table 3)
DCP_USR_ID	**User ID**	String	(see Table 3)
DCP_EV_ID	**Electric Vehicle ID**	String	(see Table 3)
DCP_Duration	**Charging duration**	Integer	*Minutes*
DCP_ChCons	**Energy consumption**	Floating point	*kWh*
DCP_ChType	**Charge type**	String	fast charge/ slow charge/ battery swapping
DCP_Error_Code	**Error Code**	String	

Suggested Frequency of data collection: per charge
Suggested Periodicity of data reporting: monthly

Variable specifications:

- **Initial date/time:** *date and time in which the charging process starts.*
- **Final date/time:** *date and time in which the charging process finishes.*
- **Charging duration:** *total minutes that the charging process lasts.*
- **Energy consumption:** *energy consumed from the grid in the charging process in kWh.*
- **Charge type:** *Type of charge process.*
- **Error Code:** *An error code should be defined in case the charging process is suddenly interrupted either by the user (e.g. removing the cable) or the system itself (e.g. power failure).*

FILE:

Following a JSON example file for the charging events is presented. The file should contain as many records as the number of charging events being registered.

```
[
    {
        "DCP_TC": "ES",
        "DCP_DATE_0": "30/05/2011",
```

```
        "DCP_TIME_0": "11:21:05",
        "DCP_DATE_F": "30/05/2011",
        "DCP_TIME_F": "17:21:15",
        "DCP_CP_ID": "EMPRO_ES_CP1",
        "DCP_USR_ID": "EMPRO_ES_USR1",
        "DCP_EV_ID": "EMPRO_ES_EV1",
        "DCP_Duraion": 30,
        "DCP_ChCons": 20,
        "DCP_ChType": "fast charge",
        "DCP_Error_code": "Success"
    },
    {
        "DCP_TC": "ES",
        "DCP_DATE_0": "04/06/2011",
        "DCP_TIME_0": "20:21:05",
        "DCP_DATE_F": "06/06/2011",
        "DCP_TIME_F": "05:11:00",
        "DCP_CP_ID": "EMPRO_ES_CP2",
        "DCP_USR_ID": "EMPRO_ES_USR2",
        "DCP_EV_ID": "EMPRO_ES_EV2",
        "DCP_Time": 530,
        "DCP_V2GM": "not active",
        "DCP_V2GU": "",
        "DCP_Gen": "",
        "DCP_THDi": 1,
        "DCP_PowF": 0.98,
        "DCP_PeakP": 3.6,
        "DCP_ChCons": 18,
        "DCP_ChType": "slow charge",
        "DCP_ChType": "Success",
    }
]
```

Comments and recommendations

Figure 3 shows a charging process (without V2G) and how the peak values, the time and the energy consumption have to be calculated. Also the difference between charging time and plugged time is being presented. The field "Charging duration" on

- Table 6 refers to the "Charging time" of Figure 3.

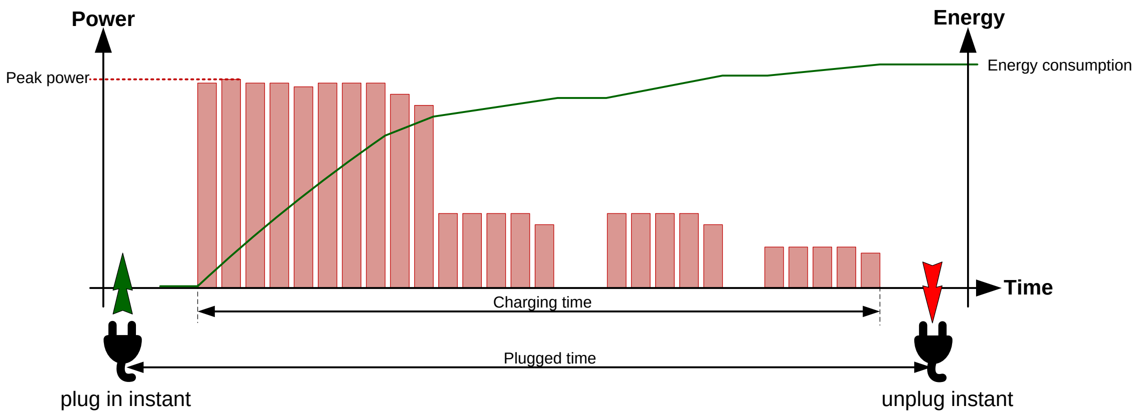

Figure 3: Charging process

Table 7: <u>EXTRA</u> DATA TO BE INCLUDED (per charging event)

	Data name	Data type	List of values / Format
DCP_TC	**Territorial Code**	String	(see Table 2)
DCP_DATE_0	**Initial Date**	Date	*DD/MM/YYYY*
DCP_TIME_0	**Initial Time**	Time	*HH:MM:SS*
DCP_DATE_F	**Final Date**	Date	*DD/MM/YYYY*
DCP_TIME_F	**Final Time**	Time	*HH:MM:SS*
DCP_CP_ID	**Charge point ID**	String	(see Table 3)
DCP_USR_ID	**User ID**	String	(see Table 3)
DCP_EV_ID	**Electric Vehicle ID**	String	(see Table 3)
DCP_V2GM	**V2G conditions 1**	String	active/ not active
DCP_V2GU	**V2G conditions 2**	String	secondary reserve/ frequency support/ others/ not applicable
DCP_Gen	**Energy generation (V2G)**	Floating point	*kWh/* *null*
DCP_THDi	**THDi**	Floating point	*Number between 0 and 100 (%)/* *null*
DCP_PowF	**Power Factor**	Floating point	*Number between 0 and 1/* *null*
DCP_PeakP	**Peak power**	Floating point	*kW/* *null*
DCP_Parking_Type	**Parking payment type**	String	free/ paid
DCP_Payment_Type	**Charging payment type**	String	free/ paid

Suggested frequency of data collection: per charge
Suggested periodicity of data reporting: monthly

Variable specifications:

- **Initial date/time:** *date and time in which the charging process starts.*
- **Final date/time:** *date and time in which the charging process finishes.*
- **Charging duration:** *total minutes that the charging process lasts.*
- **V2G conditions 1:** *V2G mode:*
    - active → *V2G is active in the charging point.*
    - not active → *V2G is not active in the charging point.*
- **V2G conditions 2:** *V2G current usage:*
    - secondary reserve → *the energy injected to the grid is used for secondary reserve.*
    - frequency support→ *the energy injected to the grid is used for frequency support.*
    - *others* → *none of the other cases.*
- **Energy generation (V2G):** *quantity of energy in kWh injected to the grid in an active V2G status.*
- **THDi:** *total harmonic distortion of the current between 0 and 100 (%).*
- **Power factor:** *ratio between the real over the apparent power between 0 and 1.*
- **Peak power:** *maximum power value during the charge in kW.*
- **Parking payment type:**
    - free → *the user can park where the charging point is located for free.*
    - paid → *the user has to pay for parking where the charging point is located.*
- **Charging payment type:**
    - free → *the user can charge the vehicle for free.*
    - paid → *the user has to pay for charging the vehicle.*

FILE:

Following, a JSON example file for the charging events is presented. The file should contain as many records as the number of charging events being registered.


```
[
    {
        "DCP_TC": "ES",
        "DCP_DATE_0": "30/05/2011",
        "DCP_TIME_0": "11:21:05",
        "DCP_DATE_F": "30/05/2011",
        "DCP_TIME_F": "17:21:15",
        "DCP_CP_ID": "EMPRO_ES_CP1",
        "DCP_USR_ID": "EMPRO_ES_USR1",
        "DCP_EV_ID": "EMPRO_ES_EV1",
        "DCP_V2GM": "not active",
        "DCP_V2GU": "not applicable",
        "DCP_Gen": null,
        "DCP_THDi": 1,
        "DCP_PowF": 0.98,
        "DCP_PeakP": 3.6,
        "DCP_Parking_Type": "free",
        "DCP_Payment_Type": "paid"
    },
```

```
    {
        "DCP_TC": "ES",
        "DCP_DATE_0": "04/06/2011",
        "DCP_TIME_0": "20:21:05",
        "DCP_DATE_F": "06/06/2011",
        "DCP_TIME_F": "05:11:00",
        "DCP_CP_ID": "EMPRO_ES_CP2",
        "DCP_USR_ID": "EMPRO_ES_USR2",
        "DCP_EV_ID": "EMPRO_ES_EV2",
        "DCP_V2GM": "not active",
        "DCP_V2GU": "not applicable",
        "DCP_Gen": null,
        "DCP_THDi": 1,
        "DCP_PowF": 0.98,
        "DCP_PeakP": 3.6,
        "DCP_Parking_Type": "paid",
        "DCP_Payment_Type": "free"
    }
]
```

5. DATA FROM ELECTRIC VEHICLES

5.1. *Electric Vehicle: static data*

STA_EV:	**Static data** of the **Electric Vehicles**

DOCUMENT TYPE: Static table of contents

Table 8: MINIMUM DATA TO BE INCLUDED (per electric vehicle)

Code	Data name	Units	List of values / Format
EV_TC	**Territorial Code**	String	(see Table 2)
EV_ID	**Electric Vehicle ID**	String	(see Table 3)
EV_DATE_0	**Enlist date**	Date	*DD/MM/YYYY*
EV_DATE_F	**Leave date**	Date	*DD/MM/YYYY*
EV_Mileage_0	**Mileage of EV on enlist date**	Floating point	km
EV_Owner	**Vehicle Ownership**	String	private owner/ private company/ public company/ municipality
EV_Use	**Vehicle Use**	String	renting/ private use/ business use/ captive fleet/ other
EV_Tech	**Vehicle technology**	String	bev/ phev/ fcev/ erev/ other
EV_Battery	**Battery technology**	String	lead-acid/ nickel metal hydride/ lithium ion/ zebra/ other
EV_Consum	**EV Battery State 1**	Floating point	kW
EV_Capac	**EV Battery State 2**	Floating point	kWh
EV_Logger	**Type of logger**	String	none/ manual/ OEM/ custom/ other
EV_DataMeth	**Data acquisition method**	String	physical/ CAN/ CAN+physical/

			physical+other/ CAN+other/ none/ other
EV_DataFreq	**Data acquisition frequency**	Integer	*Seconds*
EV_DataPoss	**Data possibilities**	String	
EV_LoggerMan	**Logger device manufacturer**	String	
EV_LoggerDevice	**Logger device model**	String	
EV_FirmwareVer	**Logger's firmware version**	String	
EV_Manufacturer	**Manufacturer**	String	
EV_Model	**Model**	String	
EV_ModelYear	**Model Year**	Integer	YYYY
EV_Type	**Type**	String	passenger car/ SUV/ LCV/ HDT/ bus/ motorcycle/ moped/ bicycle
EV_VIN	**Vehicle Identification Number**	String	

Suggested frequency of data collection: on change
Suggested periodicity of data reporting: on change

Variable specifications:

- **Enlist/Leave date:** *date in which the electric vehicle joined or left the Project.*
- **Mileage of EV on enlist date:** *the value of the vehicle's mileage in km when it joined the Project.*
- **Vehicle ownership:** *type of entity that owns the electric vehicle:*
    - private owner → *a single person owns the electric vehicle.*
    - private company → *a private company owns the electric vehicle.*
    - public company → *a public company owns the electric vehicle.*
    - municipality → *the local authorities own the vehicle.*
- **Vehicle use:** *electric vehicle principal use:*
    - renting → *vehicle used in a renting service, rented temporary by a user different to the owner.*
    - private use → *the vehicle is used for private purposes independently to the owner.*
    - business use → *the vehicle is used for business purposes independently to the owner.*
    - captive fleet → *the vehicle is included in a fleet owned by a company either public or private.*
    - other → *none of the previous cases*
- **Vehicle technology:** *technology of the electric vehicle:*
    - pev → *pure electric vehicle.*
    - phev → *plug-in hybrid electric vehicle.*
    - fcev → *fuel cell electric vehicle*
    - erev → *extended-range electric vehicle*
    - other → *none of the above.*

- **Battery technology:** *technology of the electric vehicle's battery:*
    - lead – acid→ *lead acid batteries*.
    - nickel metal hydride → *NiMH batteries or nickel metal hydride cell.*
    - lithium ion → *li-ion or LIB batteries.*
    - zebra → *zebra or Na-NiCl$_2$ batteries.*
    - *other*→ *none of the above.*
- **EV battery state 1:** *nominal power consumption in kW of the electric vehicle battery.*
- **EV battery state 2:** *nominal storage capacity in kWh of the electric vehicle battery.*
- **Type of logger:** *device or method through which data is obtained from the vehicle to be reported.*
    - none → *no data acquisition is done.*
    - manual → *data is taken manually for every trip and charge.*
    - OEM → *data acquisition system installed by the vehicle manufacturer*.
    - custom → *data acquisition system installed by an external company*.
    - *other* → *any other way of obtaining data from the vehicle.*
- **Data acquisition method:** *way in which the data acquisition device gets the values from the different parts of the vehicle.*
    - physical → *parameters are obtained by means of analogue sensors: voltage, current, tachometers, temperature probes, and so on. Digital inputs such as "ignition" (vehicle on/off) or "air conditioning" (on/off) are accepted for adding extra information.*
    - CAN → *parameters are only obtained from the data available on the CAN bus of the vehicle. Additional digital inputs such as "ignition" (vehicle on/off) or "air conditioning" (on/off) are also allowed to add extra information not available on CAN bus.*
    - CAN+physical → *complete data sets are obtained with the combination of CAN bus data, analogue sensors and digital inputs.*
    - physical+other → *complete data sets are obtained with the combination of sensed analogue data, digital inputs and any other communications bus from another part of the vehicle, for example a serial data port of the EV main controller or the BMS.*
    - CAN+other → *complete data sets are obtained with the combination of CAN bus data, digital inputs and any other communications bus from another part of the vehicle, for example a serial data port of the EV main controller or the BMS.*
    - other → *those other cases not included in the previous points, for example, the acquisition of data directly from the EV main controller or BMS through a serial port.*
    - none -> *for those cases where there is no data acquisition or it is obtained manually.*
- **Data acquisition frequency:** *rate at which the values are acquired and stored*
- **Data possibilities:** *a list of the data the logger is able to monitor.*
- **Logger device manufacturer:** *the manufacturer company of the logger.*
- **Logger device model:** *the model of the logger.*
- **Logger's firmware version:** *the version of the logger's firmware.*
- **Manufacturer:** *manufacturer of the electric vehicle.*
- **Model:** *model of the electric vehicle.*
- **Model Year:** *the year the model of the electric vehicle was released.*
- **Type:** *type of the electric vehicle:*
    - passenger car
    - SUV: Sport Utility Vehicle
    - LCV: Light Commercial Vehicle
    - HDT: Heavy Duty Truck used for goods transport
    - bus: used for urban or extra urban passenger transport, and therefore including coaches
    - motorcycle
    - moped
    - bicycle
- **Vehicle Identification Number (VIN):** *Vehicle Identification Number as defined in ISO 3833.*

FILE:

Following, a JSON example file for the electric vehicles is presented. The file should contain as many records as the number of the vehicles that participate in the Project.


```json
[
    {
        "EV_TC": "ES",
        "EV_ID": "EMPRO_ES_EV1",
        "EV_DATE_0": "30/05/2011",
        "EV_DATE_F": "30/05/2014",
        "EV_Milage_0": 650,
        "EV_Owner": "private owner",
        "EV_Use": "private use",
        "EV_Tech": "bev",
        "EV_Battery": "lithium ion",
        "EV_Consum": 80,
        "EV_Capac": 24,
        "EV_Logger": "OEM",
        "EV_DataMeth": "CAN",
        "EV_DataFreq": 200,
        "EV_DataPoss": "Speed;LatLong;External temp...",
        "EV_LoggerMan": "CompanyLoggerX",
        "EV_LoggerDevice": "DeviceX",
        "EV_FirmwareVer": "1.3",
        "EV_Manufacturer": "CarCompanyX",
        "EV_Model": "CarModelX",
        "EV_ModelYear": 2012,
        "EV_Type": "passenger car",
        "EV_VIN": "5GZCZ43D13S812715"
    }
]
```

5.2. Electric Vehicle: dynamic data

DYN_EV:	**Dynamic data** from the **Electric vehicle** for each trip

DOCUMENT TYPE: Dynamic table of contents

Table 9: MINIMUM DATA TO BE INCLUDED (per Electric vehicle and trip or charge)

	Data name	Data type	List of values / Format
DEV_TC	**Territorial Code**	String	(see Table 2)
DEV_Type	**Type of event**	String	trip/ charge
DEV_DATE_0	**Initial Date of trip or charge**	Date	*DD/MM/YYYY*
DEV_TIME_0	**Initial Time of trip or charge**	Time	*HH:MM:SS*
DEV_DATE_F	**Final Date of trip or charge**	Date	*DD/MM/YYYY*
DEV_TIME_F	**Final Time of trip or charge**	Time	*HH:MM:SS*
DEV_EV_ID	**EV ID**	String	(see Table 3)
DEV_USR_ID	**User ID**	String	(see Table 3)
DEV_CP_ID	**Charging point ID**	String	(see Table 5)/ home/ other
DEV_V2G	**V2G**	String	yes/ no
DEV_Disch	**Energy Discharged to the grid**	Floating Number	*kWh/* *null*
DEV_Duration	**Charging duration**	Floating Number	*Minutes*
DEV_ChType	**Charge type**	String	fast charge/ slow charge/ battery swapping
DEV_ChEnergy	**Energy transferred**	Floating Number	*kWh*
DEV_DistSLC	**Distance since last charging**	Floating Number	*meters*
DEV_TimeSLC	**Time since last charging**	Floating Number	*seconds*
DEV_SOC_0	**State of charge before**	Floating point	*Number between 0 and 100 (%)*
DEV_SOC_F	**State of charge after**	Floating point	*Number between 0 and 100 (%)*
DEV_Dist	**Total Distance Travelled**	Integer	*metres*
DEV_Speed	**Mean Speed**	Floating point	*km/h*
DEV_Origin_lat	**Travel Origin latitude**	Floating point	*degrees*

DEV_Origin_lon	**Travel Origin longitude**	Floating point	*degrees*
DEV_Destination_lat	**Travel Destination latitude**	Floating point	*degrees*
DEV_Destination_lon	**Travel Destination longitude**	Floating point	*degrees*
DEV_Temp	**Outside Temperature**	Floating point	*ºC*
DEV_Light	**Vehicle Lights Use**	Floating point	*Number between 0 and 100 (%)*
DEV_Air	**Vehicle A/C Use**	Floating point	*Number between 0 and 100 (%)*
DEV_TrCons	**Trip energy consumption**	Floating point	*kWh*

Frequency of data collection: per trip or charge
Periodicity of data reporting: monthly

Variable specifications:

- **Type of event:** *kind of event to which the data registered corresponds:*
  - trip → *electric vehicle trip*.
  - charge → *charging process.*
- **Initial date/time:** *date and time in which the charging process or the trip starts.*
- **Final date/time:** *date and time in which the charging process or the trip finishes.*
- **Charging point ID:**
  - *For all the cases where the charging point is monitored by the Project. (see*
  - *Table* 5*).*
  - home → *In the case where charging events at home are monitored and the geographic coordinates should not be recorded (e.g. law restrictions) then the value "home" can be provided*.
  - other → *If the electric vehicle is charged at a charging point that doesn't belong to the Project then the value "other" can be provided*.
- **V2G:** *if the transfer of electricity from the vehicle to the grid is possible/permitted*
  - yes/no→ *charging process.*
- **Energy discharged to the grid:** *in a charging process with V2G enable, the quantity of energy discharged to the grid during the charging process.*
- **Charging duration:** *in a charging process, total time of the charging process, considering the start of the charging process when the energy starts to be injected into the car (for greater details see Figure 4).*
- **Charge type:** *the type of the charging process*
  - fast charge/slow charge/battery swapping
- **Energy transferred:** *in a charging process, total energy consumed from the grid during the charging process.*
- **Distance since last charging:** *in a charging process, total distance travelled since last charging process.*
- **Time since last charging:** *in a charging process, total time since last charging process.*
- **State of charge before:** *in a charging process or a trip, state of charge of the electric vehicle battery (% of battery capacity) before the charging process or the trip.*
- **State of charge after:** *in a charging process or a trip, state of charge of the electric vehicle battery (% of battery capacity) after the charging process or the trip.*
- **Total distance travelled:** *in a trip, total distance travelled during the trip.*
- **Mean speed:** *in a trip, average speed during the trip.*
- **Travel origin latitude:** *GPS latitude coordinates expressed in degrees (e.g. 41.414588)*
- **Travel origin longitude:** *GPS longitude coordinates expressed in degrees (e.g. 2.220395)*
- **Travel destination latitude:** *GPS latitude coordinates expressed in degrees (e.g. 41.414588)*
- **Travel destination longitude:** *GPS longitude coordinates expressed in degrees (e.g. 2.220395)*

- **Outside Temperature:** *in a trip, mean of the outside temperature. (This value can be either obtained by a sensor on a vehicle or externally by meteorological observatory.)*
- **Vehicle Lights Use:** *in a trip, % of the trip in which the lights are on.*
- **Vehicle A/C Use:** *in a trip, % of the trip in which the air conditioning is on.*
- **Trip consumption:** *in a trip, energy consumed from the battery during the trip.*

FILE:

Following, a JSON example file for the trip and charging events is presented. The file should contain as many records as the number of the trips and charges are monitored during the Project.


```
[
    {
        "DEV_TC": "ES",
        "DEV_Type": "charge",
        "DEV_DATE_0": "30/05/2011",
        "DEV_TIME_0": "11:21:05",
        "DEV_DATE_F": "30/05/2011",
        "DEV_TIME_F": "12:21:15",
        "DEV_USR_ID": "EMPRO_ES_USR1",
        "DEV_EV_ID": "EMPRO_ES_EV1",
        "DEV_CP_ID": "EMPRO_ES_CP1",
        "DEV_V2G": "no",
        "DEV_Disch": null,
        "DEV_Duration": 30,
        "DEV_ChType": "fast charge",
        "DEV_ChEnergy": 26,
        "DEV_DistSLC": 23000,
        "DEV_TimeSLC": 21600,
        "DEV_SOC_0": 10,
        "DEV_SOC_F": 100,
        "DEV_Dist": null,
        "DEV_Speed": null,
        "DEV_Origin_lat": 41.414588,
        "DEV_Origin_lon": 2.220395,
        "DEV_Destination_lat": 41.414588,
        "DEV_Destination_lon": 2.220395,
        "DEV_Temp": 18,
        "DEV_Light": 0,
        "DEV_Air": 0,
        "DEV_TrCons": null
    },
    {
        "DEV_TC": "ES",
        "DEV_Type": "trip",
        "DEV_DATE_0": "06/06/2011",
        "DEV_TIME_0": "20:21:05",
        "DEV_DATE_F": "06/06/2011",
        "DEV_USR_ID": "EMPRO_ES_USR1",
```

```
        "DEV_EV_ID": "EMPRO_ES_EV1",
        "DEV_CP_ID": "",
        "DEV_V2G": "no",
        "DEV_Disch": null,
        "DEV_Duration": null,
        "DEV_ChType": "",
        "DEV_ChEnergy": null,
        "DEV_DistSLC": 25000,
        "DEV_TimeSLC": 1600,
        "DEV_SOC_0": 100,
        "DEV_SOC_F": 75,
        "DEV_Dist": 25000,
        "DEV_Speed": 40,
        "DEV_Origin_lat": 41.414588,
        "DEV_Origin_lon": 2.220395,
        "DEV_Destination_lat": 41.533333,
        "DEV_Destination_lon": 2.45,
        "DEV_Temp": 18,
        "DEV_Light": 20,
        "DEV_Air": 15,
        "DEV_TrCons": 7
    }
]
```


Instructions for filling the EV dynamic data for aggregated trips

New registers are only added in two cases:

- at **the end of a trip**
- at **the end of a charge**

This means that in

Table 9, two different types of register are going to coexist. The field “Type of event” has to be filled with the word “trip” or “charge” depending on the condition that has motivated the addition of a new register. Figure 4 explains graphically those moments when the new registers have to be added in

Table 9.

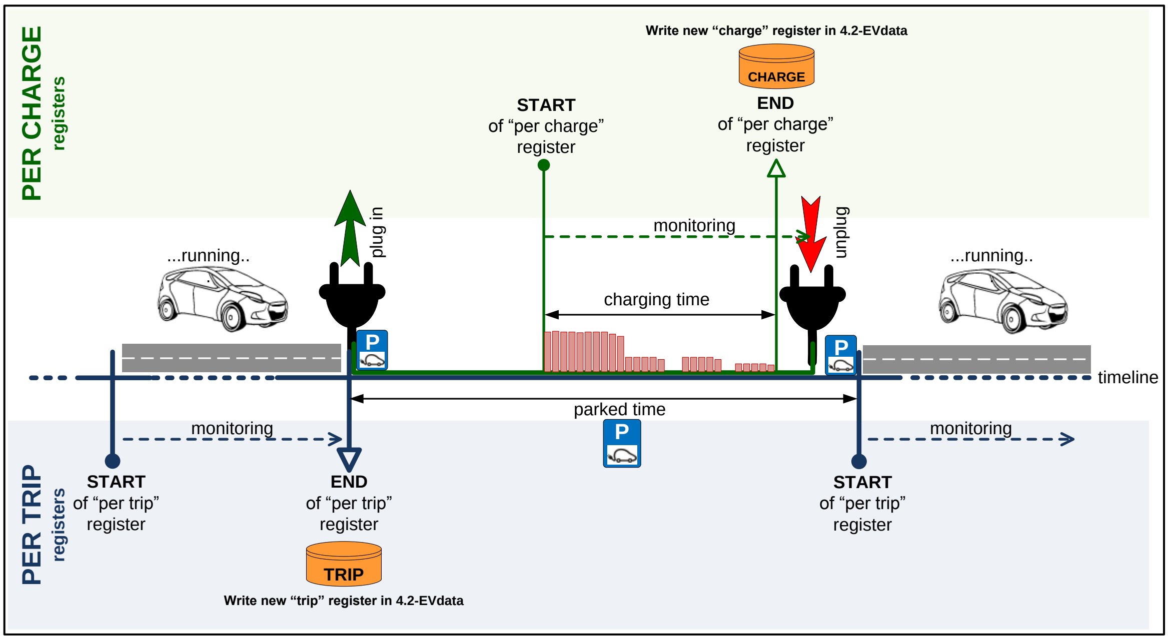

Figure 4: Logging the aggregated trip and charging events

Any method of logging is valid for acquiring and calculating the final values that have to be written in a new register. Any methodology that varies from the one prescribed in this document needs to be specified and explained.

On the other hand, some important considerations have to be taken into account to avoid differences in the way each Project obtains some parameters:

- The **beginning of a trip** is at the moment of starting the vehicle.
- The **end of a trip** is considered at the moment the car is switched off.
- The **beginning of a charging process** is the instant of time when the power flow goes from the grid to the battery, and it may be different from the moment in that the EV is connected to the charging spot.
- The **end of a charging process** is the instant of time when the power flux entering from the grid stops. This instant could be different from the moment in that the EV is unplugged from the charging spot.

Table 10: EXTRA DATA TO BE INCLUDED (per Electric vehicle and trip/plug-in/charging segment)

	Data name	Data type	List of values / Format
DEV_TC	**Territorial Code**	String	(see Table 2)
DEV_DATE	**Date of event**	Date	*DD/MM/YYYY*
DEV_TIME	**Time of event**	Hour	*HH:MM:SS*
DEV_EV_ID	**EV ID**	String	(see Table 3)
DEV_USR_ID	**User ID**	String	(see Table 3)
DEV_Status	**Vehicle status**	String	start of trip/ in motion/ end of trip/ plug-in/ unplug/ start of charge/ charging/ end of charge
DEV_Activity	**Activity**	String	home/ work/ shopping/ study/ leisure/ others
DEV_CP_ID	**Charging point ID**	String	(see Table 5)/ home/ other
DEV_ChEnergy	**Energy transferred**	Floating Number	*kWh*
DEV_DistSLR	**Distance since last register**	Integer	*metres*
DEV_TimeSLR	**Time since last register**	Integer	*seconds*
DEV_SOC	**State of Charge at logging time**	Integer	*Number between 0 and 100 (%)*
DEV_Speed	**Speed at logging time (km/h)**	Floating number	*km/h*
DEV_Direction	**Direction at logging time in degrees**	Floating number	*degrees*
DEV_Altitude	**Altitude in metres at logging time (m)**	Integer	*metres*
DEV_GPS_lat	**GPS latitude at logging time**	Floating point	*degrees*
DEV_GPS_lon	**GPS longitude at logging time**	Floating point	*degrees*
DEV_Slope	**Slope (%)**	Floating point	*Number (%)*
DEV_Temp	**Outside Temperature**	Floating point	*ºC*
DEV_Light	**Vehicle lights**	String	*on/ off*
DEV_Air	**Vehicle A/C**	String	*on/ off*

DEV_TrCons	**Energy consumption**	Floating point	*kWh*
DEV_FC	**Engine and Fuel data to calculate FC**	Floating point	*kg/s*

Suggested frequency of data collection: per trip/plug-in/charging segment
Suggested periodicity of data reporting: monthly

Variable specifications:

- **Date/Time of event:** *Date and time in which the event takes place.*
- **Vehicle status:** *Type of register*
    - start of trip → *the engine/motor of the vehicle starts to operate.*
    - in motion → *the engine/motor of the vehicle starts is operating*.
    - end of trip → *the engine/motor of the vehicle ends to operate*.
    - plug-in → *the vehicle is plugged-in to the grid*.
    - unplug → *the vehicle is unplugged form the grid*.
    - start of charge → *the charging process begins*.
    - charging → *the charging is in process*.
    - end of charge → *the charging process ends*.
- **Vehicle status:** *Activity trip type:*
    - home → *going home.*
    - work → *going to work*.
    - shopping → *going for shopping*.
    - study → *going to a place related with educational purpose*.
    - leisure → *going on a leisure activity*.
    - others → *none of the above*.
- **Charging point ID:** *In the case of plug-in or charging event*
    - *For all the cases where the charging point is monitored by the Project. (see*
    - *Table* 5*).*
    - home → *In the case where charging events at home are monitored and the geographic coordinates should not be recorded (e.g. law restrictions) then the value "home" can be provided*.
    - other → *If the electric vehicle is charged at a charging point that doesn't belong to the Project then the value "other" can be provided*.
- **Energy transferred:** *the energy transferred from the grid to the battery during a charging process since the last logging event in kWh.*
- **Distance since last register:** *distance travelled since last logging event in metres.*
- **Time since last register:** *time since last logging event in seconds.*
- **State of Charge at logging time:**
- **Speed at logging time:** *vehicle speed at logging time in km/h.*
- **Direction at logging time:** *direction of the vehicle in relation to the north cardinal point at logging time in degrees.*
- **Altitude at logging time:** *altitude position of the vehicle in relation to the sea level at logging time in m.*
- **GPS latitude at logging time:** *GPS latitude coordinates of the vehicle at logging time expressed in degrees (e.g. 41.414588)*
- **GPS longitude at logging time:** *GPS longitude coordinates of the vehicle at logging time expressed in degrees (e.g. 2.220395)*
- **Slope:** *Slope of the road at logging time in %.*
- **Outside Temperature:** *outside temperature at logging time in ºC.*
- **Vehicle lights:** *state of the vehicle's lights at logging time*
    - on/off
- **Vehicle A/C:** *state of the vehicle's air condition at logging time.*
    - on/off

- **Energy consumption:** *the energy consumed during a trip event from the battery since the last logging event in kWh.*
- **Engine and Fuel data to calculate FC:** *Suggested fuel consumption measurement in kg/s.*

  This involves engine intake air flow and excess air ratio detection by means of engine debimeter and λ sensor at engine tailpipe respectively. The calculation of the instantaneous fuel mass flow is as follows:

$$\lambda_i = \frac{A/F_i}{(A/F)_{st}} = \frac{\frac{\dot{m}_{a,i}}{\dot{m}_{b,i}}}{(A/F)_{st}} <=> \dot{m}_{b,i} = \frac{\dot{m}_{a,i}}{\lambda_i \cdot (A/F)_{st}}$$

Where:

$\dot{m}_{b,i}$ *is the instantaneous fuel flow rate, kg/s.*

$\dot{m}_{a,i}$ *is the instantaneous intake air mass flow rate, kg/s.* [5]

A/Fst *is the stoichiometric air to fuel ratio (fuel dependent), kg/kg.*[6]

λ_i *is the instantaneous excess air ratio.* [5]

Air flow meter and analyzers as well the total system shall meet the linearity requirements of prescribed by the legislator. If an air to fuel ratio measurement instrument such as a zirconia type sensor is used for the measurement of the excess air ratio, it shall meet the specifications prescribed by the legislator as well.

FILE:

Following, a JSON example file for the trip, plugging and charging segments is presented. The file should contain as many records as the segments of the trips, plugging events and charges are monitored during the Project.


```
[
    {
        "DEV_TC": "ES",
        "DEV_DATE": "30/05/2011",
        "DEV_TIME": "09:21:05",
        "DEV_EV_ID": "EMPRO_ES_EV1",
        "DEV_USR_ID": "EMPRO_ES_USR1",
        "DEV_Status": "charge",
        "DEV_Activity": "work",
        "DEV_CP_ID": "EMPRO_ES_CP1",
        "DEV_ChEnergy": 0.5,
        "DEV_DistSLR": 0,
        "DEV_TimeSLR": 60,
        "DEV_SOC": 50,
        "DEV_Speed": 0,
        "DEV_Direction": 0,
        "DEV_Altitude": null,
        "DEV_GPS_lat": 41.414588,
        "DEV_GPS_lon": 2.220395,
```


[5] It can be measured with On-Board Diagnostics or an Engine Control Unit

[6] It is fuel dependent and can be found on national data

```
        "DEV_Slope": null,
        "DEV_Temp": 18,
        "DEV_Light": "off",
        "DEV_Air": "off",
        "DEV_TrCons": null,
        "DEV_FC": null
    },
    {
        "DEV_TC": "ES",
        "DEV_DATE": "30/05/2011",
        "DEV_TIME": "19:21:05",
        "DEV_EV_ID": "EMPRO_ES_EV1",
        "DEV_USR_ID": "EMPRO_ES_USR1",
        "DEV_Status": "in motion",
        "DEV_Activity": "home",
        "DEV_CP_ID": "EMPRO_ES_CP1",
        "DEV_ChEnergy": null,
        "DEV_DistSLR": 500,
        "DEV_TimeSLR": 10,
        "DEV_SOC": 45,
        "DEV_Speed": 30,
        "DEV_Direction": 20,
        "DEV_Altitude": 0,
        "DEV_GPS_lat": 41.414588,
        "DEV_GPS_lon": 2.220395,
        "DEV_Slope": 2,
        "DEV_Temp": 18,
        "DEV_Light": "on",
        "DEV_Air": "off",
        "DEV_TrCons": 1,
        "DEV_FC": 0.012
    }
]
```


New registers should be added every time the State of Charge of the battery changes (either reduced due to vehicle usage or increased due to charging/regeneration) by **1%** and at least every **2 km** or **300 seconds**, but a more frequent logging (e.g. 1 sec) is preferred. Depending on the status (start of trip, in motion, end of trip, plug-in, unplug, start of charge, charging, end of charge) of the vehicle the relevant data should be recorded. Figure 5 explains graphically those moments when the new registers have to be added in**Error! Reference source not found.**.

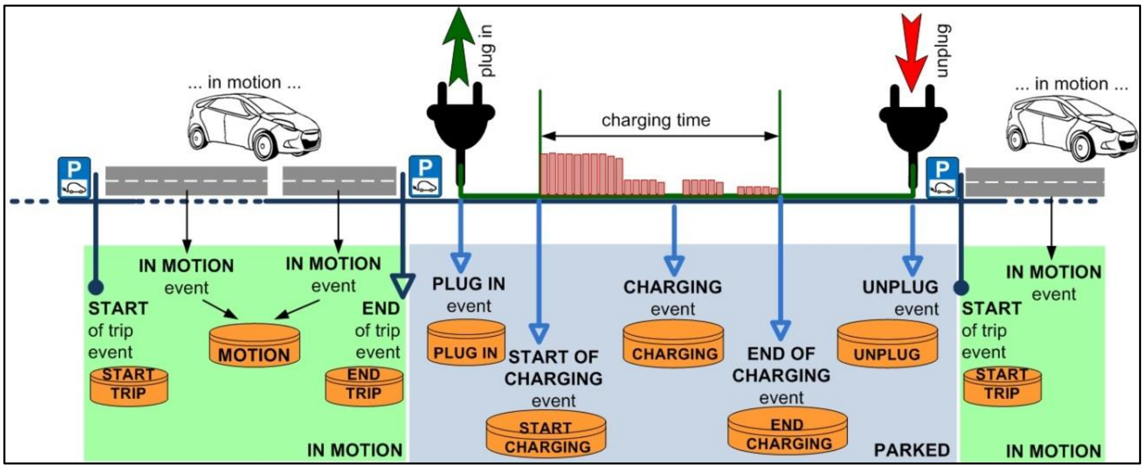

Figure 5: Logging the instantaneous trip, plugging and charging events

Important Notes

- If a charger cannot detect the plug-in and unplug events, then only the start of charge and end of charge times will be recorded.
- If at some point there is no GPS signal (e.g. vehicle is into a tunnel, charging event is taking place in an underground parking) then the last available GPS coordinates should be taken into account.

6. DATA FROM USERS

6.1. User: static data

DOCUMENT TYPE: Static table of contents

Table 11: MINIMUM DATA TO BE INCLUDED (per user)

Code	Data name	Data type	List of values / Format
USR_TC	**Territorial Code**	String	(see Table 2)
USR_ID	**User ID**	String	(see Table 3)
USR_DATE_0	**Enlist date**	Date	*DD/MM/YYYY*
USR_DATE_F	**Leave date**	Date	*DD/MM/YYYY*
USR_Type	**Type of user**	String	owner/ fleet/ rent
USR_Gender	**Gender of user**	String	male/female
USR_Age	**User's year of birth**	Integer	YYYY
USR_Usage_for_Work	**Percentage of usage of the vehicle for work**	Integer	value from 0 to 100 (%)
USR_Usage_for_Leisure	**Percentage of usage of the vehicle for leisure**	Integer	value from 0 to 100 (%)
USR_Usage_for_Public_Service	**Percentage of usage of the vehicle for public service**	Integer	value from 0 to 100 (%)

Frequency of data collection: on change
Periodicity of data reporting: on change

Variable specifications:

- **Enlist/Leave date:** *date in which the user joined or left the Project.*
- **Type of user:** *type of users identified with this ID:*
    - owner → *private person who owns the vehicle.*
    - fleet → *set of people belonging to a fleet who will use alternately the vehicle.*
    - rent → *set of people who have rented a specific vehicle.*
- **Gender of user:** *for statistical purposes*
    - male/female
- **User's year of birth:** *for statistical purposes*
- **Percentage of usage of the vehicle for work/leisure/public service:** *Identification of the vehicle's use purpose based on average values. The project coordinator can enter these values every time a user is enlisted into the project. These values are considered a general approach but they can identify vehicles that are used for example:*

- *exclusively for work purpose e.g. Municipality vehicles (Usage_for_Public_Service= 100%)*
- *or private users that they use it as their main car: Work = 70%, Leisure = 30%*
- *or cars used from companies and are not allowed for personal use: Work = 100%*

FILE:

Following, a JSON example file for the users is presented. The file should contain as many records as the users participating in the Project.


```
[
    {
        "USR_TC": "ES",
        "USR_ID": "EMPRO_ES_USR1",
        "USR_DATE_0": "30/05/2011",
        "USR_DATE_F": "30/05/2014",
        "USR_Type": "owner",
        "USR_Gender: "female",
        "USR_Age": 1975,
        "DEV_Usage_for_Work": 60,
        "DEV_Usage_for_Leisure": 40,
        "DEV_Usage_for_Public_Service": 0
    },
    {
        "USR_TC": "ES",
        "USR_ID": "EMPRO_ES_USR2",
        "USR_DATE_0": "01/06/2012",
        "USR_DATE_F": "01/06/2014",
        "USR_Type": "fleet",
        "USR_Gender: "male",
        "USR_Age": 1969,
        "DEV_Usage_for_Work": 0,
        "DEV_Usage_for_Leisure": 0,
        "DEV_Usage_for_Public_Service": 100
    }
]
```


Comments and recommendations

The purpose of this table is to identify every single user that participates in the data collection process for statistical analysis of drivers' behavior and patterns. In the case of a shared vehicle (e.g. within a family), a separate user register should be added for each one that uses the vehicle.

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