Grant number: 769016
Project duration: Sept 2018 - Feb 2022
Project Coordinator: Jacqueline floch, SINTEF

HORIZON 2020: Mobility for Growth
MG-4.2-2017
Supporting Smart Electric Mobility in Cities
Project Type: Innovation Action

greencharge2020.eu

GreenCharge Project Deliverable: D5.6

Open Research Data

Authors:

Marit Kjøsnes Natvig, SINTEF

Shanshan Jiang, SINTEF

Svein Hallsteinsen, SINTEF

Regina Enrich Sard, EURECAT

Andi Dittrich, PMC

www.civitas.eu

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016

About GreenCharge

GreenCharge takes us a few important steps closer to achieving one of the dreams of modern cities: a zero-emission transport system based on electric vehicles running on green energy, with traffic jams and parking problems becoming things of the past. The project promotes:

Power to the people!	The GreenCharge dream can only be achieved if people feel confident that they can access charging infrastructure as and when they need it. So GreenCharge is developing a smart charging system that lets people book charging in advance, so that they can easily access the power they need.
The delicate balance of power	If lots of people try to charge their vehicles around the same time (e.g. on returning home from work), public electricity suppliers may struggle to cope with the peaks in demand. So we are developing software for automatic energy management in local areas to balance demand with available supplies. This balancing act combines public supplies and locally produced reusable energy, using local storage as a buffer and staggering the times at which vehicles get charged.
Getting the financial incentives right	Electric motors may make the wheels go round, but money makes the world go round. So we are devising and testing business models that encourage use of electric vehicles and sharing of energy resources, allowing all those involved to cooperate in an economically viable way.
Showing how it works in practice	GreenCharge is testing all of these innovations in practical trials in Barcelona, Bremen and Oslo. Together, these trials cover a wide variety of factors: *vehicle type* (scooters, cars, buses), *ownership model* (private, shared individual use, public transport), *charging locations* (private residences, workplaces, public spaces, transport hubs), energy *management* (using solar power, load balancing at one charging station or within a neighbourhood, battery swapping), and *charging support* (booking, priority charging).

To help cities and municipalities make the transition to zero emission/sustainable mobility, the project is producing three main sets of results: (1) *innovative business models*; (2) *technological support;* and (3) *guidelines* for cost efficient and successful deployment and operation of charging infrastructure for Electric Vehicles (EVs).

The *innovative business models* are inspired by ideas from the sharing economy, meaning they will show how to use and share the excess capacity of private renewable energy sources (RES), private charging facilities and the batteries of parked EVs in ways that benefit all involved, financially and otherwise.

The *technological support* will coordinate the power demand of charging with other local demand and local RES, leveraging load flexibility and storage capacity of local stationary batteries and parked EVs. It will also provide user friendly charge planning, booking and billing services for EV users. This will reduce the need for grid investments, address range/charge anxiety and enable sharing of already existing charging facilities for EV fleets.

The guidelines will integrate the experience from the trials and simulations and provide advice on localisation of charging points, grid investment reductions, and policy and public communication measures for accelerating uptake of electromobility.

For more information

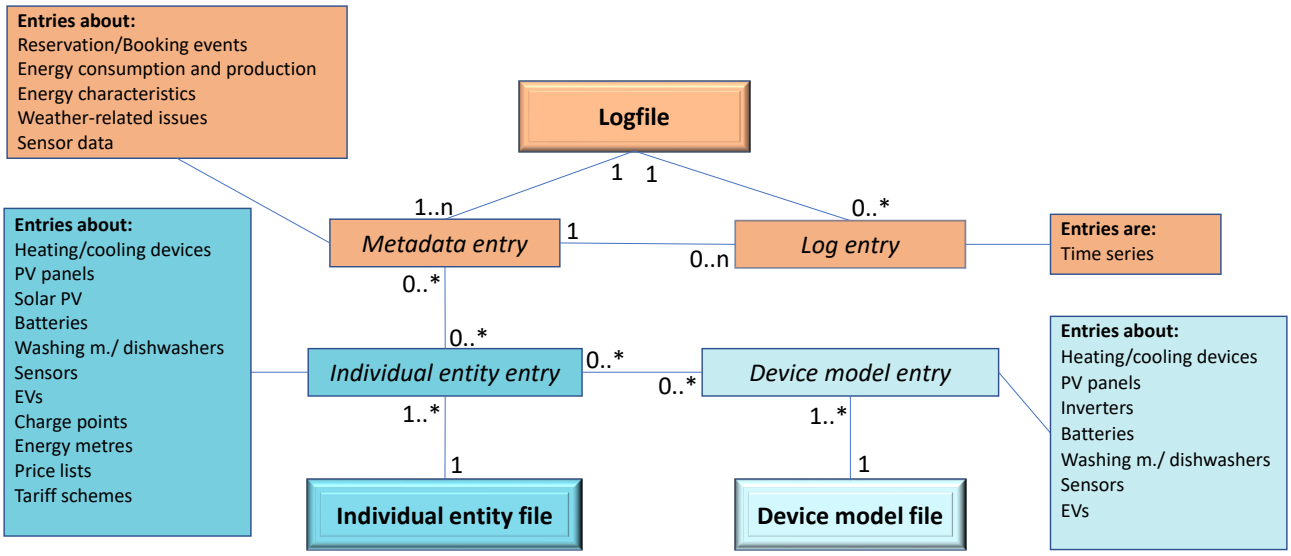
Project Coordinator: Jacqueline Floch, jacqueline.floch@sintef.no

Dissemination Manager: Reinhard Scholten, reinhard.scholten@egen.green

Executive Summary

This deliverable provides detailed specifications of the research data on activities registered in the demonstrators in GreenCharge.

The research data are published as open research data in the open research data repository Zenodo (https://zenodo.org/). The datasets are uploaded to the H2020 GreenCharge community and the European Commision Funded Research (OpenAIRE) community.



The demonstrators and their activities are described by three types of files and four types of data entries as illustrated in the figure above:

- *Device model files* with *Device model entries*. The entries define the generic characteristics of brands and models of devices/hardware entities (e.g., by means of characteristics collected from data sheets).
- *Individual entity files* with *Individual entity entries*. The entries describe actual device entities involved in the demonstrators and refer to the relevant Device model entries.
- *Logfiles* with *Metadata entries* and *Log entries*. The Metadata entries provide overall data about the events/activities/issues that are logged and refer to the Individual entry entities involved. A Metadata entry may be followed by one or more Log entries. These provide time series showing for example the energy use of the Individual entity entities referred to by the associated Metadata entry.

The figure also shows what the entries are about.

The data structures of the entries are adapted to the type of content, as illustrated by the following examples:

- A Device model entry describing an electric vehicle (EV) model will provide the EV brand name and characteristics, among others the battery capacity.
- An Individual entity entry of an individual EV will link to the device model entry where the characteristics of the EV model are defined.
- A Metadata entry for a charging session will link to the individual EV entity of the electric vehicle being charged and the individual charge point entity of the charge point where the EV is charged. Data about the charging session such as plug in and plug out time, power used, battery energy content at start and end, etc. will also be provided.
- Log entries following the Metadata entry will describe the charging profile of the EV for the charging session (i.e., time series with energy amounts charged).

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Table of Contents

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Table of Figures

List of Tables

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

List of Abbreviations

Table 0-1: List of abbreviations

Abbreviation	Explanation
AC	Alternating Current.
AET	Actual end time.
AST	Actual start time.
CHAdeMO	CHArge de Move. Trade name of charging method.
CP	Charge point.
CCS	Combined Charging System. An electric vehicle charging standard.
CSV	Comma Separated Values. The file format used to provide the data.
DC	Direct Current.
DSO	Distribution System Operator.
EST	Earliest start time.
EV	Electric vehicle.
GDPR	General data protection regulation.
HC	Heating/Cooling
ID	Identifier.
kW	Kilo Watt
kWh	Kilo Watt per hour
kWp	Kilo Watt peak
LFT	Latest finish time.
Noct	Nominal operating cell temperature.
PV	Photovoltaics, also called solar cells.
RES	Renewable energy source.
SoC	State of charge. The state of the battery.
UFT-8	8 -bit Unicode Transformation Format.
UTC	Coordinated Universal Time
UUID	Universally Unique Identifier.
V2G	Vehicle-to-grid.
VAT	Value added tax.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

1 About this Deliverable

The GreenCharge D5.6 Open Research Data deliverable consists of

- Open research data published in the open research data repository Zenodo[1] (https://zenodo.org/)
- This document, which provides a specification of the data.

The research data from interviews and questionnaires are not published as open research data since they may contain personal data. Thus, these data are not further addressed in this deliverable. Data on business aspects (prices and tariffs) are also withdrawn from publications since they are considered to be business sensitive data.

1.1 Why would I want to read this deliverable?

The GreenCharge project has collected research data from the GreenCharge demonstrators. Anonymous parts of these data are published as open research data. This document provides a specification of the open research data to arrange for its re-use. In addition, the data specifications may also be re-used in other projects that will collect research data related to green and smart charging.

1.2 Intended readership/users

Researchers and others aiming for smart and green mobility combined with local energy management can use the specifications provided in this document to

- **Understand the open research data published** by the GreenCharge project. Such an understanding is for example required if the data is to be re-used in analysis and simulations of how the charging of electric vehicle can affect the use of energy, and of how solutions for local energy management can contribute to more sustainable use of energy when eMobility is adopted.
- **Collect more research data** related to smart charging and local energy management. The specifications provided can be used in decisions on what data to collect and in the formatting of the data.

The specifications provided are quite technical, and the data are provided as digital data structures. Thus, technical skills are required to understand much of the content of this deliverable.

1.3 Structure

Chapter 2 provides an overview the data types and files provided.

Chapter 3 describes the configuration of the demonstrators that have provided data.

Chapter 4 provides a detailed specification of the data structures used to provide the data.

Chapter 5 is the conclusion and provides information on where the open research data can be accessed.

Annex A provides examples of data structures for price models and tariffs.

1.4 Other project deliverables that may be of interest

The content presented in this document is based on **inputs from the following deliverables**:

1. Deliverables providing input on how the research data is to be established and managed:
   - D1.1 – Data Management Plan: This deliverable is the plan for the data management, and for the publication of open research data.
   - D9.1 – POPD – Requirement No. 1: This deliverable provides guidelines on how to fulfil the GDPR requirements, i.e., responsibilities and strategies on how data should be collected, managed, and anonymised to facilitate the publication of open research data.
2. Deliverables providing input on which research data to collect and how to collect the data:

[1] https://zenodo.org/

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- D2.2 – Revised Strategic Plan for Pilots: This deliverable describes the GreenCharge pilots and the basis for decisions on which data to collect from each pilot.
- D3.4 – Final Business Model Designs. This deliverable describes the business models demonstrated by the pilots and have influenced the data on price models and costs.

The content presented in this document provide **inputs to the following deliverables (s**ince the due date is at the end of the project, this is organised through the sharing of internal documents providing specification of the research data):

3. Deliverables collecting or generating the research data
   - D4.5 – Final Version of Integrated Prototype. This deliverable describes the software running at the pilot sites doing automated collection of research data.
4. Deliverables using the research data
   - D5.3 – Simulation and Visualisation Tools. This deliverable describes the simulator that uses research data from the demonstrators as input to simulations.
   - D5.5/D6.4: Final Result for Innovation Effects Evaluation / Stakeholder Acceptance Evaluation and Recommendations. This is a combined deliverable providing the final evaluation results from the GreenCharge.
5. Deliverable using the data specifications
   - D4.2 Final Architecture for design and Interoperability Specification. The specification of the open research data is used as an input to an information model supporting the information exchange in smart and green charging solutions.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

2 Data files and entry types

The open research data published from GreenCharge originate from demonstrators. This is

- Data on the configurations of the demonstrators, i.e., data on hardware like devices and equipment, and other static/semi-static elements like location, price models and tariffs.
- Logs describing dynamic events/activities/issues in the demonstrators like energy production, use, and storage; weather issues; energy characteristics; and charging events.

This section describes the file and entry types used to represent these data.

2.1 Data files

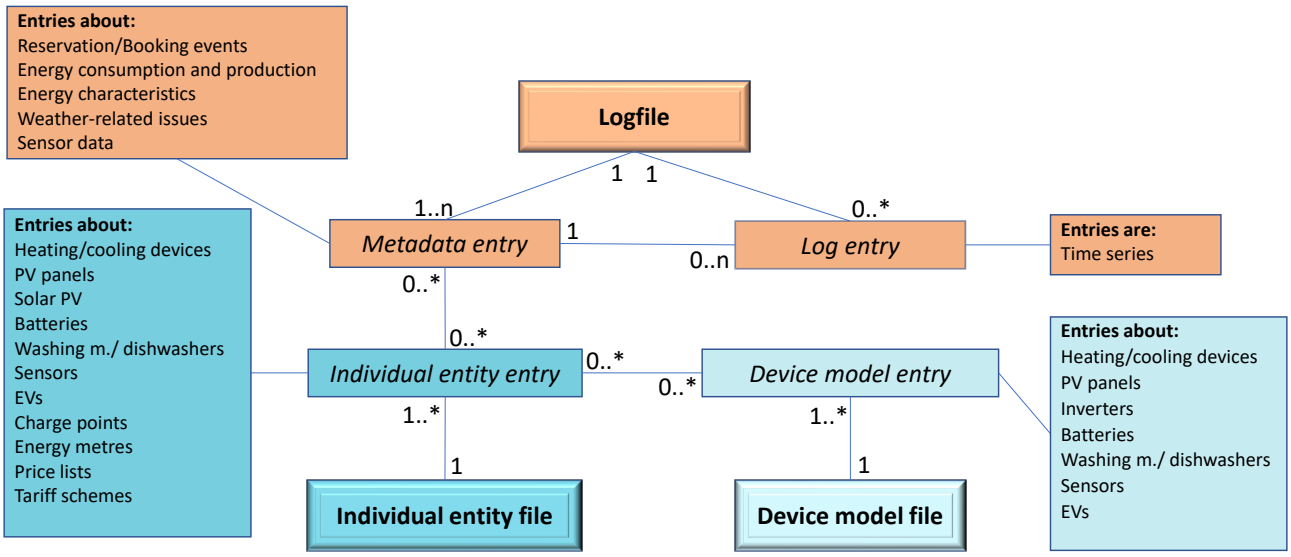


Figure 2-1 Files and data entries

Figure 2-1 shows the file types providing the data, the types of entries in these files, and what the entries are about. The figure also illustrates that one entry may refer to other entries. Metadata entries may for example refer to individual entity entries.

The files and entry types are as follows:

1. **Device model files** contain
    - One or more **Device model entries** defining the generic characteristics of brands and models of devices/hardware entities (e.g., by means of characteristics collected from data sheets). A device model entry provide data on the characteristics of all Individual entity entries of the same brand and model.
2. **Individual entity files** contain
    - One or more **Individual entity entries** describing actual device entities involved in a demonstrator. Each Individual entity entry has a unique identifier, and if relevant, it is described through a reference to associated Device model entities and/or by additional data elements.
3. **Logfiles** contain one or more (depending on the number of sessions) sequences of
    - One or more **Metadata entry** providing overall data about the events/activities/issues that are logged. It may refer to Individual entry entities (i.e., individual systems/devices and price models) through use of unique identifiers. The metadata entry may be followed by one or more Log entries.
    - Zero or more **Log entries** providing time series showing for example the energy use of the Individual entity entities referred to by the associated Metadata entry.

provides an overview of the entity types addressed in Device model and Individual entity files and in different types of Logfiles (also listed in Figure 2-1).

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- Column 1 lists the individual entity types addressed.
- The next two columns indicate the existence of associated entries in Device model and Individual entity files. If there are x-es in both columns, the Individual entity entry will refer to the Device models entry of relevance.
- The last five columns indicate the existence of associated entries in Logfiles. The Logfiles are divided into five sub-groups.

Table 2-1 Entity types addressed by different file entries

Entity types	Entries in Device Model Files	Entries in Individual entity files	Entries in Logfiles - Overall types of logfiles				
			Booking/ Reservation	Energy consumption & production	Energy characteristics	Weather data	Sensor data
Location		x	x	x	x	x	
Heating/cooling devices	x	x		x			
PV panels	x	x		x			
Solar plants				x			
Inverters	x			x			
Batteries	x	x		x			
Washing m./ dishwashers	x	x		x			
Sensors	x	x					x
EVs	x	x	x	x			
Charge points		x	x	x			
Energy metres		x			x		
Price models		x	x	x			
Tariffs		x	x	x	x		

2.2 File formats and encoding rules

All files are of type CSV.

The CSV files contain data according to the data structures defined in Chapter 4. The following rules are applied:

- The delimiter between the data elements is ";"
- File encoding is UFT-8
- Escaping strings (enforced) are double quotes. Escape strings surround text containing whitespace and/or semicolons or text that for other reasons is to be considered as one element.
- If a value cannot be provided to an optional element, the value is empty (;;)
- If a value to a mandatory element is not relevant or unknown, it is set to “NULL"
- "." is used as a decimal sign.
- For details on the coding of the data elements, see details in 2.3 and 2.3.3 (on coding when cardinality is 0..n or 1..n, coding of composite elements, etc.).
- Date/times are provided as UTC with format yyyymmddThhmmss

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

2.3 Data content

2.3.1 Data anonymisation

The open research data published is anonymous. Before publishing, all data that can be linked back to a person are removed or replaced. Identifiers like EV registration numbers and charge point identifiers are replaced by anonymous identifiers, preferably an UUID.

2.3.2 Data entries in Device model files and Individual entity files

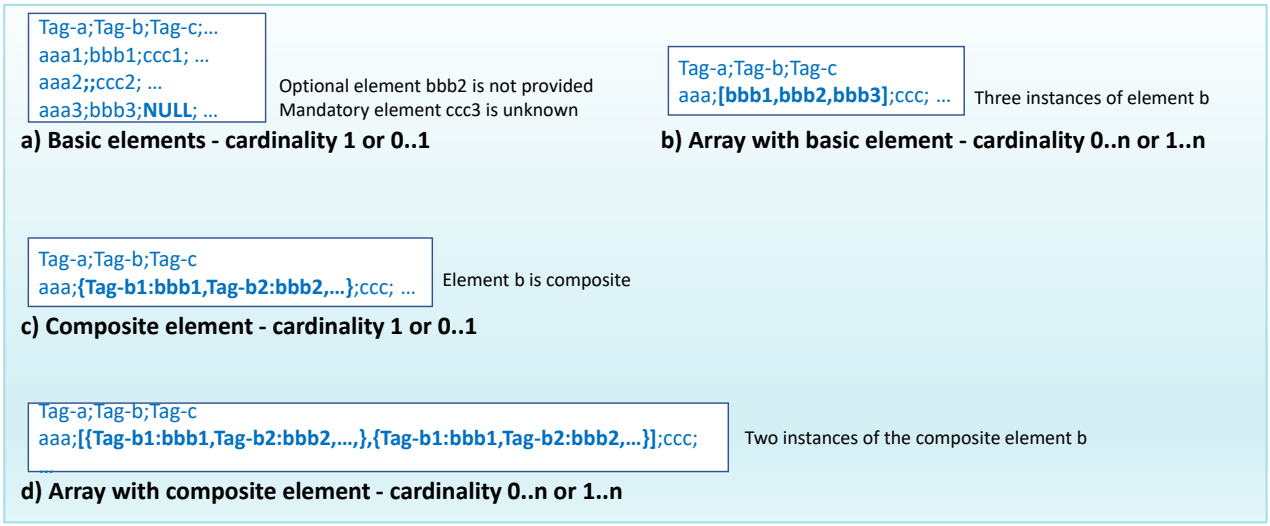


Figure 2-2 Data content in Device model files and Individual entity files

Device model files and Individual entity files may have a content as illustrated in Figure . The coding varies depending on the cardinality of the elements (how many instances that are allowed) and on whether a data element is of a basic type (just one value) or composite (consists of several sub-elements with values).

If the elements are of basic types, the structure is as depicted in Figure a):

- One line with Tags identifying the data elements in the data file - to improve the readability of the data.
- One or more lines with the values of the associated data elements

There may be several instances of a basic element (cardinality 0..n or 1..n). In such cases the structure is depicted in Figure b):

- One line with Tags identifying the data elements in the data file - to improve the readability of the data.
- One or more lines with the values of the associated data elements.
- Arrays (i.e., several instances of the same element) are wrapped in square brackets and the values are separated by commas: [value-1,value-2,…,value-n]. This coding is according to the JSON standards.

Composite elements with max one instance (cardinality 0..1 or 1) have the structure depicted in Figure c):

- One line with Tags identifying the data elements in the data file - to improve the readability of the data.
- One or more lines with the values of the associated data elements.
- Composite elements are wrapped by curly brackets, and each element of the composite element is represented by the tag and the value, separated by a colon. Tags and values for the different elements are separated by commas: {Tag1:value-1,Tag2:value-2,…, Tag-n:value-n}

Composite elements with more than one instance (cardinality 0..n or 1..n) have the structure depicted in Figure d):

- One line with Tags identifying the data elements in the data file - to improve the readability of the data.
- One or more lines with the values of the associated data elements.
- Arrays with composite elements are wrapped within square brackets. Each instance of the composite elements is wrapped by curly brackets, and separated by commas: [{Tag1:value-1.1, Tag2:value-2.1, …, Tag-n:value-n.1},{Tag1:value-1.2, Tag2:value-2.2,…,Tag-n:value-n.2,…}]

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

For all the cases described above, the encoding rules provided in 2.2 must be applied.

Details on tags and data elements for the Device model files are defined in tables in section 4.1. Details on tags and data elements for the Individual entity files are provided in section 4.2.

2.3.3 Data entries in Logfiles

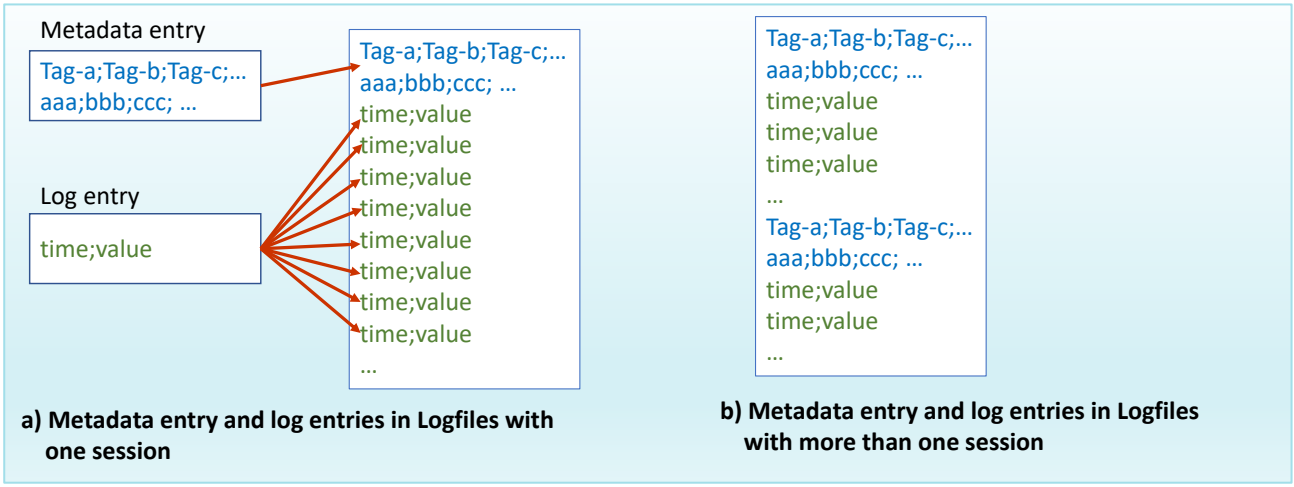


Figure 2-3 Data content in Logfiles

Logfiles may have two types of entries, as illustrated in Figure 2-3. Details on tags and data elements are provided in section 4.3.

Metadata entries contain

- One line with tags (with a delimiter in between) identifying the data elements in the data files. These tags are included to improve the readability of the data.
- One line with the values (with a delimiter in between) of the associated data elements. They provide overall information about the log and the conditions of relevance. If the cardinality allows more than one instance of a data element, the same coding rules applies as described in section 2.3.2.

Log entries contain

- Timeseries, i.e., one or more lines with a timestamp and a value. The time series may represent one of the following types of data:
  - Accumulated energy production/consumption
  - Varying price information
  - Weather data

All logfiles contain metadata. Some logfiles may have no log entries. This is described as a part of the detailed description of the data elements in section 4.3.

A logfile may contain metadata and log entries for one or more sessions:

- For continuous operations, e.g., the charging and discharging of stationary batteries, there is just one section (as in Figure 2-3a).
- For operations that are limited in time, e.g., EV charging sessions, there may be a new metadata entry followed by log entries for each charging session (as in Figure 2-3a).
- If the conditions described by the metadata change, there will also be a new section (as in Figure 2-3b), e.g., if the set point for heating/cooling devices changes.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

2.4 Filenames

Filenames for device model files and individual entity files

The filenames of device model and individual entity files will follow a naming convention:

<filetype>-<demo>-<timestamp>-<type>

The file name elements are as follows

- <filetype> is
  - *MODEL* for device model files
  - *INDIVIDUAL* for individual entity files
- <demo> is *<demo id>* - See Table 3-1 Demo and location with identifiers in section 3.1.
- <timestamp> is *<the time when the file was created>* (format is yyyymmddThhmmss)
- <type> is
  - LOC for location
  - HC for Heating/cooling devices
  - PV for PV panels and solar plants
  - WASH for washing machines/dishwashers
  - BAT for batteries
  - INV for inverters
  - SEN for sensors
  - CP for charge points
  - METRE for energy metres
  - PRICE for price models
  - TARIFF for tariff
  - EV for EV models and EVs

Filenames for Logfiles

The filenames of the logfiles will follow a naming convention:

<filetype>-<demo>-<location>-<timestamp>-<logtype>-<what is logged>

The file name elements are as follows

- <filetype> is *LOG*
- <demo> is *<demo id>* - See Table 3-1 Demo and location with identifiers in section 3.1.
- <location> is
  - ALL if the data for the whole demo (common to all locations)
  - <location id> - See Table 3-1 Demo and location with identifiers in section 3.1.
- <timestamp> is *<the start of the data collection period>* (format is yyyymmddThhmmss)
- <logtype> is
  - BOOKING for booking files
  - ENERGY for files on energy consumption and production
  - ENCHAR for files on energy characteristics
  - MET for files on methodological issues
- < what is logged> defines the scope of log. Values are
  - If <logtype> is BOOKING:
    - *CP-*<CP-id> *or no CP-id if no CP is assigned*
  - If <logtype> is ENERGY:
    - *CHARGE-*<CP-id> *for data on charging/discharging sessions*
    - *HC-<device id > for data on energy use on heating/cooling*

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- *WASH-<device id > for data on energy use on washing machines and dishwashers*
- *PV-<device id > for data on solar plants*
- *BAT-<device id > for data on stationary batteries*

- If <logtype> is ENCHAR:
  - *IMP-EXP-<metre id> for energy import/export*
  - *PG-COST for data on energy costs in public grid*
  - *PG-MIX for data on energy mix in public grid*
- If <logtype> is MET:
  - *PREDICTION-TMP for temperature predictions*
  - *PREDICTION-INS for insolation predictions*
  - *PREDICTION-WND for wind predictions*
  - *PRE*DICTION-PRE *for precipitation predictions*
  - *MEASUREMENT-TMP for temperature measurements*
  - *MEASUREMENT-INS for insolation measurements*
  - *MEASUREMENT-WND for wind measurements*
  - *MEASUREMENT-PRE for precipitation measurements*
- If <logtype> is SEN:
  - *MEASUREMENT-TMP-<sensor id> for temperature measurements*

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3 What is the data about?

This section provides an overview of the data published as open research data. As described in the introduction of Chapter 2, this is

- Data on the demonstrator setups (configurations or context), i.e., data on hardware devices.
- Logs describing dynamic events/activities/issues in the demonstrators like energy production, use, and storage; weather issues; energy characteristics; and charging events.

Note: Some datasets covered by the specifications in Chapter 4 are not published as open research data. We have anyway included the specifications to arrange for re-use of the data structures. The datasets not published are:

- Data collected but not considered to be complete and with a sufficient quality are not published.
- Data on washing sessions are not published since no such data are collected.
- Data considered as business sensitive data are not published. These are the data on price models and tariffs.
- Data on predicted weather conditions are not published since they are artificial data generated by a system.

3.1 Demonstrator setup

This section describes the setup of the demonstrators and provides an overview if the data provided from each demonstrator.

One pilot site (P) may have one or more demonstrators (D), and the demonstrators may have one or more locations (L). The demonstrators at the pilot sites and the associated location have identifiers. These are listed in Table .

Table 3-1 Demo and location with identifiers

Pilot	Pilot P1		Pilot P2		Pilot P3	
Demo id	• P1D1	• P1D3	• P2D1	• P3D1	• P3D2	• P3D3
Location id	• P1D1L1	• P1D3L1 • … • P1D3L9	• P2D1L1 • P2D1L3	• P3D1L1	• P3D2L1 • P3D1L2	• P3D3L1

Demonstrators will include a set of individual entities (that may have associated device models). Table 3-2 lists the individual entities of each type for each demonstrator. The datasets providing the related data are also referred.

Table 3-2 The number of individual entities

Device types	Datasets providing data	# at demo sites					
		P1D1	P1D3	P2D1	P3D1	P3D2	P3D3
Charge points	• Individual Charge points – see 4.2.8	30		5	1	3	5
EVs	• EV models – see 4.1.7 • EVs – see 4.2.5	23 44		10	6	2	5
Stationary batteries	• Battery model – see 4.1.4 • Inverter models – see 4.1.5 • Stationary battery - 4.2.6	1					1
RES	• PV panel models – see 4.1.2 • Inverter models – see 4.1.5 • Individual Solar plants – see 4.2.3	1		2		1	1
Heating/ cooling devices	• Heating/Cooling device models – see 4.1.1 • Individual Heating/Cooling devices – see 4.2.2	1	4 61			1	
Energy metres	• Individual Energy metres – see 4.2.9	1	15	2	1	2	1
Sensors	• Sensor models – see 4.1.6 • Individual Sensors – see 4.2.7		38			3	5

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3.2 Demonstrator events/activities/issues

With the setups described above, the demonstrators have collected research data on event, activities and other issues as identified in Table .

Some numbers are followed by

- "S" when the number is the number of sessions
- "D" when the number is the number of days covered by the data
- "M" when the number is the number of months covered by the data

Table 3-3 The amount of data on dynamic events, activities, and issues

Functionality demonstrated	Datasets collected	P1D1	P1D3	P2D1	P3D1	P3D2	P3D3
Booking/reservation of charge point/ energy	Reservation/booking events: See 4.3.2	1386		209			
Charging/discharging sessions	Metadata on EV charging/discharging sessions + log entries: See 4.3.3.1 and 4.3.1	4999 S		206 S	399 S	20 S	5 S
Energy production from local RES	Metadata on solar plant sessions + log entries: See 4.3.3.4 and 4.3.1	26 M		25 M		380 D	
Use of stationary energy storage	Metadata on battery sessions + log entries: See 4.3.3.5 and 4.3.1	4 M					
Heating/cooling device sessions	Metadata on heating/cooling sessions + log entries: See 4.3.3.2 and 4.3.1		11 M[4]			210 S	
Washing machines/ Dishwasher sessions	Metadata on Washing machines/ Dishwasher sessions + log entries: See 4.3.3.3 and 4.3.1						
Energy characteristics	Metadata on energy import and export + log entries: See 4.3.4.1 and 4.3.1	25 M	11 M	29 M	7 M	290 D	
	Average grid mix in public grid: See 4.3.4.2	1 file[2]		36 M		290 D	
	Energy cost public grid + log entries: See 4.3.4.3 and 4.3.1	25 M				290 D	
Weather conditions	Metadata on measured weather data + log entries: See 4.3.5.2 and 4.3.1	26 M					
Sensor data	Metadata on sensors + log entries: See 4.3.6 and 4.3.1		11 M			290 D	

[2] In Norway the grid mix is almost constant due to the high degree of hydro power. Thus, just one file is needed.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4 Data content

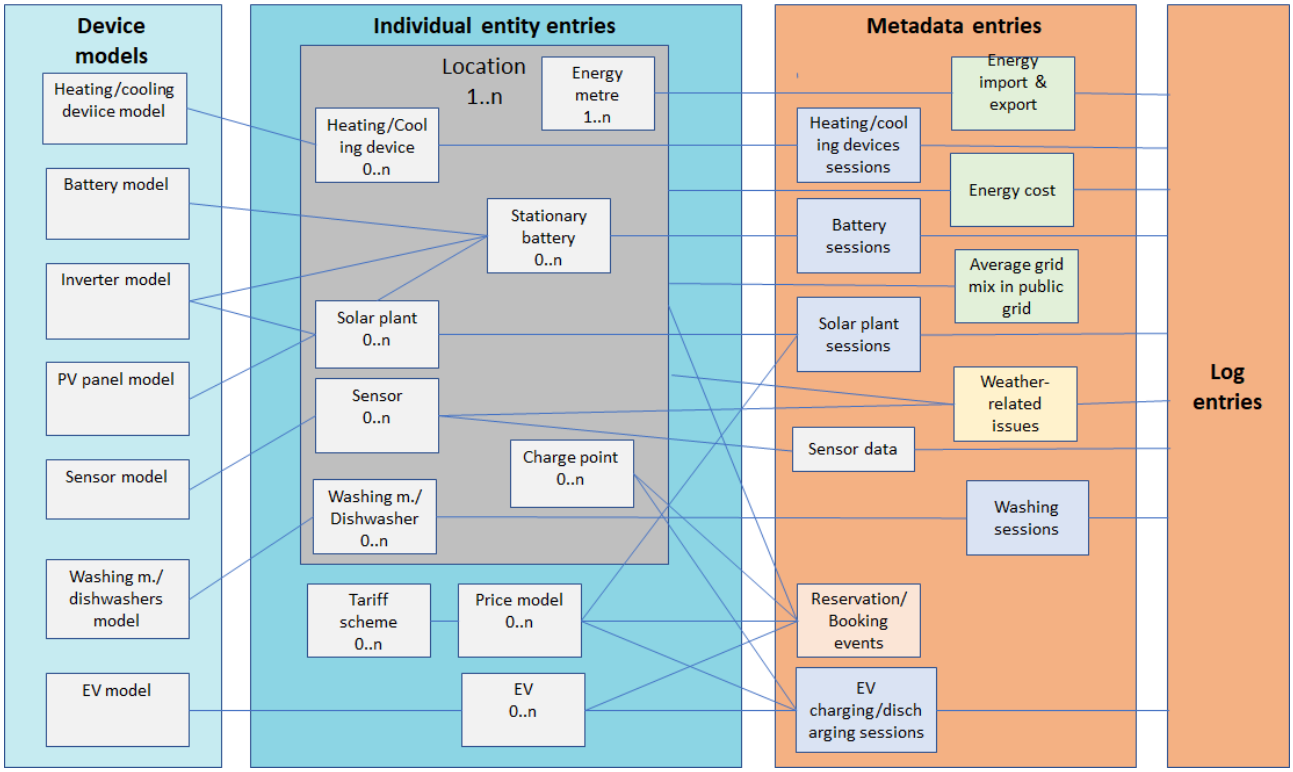


Figure 4-1 Overview of entities and their relations

Figure 2-1 provide an overview of the research data provided by the demonstrators, and Figure zooms into the actual entry types to be provided and their relations (note that all data types are not delivered as open research data – see section 3):

- **Individual entities** in the middle define the setup of demonstrators. Some entities represent physical devices at the locations involved. Electric vehicles (EVs) may however move between different locations. In addition, price models and tariffs describe the implementation of business models.
- **Device models entries** to the left characterise the involved entities.
- **Metadata and log entries** to the right describe demonstrator activities. Some of the metadata entries have log entries but not all. The metadata entries are organised into six groups:
    - Reservation/Booking events
    - Energy consumption and production (EV charging/discharging sessions, Heating/cooling sessions, washing sessions, solar plant sessions, and battery sessions)
    - Energy characteristics (energy import and export, average grid mix in public grid, energy cost)
    - Weather-related issues (predicted weather data, measured weather data)
    - Sensor data.

The following sections provide tables describing the data structures of the datasets for the respective entities. The tables have the following columns:

- Data elements – the name of the data element
- Tag – the code used to represent the data element in the files
- Cardinality - indicates whether data elements are mandatory or not and the possible number of entries. Possible values are
    - 1: Mandatory – one element
    - 0..1: Optional – zero or one elements
    - 1..n: Mandatory - one or more elements
    - 0..n: Optional – zero or more elements
- Type – the data type of the element. This may be basic types (e.g., string, int, float) and composite types
- Description – a description of the data element.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.1 Device model entries

The data structures on the device model entries are described below.

4.1.1 Heating/Cooling device models

For each Heating/Cooling device model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the device
Type	Type	1	string	Possible values: Heater cable, hot-water tank, air conditioner, heat pump, heater, cooler, other
Power levels	PowerLevel	1..n	float	One or more values. Unit: kW The format to be used for the array is described in section 2.3.2.

4.1.2 PV panel models

For each PV panel model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the solar plant model.
Year	Year	1	string	Year of installation
Type	Type	1	string	Possible values: Si:mono or poly crystalline, CIGS, CIS, CdTe, etc
Installed peak power	PeakPower	1	float	unit: kWp (kilo Watt peak)
Size	Size	1	float	Unit: m^2
Noct	Noct	0..1	int	Nominal operating cell temperature in degree Celsius
Albedo	Albedo	0..1	float	Module ground reflectance, typically 0.1-0.4 for surfaces on ground See possible reference values2
Temperature Coefficient P	TempCoeffP	0..1	float	Maximum Power Peak temperature loss coefficient in percent per Kelvin. Might be available in the datasheet or technical manual of PVs
Temperature Coefficient U	TempCoeffU	0..1	float	Maximum Power Peak temperature uncertainty coefficient in percent per Kelvin. Might be available in the datasheet or technical manual of PVs
Temperature Coefficient I	TempCoeffI	0..1	float	Maximum Power Peak temperature coefficient of short circuit current in percent per Kelvin. Might be available in the datasheet or technical manual of PVs

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.1.3 Washing machine or dishwasher models

For each washing machine or dishwasher model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the device
Type	Type	1	string	Possible values: Washing machine, dishwasher, other
Programs	Pgms	1	string	

4.1.4 Battery models

For each Battery model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the device Manufacturing data on producer and C-rate. Number of battery units.
Type	Type	1	string	Possible values: Stacked battery, other
Capacity	Capacity	1	float	Useable capacity which is corrected for depth of discharge (DoD)[3]. Unit: kWh
Efficiency of charging	CEfficiency	1	float	Percent of charged energy available for storage in battery
Efficiency of discharging	DisCEfficiency	1	float	Percent of discharged energy from battery available for consumption
Max charging power	MaxCPower	1	float	Used in case of a linear battery model. Unit: kW
Max discharging power	MaxDisCPower	1	float	
Cycle no	Cycle	1	int	This is the lifetime of the battery, i.e., the number of cycles that it lasts.

[3] There are (at least) three different capacity values: nameplate capacity, useable capacity, actual capacity. The 'actual capacity' is the instantaneous capacity per time step and will be reported in the logfiles as the 'energy content'. DoD for Lead-acid batteries may be 50%, but Li-ion batteries around 80-90%. The DoD is set such that the lifetime of the battery is maximised. So, this is a design-value that is chosen by the battery manufacturer and can hence be found in the data sheet of each individual battery.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.1.5 Inverter models

For each inverter model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the device model
Inverter type	InvType	1	string	Possible values: PV, battery, PV and battery
Size	Size	1	Float	Unit: kW
Max input power	MaxInpPower	1	float	Unit: kW
Max output power	MaxOutPower	1	float	Unit: kW
Efficiency	Efficiency	1	float	For PV panels this is the European Efficiency. Else, this is the mean efficiency of the inverter. Unit: %
Type	Type	1	string	Possible values: AC/DC, DC/AC, AC/AC, DC/DC

4.1.6 Sensor models

For each Sensor model, the following data is defined:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	Identifies the sensor
Max resolution	MaxRes	1	int	Unit: int/second
Type	Type	1..n	string	One or more values. Possible values are: Temperature, electricity consumption, electricity production The format to be used for the array is described in section 2.3.2.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.1.7 EV models

For each EV model, the following data is defined:

Data elements	Tag	Type	Cardinality	Description
EV model	MakeM	string	1	EV model ID. Manufacturers data on car model - a concatenation of the make, model and year of manufacture.
Battery capacity	BatCap	float	1	Unit: kWh
Battery nameplate capacity	BatCapNameplate	float	1	Unit: kWh
Efficiency of charging AC	EffCharAC	float	0..1	For AC - Percent of charged energy available for storage in battery (from data sheet of EV)
Efficiency of discharging AC	EffDischarAC	float	0..1	For AC - Percent of discharged energy from battery available for consumption
Efficiency of charging DC	EffCharDC	float	0..1	For DC - Percent of charged energy available for storage in battery (from data sheet of EV)
Efficiency of discharging DC	EffDischarDC	float	0..1	For DC - Percent of discharged energy from battery available for consumption
Max charging power AC	MaxChPwrAC	float	0..1	Unit: kW
Max charging power DC	MaxChPwrDC	float	0..1	Unit: kW
Max discharging power AC	MaxDischPwrAC	float	0..1	Only available when V2G is possible. AC is not implemented in any vehicle.
Max discharging power DC	MaxDischPwrDC	float	0..1	

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2 Data on individual entity entries

The data structures on the individual entity entries are described below.

4.2.1 Location

For each location involved, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Location id	LOC	1	string	Location identifier. See Table 3-1 Demo and location with identifiers in section 3.1
Demo id	Demo	1	string	See Table 3-1 Demo and location with identifiers in section 3.1
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Meter name	MeterID	1	string	Meter identifier (see 4.2.9)
Max power	MaxPower	1..n	float	Max capacity for the connection to the public grid (Unit: kW). The format to be used for the array is described in section 2.3.2.

4.2.2 Individual Heating/Cooling devices

For each heating and/or cooling device monitored, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Device id	HCID	1	string	Unique and anonymous identifier of device
Location id	LOC	1	string	See section 4.2.1.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Device model	MakeM	1	string	See 4.1.1
Sub-location	SUBLOC	0..1	string	Identifies sub-location, e.g., room

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2.3 Individual Solar plants

For each Solar plant monitored, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Device id	SolarPlantID	1	string	Unique and anonymous identifier of device
Location id	LOC	1	string	See section 4.2.1.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
peak power	PeakPower	1	float	unit: kW
Battery id	BatteryID	0..1	string	See 4.2.5
Inverter device model	InvMakeM	1	string	See 4.1.5
Number of Inverters	InvNum	1	int	Number of installed inverters (cluster)
PV panel group	PVpanels	1..n	PV panel info	One or more entries (see table below) each describing one or more panels of the same model with the same orientation (azimuth, tilt). The format to be used for the array with composite elements is described in section 2.3.2.

For each PV panels info, the following data will be provided:

Data elements	Tag	Cardinality	Type	Description
Device model	MakeM	1	string	PV panel device model. See 4.1.2
No	Num	1	int	Number of PV panels of this model
Azimuth	Azimuth	1	int	Degree (e.g., 0 = South, -90 = East, 90 = West). All panels in the record must have the same azimuth.
Tilt	Tilt	1	int	Degree (e.g., 0= flat, 90 = Vertical). All panels in the record must have the same azimuth.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2.4 Individual Washing machines or dishwashers

For each washing machine or dishwasher monitored, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Device id	WashID	1	string	Unique and anonymous identifier of device
Location id	LOC	1	string	See section 4.2.1
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Device model	MakeM	1	string	See 4.1.3

4.2.5 Individual EVs

For each EV involved, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
EV id	EVID	1	string	Unique and anonymous identifier of EV
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Milage	Distance	0..1	float	Distance driven when EV is registered in the App
EV model	MakeM	1	string	See section 4.1.7.

4.2.6 Individual Stationary Batteries

For each battery monitored, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Device id	BatID	1	string	Unique and anonymous identifier of device
Location id	LOC	1	string	See section 4.2.1
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Device model	MakeM	1	string	See 4.1.4
Year of installation	Year	1	string	Required since the battery may lose capacity over time.
Inverter model	InvMakeM	1	string	See 4.1.5
Number of Inverters	InvNum	1	int	Number of inverters used (cluster)

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2.7 Individual Sensors

A Sensor entity is used to model a variety of sensor, except the main meter of a location. For the main metre, the Individual Energy metre entity is used.

For each Sensor monitored, the following data are provided

Data elements	Tag	Cardinality	Type	Description
Device id	SensorID	1	string	Unique and anonymous identifier of device
Location id	LOC	1	string	See section 4.2.1.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Device model	MakeM	1	string	See 4.1.6
Sub-location	SUBLOC	0..1	string	Identifies sub-location, e.g., room

4.2.8 Individual Charge points

For each Charge Point (CP) involved (i.e., EVSE), the following data are provided:

Data elements	Tag	Cardinality	Type	Description
CP id	CPID	1	string	Unique and anonymous identifier of CP
Location id	LOC	1	string	See section 4.2.1.
CP name	CPName	1	string	The descriptive name of the CP.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Charging capacity	ChrgCap	0..1	float	Total capacity for the CP (Unit: kW) if there is a max capacity.
Comment	Com	0..1	string	Explanations regarding max capacity that are of relevance to the models in case of simulations.
Connectors	Connector	1..n	Connector type	One or more connector types (see table described below). The format to be used for the array with composite elements is described in section 2.3.2.

The table below provides the data structure for Connector type elements.

Data elements	Tag	Cardinality	Type	Description
CP type	CPType	1	string	Possible values: AC, DC
Connector type	Connector Type	1	string	Possible values: CHAdeMO, Type 1, Type 2, CCS-combo, …

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2.9 Individual Energy metres

An Individual energy metre entity is used to model a main metre measuring energy import/export to a location, associated to a contract with the energy retailer.

For each energy metre equipment involved, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Meter id	MeterID	1	string	Unique ID of metre. A metre can be the main metre of a location or a metre for a subset of the local grid.
Location id	LOC	1	string	See section 4.2.1.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is. Format is yyyymmddThhmmss

4.2.10 Individual price models

This is data on the price models used in the demonstrators. Each price model may have several price elements (tariffs – see 4.2.11). Several price elements may have to be combined to get the full price.

Price models entries may for example be:

- **Price model for charging services**. The price model may for example refer to the following tariffs (see 4.2.11).:
  - Subscription fee
  - Price for the actual charging - e.g., per kW or minute. Different tariffs will cover the price for sub-services such as priority charging.
  - Rewarding
  - Penalties
- **Tariffs for locally produced energy** (static tariffs)
- **Price model for energy tariffs to be paid to the DSO**. These are pre-defined and static tariffs, and the price model may for example refer to the following tariffs (see 4.2.11):
  - Grid tariff for energy (per kWh). May be combinations of the following:
    i. Fixed
    ii. Time of use
    iii. Fees and surcharges per kWh
  - Power tariff per kW per hour peak. Must know how the peak is calculated. Possible models
    iv. Highest per month
    v. Highest last year
    vi. Average of the three highest per month
  - Fixed grid tariff. May be
    vii. Fixed price per year
- **Price model for the <u>static</u> price components to be paid to the electricity retailer** in addition to the variable market price (covered by 4.3.4.3). It may for example refer to the following prices:
  - Energy fee - Fixed price per kWh
  - Monthly fee - Fixed price per month
  - Fees and surcharges
  - VAT – Percentage of the total cost to be paid in addition to the market price

Examples of data content in price model datasets and related datasets on tariffs are provided in Annex A.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

For each price model involved, the following data are provided (see also examples below).

Data elements	Tag	Cardinality	Type	Description
Price model id	PriceM0delD	1	string	Price model identifier. Unique for location.
Location id	LOC	1	string	See section 4.2.1.
Price model type	Type	1	string	Possible values: See list below
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Payer	Payer	1	string	Possible values: See list below
Receiver	Receiver	1	string	Possible values: See list below
Tariffs id	TariffID	1..n	string	ID of one or more tariffs – see 4.2.11. The format to be used for the array is described in section 2.3.2.

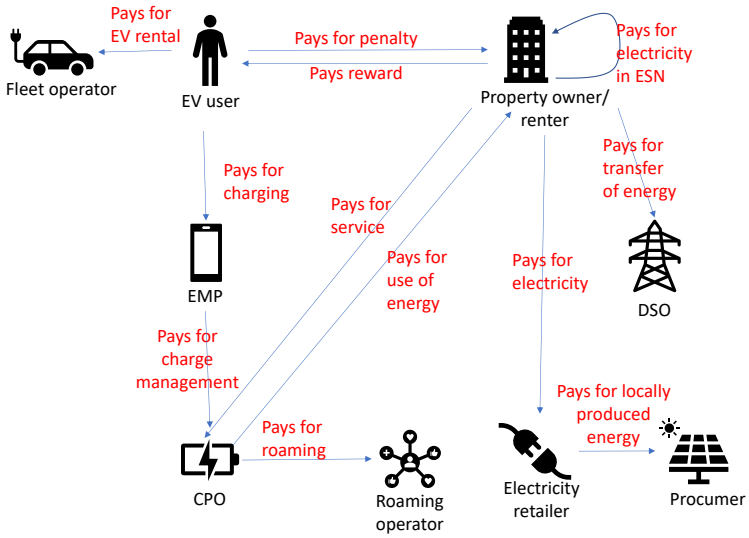
The possible values for **Payer** and **Receiver** are:

- EV User
- EMP
- CPO
- Property owner/renter
- DSO
- Energy retailer
- Prosumer
- Fleet operator
- Roaming operator

Note: Employer can be represented by Property owner/renter.

Possible values for **price model type** are:

- Charging
- EV rental
- Penalty
- Reward
- Transfer of energy
- Electricity
- Charge management
- Roaming
- Use of energy
- Service
- Locally produced energy
- Electricity in ESN



The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.2.11 Individual tariffs

An individual tariff is an individual price element linked to a price model (see 4.2.10)
For each tariff entry, the following data are provided:

Data elements	Tag	Cardinality	Type	Description
Price model id	PriceModelD	1	string	Price model identifier. See 4.2.10
Tariff id	TariffID	1	string	Identifies the tariff, e.g., priority, flexibility, dynamic price, grid price, subscription.
Entry time	EntryTime	1	time	Time when entered into the system. Format is yyyymmddThhmmss
Exit time	ExitTime	0..1	time	Time when removed from the system. Format is yyyymmddThhmmss
Start time	StartTime	1	time	Start time for use of tariff. Format is yyyymmddThhmmss If price depends on the time of day, yyyymmdd should not be provided. The data element starts with T
End time	EndTime	0..1	time	End time for use of tariff. Format is yyyymmddThhmmss If price depends on the time of day, yyyymmdd should not be provided. The data element starts with T
Description	Type	0..1	string	E.g., to say that price component defined is conditional, e.g., a penalty under certain conditions.
Price type	PriceType	1	string	Possible values: See list below
Time unit	Period	0..1	string	In case of time unit in price model Possible values: See list below
Price unit	Unit	1	string	Currency
Price value	Price	1	string	The price. NOTE: The value is positive if it contributes to a higher price and negative if it contributes to a price reduction.

For Price type the possible values are:

- Fixed price
- Price per time unit
- Price per kWh
- Price per highest kW
- Percentage added to total

For Time unit, possible values are:

- Minute
- Hour
- Day
- Week
- Month
- Year

Note: If price is "Per time unit"

1. Penalties should use time unit Minute or Hour
2. Subscription should use time unit Month or Year

See examples provided in Annex A.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3 Data in Logfiles

The data structures on the metadata and log entries are described below. Table below provides an overview of what is logged, how scope of each logfiles, are the entries in the files.

Table 4-1 Overview of what is logged

What is logged	Metadata files	Metadata and logfile entries
Reservation/Bookings		
Reservation/Bookings events	One file per charge point per month or a shorter period.	Metadata – see 4.3.2 No log entries
Energy consumption and production		
EV charging/discharging session	One file per charging session per charge point.	Metadata entry - see 4.3.3.1 Log entries - 4.3.1
Heating/cooling devices session	One file per HC devices per month or a shorter period. A new metadata entry if the setpoint and/or the start/end time is changed.	Metadata entry - see 4.3.3.2 Log entries - see 4.3.1
Washing machine/ Dishwasher session	One file per device per month or a shorter period. A new metadata entry for each session.	Metadata entry - see 4.3.3.3 Log entries - see 4.3.1
Solar plant session	One file per solar plant per month or a shorter period. A new metadata entry if the price model is changed.	Metadata entry - see 4.3.3.4 Log entries - see 4.3.1
Battery session	One file per battery per month or a shorter period Just one metadata entry is needed.	Metadata entry - see 4.3.3.5 Log entries - see 4.3.1
Energy characteristics		
Energy import export	One file per metre per month or a shorter period.	Metadata entry - see 4.3.4.1 Log entries - see 4.3.1
Average grid mix in the public grid**	One file for per demo per month or a shorter period. A new metadata entry for each sampling.	Metadata entry - see 4.3.4.2 No log entries
Energy cost of energy in public grid	One file per demo per month or a shorter period. Just one metadata entry is needed. If cost/price for import/export varies, two files are needed.	Metadata entry – see 4.3.4.3 Log entries entry - see 4.3.1
Weather-related issues		
Predicted temperature	One file per location for each topic per month or a shorter period. Data one day ahead. Just one metadata entry is needed.	Metadata entry – see 4.3.5.1 Log entries entry - see 4.3.1
Predicted insolation		
Predicted wind		
Predicted precipitation		
Measured outside temperature	One file per location for each topic per month or a shorter period. Just one metadata entry is needed.	Metadata entry – see 4.3.5.2 Log entries - see 4.3.1
Measured insolation		
Measured wind		
Measured precipitation		
Sensor measurements		
Sensor data	One file per sensor per month or a shorter period. Just one metadata entry is needed.	Metadata entry – see 4.3.6 Log entries - see 4.3.1

** Variable time resolution for log entries. Just changes in values are logged. ** The average values since previous sample.*

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.1 Log entries

The log entries will be timeseries that may represent different issues

- The accumulated energy use/production (kWh) (accumulated over the time period covered by the logfile).
- Weather data over time
- Sensor data over time
- Energy market price over time

NOTE that just changes in values should be logged. This means that the time resolution in the logfile may vary and may be different from the sampling rate.

The timeseries in the log entries of the logfile will have the following structure (see the Table in section 4.3 for information on which logfiles that have log entries):

Data elements	Type	Cardinality	Description
timestamp	time	1	Format: yyyymmddThhmmss
value	float	1	• Accumulated energy use or accumulated energy production • Meteorological data (measurement/prediction). • Energy market price per kWh.

4.3.2 Metadata entries on reservation/booking events

A reservation/booking events will usually link to a charging/discharging session (see 4.3.3.1). If the request is cancelled or if the EV does not show up at the charge point, there may however not be such a link.

A Reservation/booking event entry defines a charging request with associated charging constraints. The charging constrains may for example be used to book a charge point in advance or to request a certain amount of energy. In both cases, the earliest start time and the latest finish time are also provided.

The history of a request is represented by one or a series of entries – an initial request event, and if relevant, one or more update events and/or a cancellation event. The Event type data element indicates the type of event by the following values:

- Initial - for initial events
- Update - for update events
- Cancelled – for cancellation events

To avoid repetitions, only updated values are provided when a request is updated. The other elements are empty.

If a charging request is not provided via an App (RFID alone is used to authorise the charging), the event type data element indicates this by the following value:

- Empty – to indicate that no charging constraints are provided

The following metadata are provided (NOT followed by log entries).

Data elements	**Tag**	**Cardinality**	**Type**	**Description**
Request ID	ReqID	1	string	Link between records addressing the same booking (initial request, possible cancellation, etc.)
CP id	CPID	0..1	string	No value if CP is not assigned (the location will define the options). When reservation/booking approved, a CP identifier (see 4.2.8)

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Location id	LOC	1	string	See section 4.2.1
Charging session ID	ChrgSessID	0..1	string	Link the request to the actual charging (in 4.3.3.1). - No value before authorisation or if rejected. - Value when authorisation is done.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss. The time when the booking was done.
EV id	EVID	1	string	EV identifier (see 4.2.5)
Connector type	Conn	1	string	Possible values: CHAdeMO, Type 1, Type 2, CCS-combo, …
Event type	EventType	1	string	Possible values are: - Initial (for initial request) - Update (if charging request is updated) - Cancelled (if request is cancelled) - Empty (if no constrains are provided, e.g., if App is not used)
Status	Status	1	string	Possible values are: - Confirmed (if request is approved or event type is empty) - CP rejection (if CP booking is rejected) - Energy rejection (if energy is not available)
Charging constraint	ChrgConstraint	1	Constraint	See below. The format to be used for the composite elements is described in section 2.3.2.
Price model id	PriceModelID	0..1	string	Identifies price model used (see 4.2.11). Depends on Event type: - If Initial: Value must be selected/used price model. - If Update AND new price model: Value must be selected/used price model. - If Cancelled OR Update with same price model: No value.
Tariff id	TariffID	0..n	string	If price model is not provided: No value. Else: Identifiers of the tariffs used from the selected Price model. See 4.2.10 The format to be used for the array is described in section 2.3.2.
Software id	SwID	1	string	System (name and version) providing the data.

Constraint: The data structure for the constraint type is described below.

Note: The Earliest start time (EST) and Latest finish time (LFT) are planned times. The Plug-in/Plug-out times in the EV charging/discharging session metadata (see 4.3.3.1) will show the actual plug in/plug out times.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Data elements	Tag	Cardinality	Type	Description
EST	EST	0..1	time	Earliest start time. Value depends on event type: • Event type Initial or Update with a change in EST: EST value (new or updated) • Else: No value
LFT	LFT	0..1	time	Latest finish time. Value depends on event type: • Event type Initial or Update with a change in LFT: LFT value (new or updated) • Else: No value
Initial energy content	EnergyStart	0..1	float	Used if energy is to be provided and not SoC (see below). EnergyStart and EnergyEnd are the predicted or actual SoC at connection and requested SoC at departure. EnergyMin is a minimum "standby" charge level in case an unforeseen need to use the car occurred. Smart charging will try to reach this level ASAP, while the rest could be subject to load shifting. Also, it will be treated as a threshold for discharging in the case of V2G. Value depends on event type: • Event type initial or update with a change: Value (unit: kWh) or no value (optional) • Else: No value
Target energy content	EnergyEnd	0..1	float	
Min energy content	EnergyMin	0..1	float	
Initial SoC	SOCStart	0..1	float	Used if SoC is to be provided and not energy (see above). Value depends on event type: • Event type Initial or Update with a change: Value (unit: %) or no value (optional) • Else: No value
Target SoC	SOCEnd	0..1	float	
Priority	Priority	0..1	float	Value depends on event type: • If event type Initial or Update with a change in LFT: Value between 0 and 1. 0 is no priority. • Else: No value
V2G allowed	V2G	0..1	Boolean	Value depends on event type: • If event type Initial or Update with a change in LFT: Value 1 if allowed. 0 if no allowed • Else: No value

There are no log entries in the logfiles associated to this metadata entry.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.3 Metadata entries on energy consumption and production

All logfiles will contain metadata and log entries.

4.3.3.1 EV charging/discharging sessions

Note that charging/discharging sessions may be linked to a Reservation/booking event (see 4.3.2) that provides the charging constraints. The charge session id will link the charging/discharging session to the reservation/booking event.

For each charging/discharging session, the following metadata are provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
CP id	CPID	1		CP identifier (see 4.2.8)
Location id	LOC	1	string	See section 4.2.1.
Charging session ID	ChrgSessID	1	string	0 before confirmation. Will link a booking (see 4.3.2) if booking exists.
timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
EV id	EVID	1	string	EV identifier (see 4.2.5)
Plug in time	PluginTime	1	time	Unix time
Plug out time	PlugoutTime	1	time	Unix time
Energy content at start	SOCStart	0..1	float	kWh Provided by EV user (may not be accurate)
Energy content at end	SOCEnd	0..1	float	kWh Provided by EV user (may not be accurate)
Charging time	ChrgTime	1	string	The accumulated time used for charging. This is the duration of all charging sub-sessions (the charging session may start and stop many time). Format: hh:mm:ss
Max charging power AC	MaxChACPower	float	0..1	Provided in case the values from the device model are overridden at the time of charging by the driver (e.g., to charge slower at fast chargers to save the battery). If no values are provided, the values from the EV's device model should be used. The data on the CP must also be considered. Unit: kW
Max charging power DC	MaxChDCPower	float	0..1	
Max discharging power AC	MaxDischACPower	float	0..1	
Max discharging power DC	MaxDischDCPower	float	0..1	
Software id	SwID	1	string	System (name and version) providing the data.
Power charged	PowerCh	float	0..1	The total energy charged, unit: kWh

Log entries - see 4.3.1: The accumulated energy level is increased in case of charging and decreased in case of discharging.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.3.2 Heating/cooling sessions

For each heating/cooling session, the following metadata are provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Device id	HCID	1	string	Identifies device (see 4.2.2)
Software id	SwID	1	string	System (name and version) providing the data.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Setpoint	SetPt	1	float	Temperature in Celsius
Allowed deviation	AllowedDev	0..1	float	Optional. Will in many cases depend on the device
Actual start time	AST	1	time	If it is difficult to extract such info from continuous meter reading, the start of the reading is used as AST, and the end of the reading as AET
Actual end time	AET	1	time	

For log entries - see 4.3.1: The accumulated energy level is increased according to the energy use.

4.3.3.3 Washing sessions

For each session, the following metadata will be provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Device id	WashID	1	string	Identifies device (see 4.2.4)
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Earliest start time	EST	1	time	
Latest end time	LET	1	time	
Actual start time	AST	1	time	
Actual end time	AET	1	time	
Program	Pgm	1	string	
Software id	SwID	1	string	System (name and version) providing the data.

For log entries - see 4.3.1: The accumulated energy level is increased according to the energy use.

4.3.3.4 Solar plant sessions

One session may last for hours, days, weeks or months, and the following metadata will be provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Device id	PlantID	1	string	Identifies device – see 4.2.3
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Price model id	PriceModelID	0..1	string	Identifies price model used (see 4.2.10)
Software id	SwID	1	string	System (name and version) providing the data.

For log entries - see 4.3.1: The accumulated energy level is increased according to the energy production.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.3.5 Battery sessions

One session may last for hours, days, weeks or months, and the following metadata will be provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Device id	BatID	1	string	Identifies device – see 4.2.5
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Energy content at start	SOCStart	1	float	kWh
Energy content at end	SOCEnd	1	float	kWh
Software id	SwID	1	string	System (name and version) providing the data.

Log entries - see 4.3.1: The accumulated energy level is increased in case of charging and decreased in case of discharging.

4.3.4 Metadata entries on energy characteristics

All logfiles will contain metadata and log entries.

4.3.4.1 Energy import and export

The following metadata on energy import/export are described in the table below (and followed by log entries).

Data elements	Tag	Cardinality	Type	Description
Meter name	MeterID	1	string	Meter identifier (see 4.2.9)
Timestamp	Time	1	time	Log entry creation time. Format: yyyymmddThhmmss
Software id	SwID	1	string	System (name and version) providing the data.

Log entries - see 4.3.1: The accumulated energy level is increased in case of import and decreased in case of export.

4.3.4.2 Average grid mix in public grid

The following metadata on energy mix in the public grid are provided (not followed by log entries):

Data elements	Tag	Cardinality	Type	Description
Location id	LOC	1	string	See section 4.2.1.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Start time	Start	1	time	Time period for which the grid mix is provided
End time	End	1	time	
Biomass	Biomass	1	float	Percent of total energy coming from biomass
Fossil brown coal/Lignite	Lignite	1	float	Percent of total energy coming from fossil brown coal
Fossil coal-derived gas	Coal	1	float	Percent of total energy coming from gas derived from gas
Fossil gas	Gas	1	float	Percent of total energy coming from gas
Fossil hard coal	HardCoal	1	float	Percent of total energy coming from hard coal

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Fossil oil	Oil	1	float	Percent of total energy coming from fossil oil
Fossil oil shale	Shale	1	float	Percent of total energy coming from fossil oil shale
Fossil peat	Peat	1	float	Percent of total energy coming from fossil peat
Other fossil	OtherFossil	1	float	Percent of total energy coming from other fossil sources
Geothermal	Geothermal	1	float	Percent of total energy coming from geothermal
Hydro pumped storage	HydroPumped	1	float	Percent of total energy coming from hydro pumped storage
Hydro	Hydro	1	float	Percent of total energy coming from hydro either run-of-river and poundage and water reservoir
Marine	Marine	1	float	Percent of total energy coming from marine
Nuclear	Nuclear	1	float	Percent of total energy coming from nuclear
Other renewable	OtherRES	1	float	Percent of total energy coming from other renewable energy sources not detailed in other fields
Solar	Solar	1	float	Percent of total energy coming from solar
Waste	Waste	1	float	Percent of total energy coming from waste
Wind Offshore	WindOffShore	1	float	Percent of total energy coming from wind offshore
Wind Onshore	WindOnShore	1	float	Percent of total energy coming from wind onshore
Software id	SwID	1	string	System (name and version) providing the data.

4.3.4.3 Energy cost in public grid

The data structure described here is used to represent the ***variable*** **energy price paid to the electricity retailer** and also the ***variable*** **energy payment to prosumers.**

The total price paid will be a combination of one or more of the following price components such as the variable price (market price – varying energy price per kWh) and static price elements.

NOTE that the static price components are provided via the individual price model (see 4.2.10). This also includes the Payment to the DSO. The DSO has no varying price components.

See examples provided in Annex A.

The metadata for the varying market price are specified below.

Data elements	Tag	Cardinality	Type	Description
Location id	LOC	1	string	See section 4.2.1.
Type	Type	1	string	Possible value: • Consume (energy from grid to consumer) • Produce (energy from prosumer to grid)
Timestamp	Time	Time	string	Log time. Format: yyyymmddThhmmss
Price unit	PriceUnit	1	string	Currency used for log entries

The metadata described above will be followed by one or more log entries providing data on the market price, as defined in 4.3.1. **NOTE:** If the prices for import and export are different, two files are needed. If the prices are the same, just one file is needed.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.5 Metadata entries on weather-related issues

4.3.5.1 Predicted weather data

Metadata on predicted weather (at least 1 day ahead if data is available) are as follows:.

Data elements	Tag	Cardinality	Type	Description
Location id	LOC	1	string	See section 4.2.1.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Prediction time	PredTime	1	time	Time when prediction was done
Type	Type	1	string	Possible values: See table below
Unit	Unit	1	string	

Possible values for type and unit are provided in the table below.

Data	Type	Unit
Predicted outside temperature	PRE-TMP	degrees Celsius
Predicted insolation	PRE-INS	kWh per m2
Predicted wind	PRE-WND	m per s
Predicted precipitation	PRE-PRE	mm per hour

Log entries - see 4.3.1: They contain time series with values corresponding to the type and unit provided.

4.3.5.2 Measured weather data

The following metadata are provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Location id	LOC	1	string	See section 4.2.1.
Sensor id	SensorID	0..1	string	Sensor doing the measurement or reference to external source.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Type	Type	1	string	Possible values: See table below
Unit	Unit	1	string	

Possible values for type and unit are provided in the table below.

Data	Type	Unit
Measured outside temperature	MEA-TMP	degrees Celsius
Measured insolation	MEA-INS	kWh per m2
Measured wind	MEA-WND	m per s
Measured precipitation	MEA-PRE	mm per hour

Log entries - see 4.3.1: They contain time series with values corresponding to the type and unit provided.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.6 Metadata entries on sensor data

The following metadata will be provided (and followed by log entries)

Data elements	Tag	Cardinality	Type	Description
Sensor id	SensorID	1	string	The sensor used to do the measurement or reference to external source.
Timestamp	Time	1	time	Log time. Format: yyyymmddThhmmss
Type	Type	1	string	Possible values: See table below
Unit	Unit	1	string	

Possible values for type and unit are provided in the table below.

Data	Type	Unit
Temperature	TMP	degrees Celsius

Log entries - see 4.3.1: The measurements are provided as time series.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

5 Conclusions

The research data collected during the GreenCharge project are published as open research data in the open research data repository Zenodo[4] (https://zenodo.org/). The datasets are uploaded to the *H2020 GreenCharge community*[5] and in addition, linked to the *European Commission Funded Research (OpenAIRE) community* [6]to secure maximum findability. All uploads will be enriched with Zenodo metadata.

[4] https://zenodo.org/
[5] https://zenodo.org/communities/h2020-greencharge/?page=1&size=20
[6] https://zenodo.org/communities/ecfunded/?page=1&size=20

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Annex A Price model and tariff examples

Section 4.2.10 (individual price models) and 4.2.11 (individual tariffs) describe the data structures used to represent price models with price elements. This may for example be prices paid to the DSO, to the electricity retailer, and to providers of charging services and EV fleets.

In addition, section 4.3.4.3 describes the price components to be paid to the electricity retailer. The static price components are further described using the individual tariff in 4.2.11. The varying market price is however described by log entries following the metadata in 4.3.4.3.

Here we provide some examples of the content.

A.1 Prices paid to DSO

The table below show examples of data entries for the individual price models (see 4.2.10) for energy tariffs paid to the DSO.

Individual price model entries						
Price model id	… (misc. attributes)	Entry Time	Exit Time	Payer	Receiver	Tariffs id
GridTariff1	…	20200101T000000		Building owner	DSO	TimeOfUseWinter1
						TimeOfUseSummer1
						TimeOfUseAutumn1
						FeesSurch1
PowerTariff1		20200101T000000		Building owner	DSO	HighestPerMonth1
FixedGridTariff1		20200101T000000		Building owner	DSO	FixedPrice1

The table below show corresponding example of data entries for the individual tariff (see 4.2.11) (all data elements are not included).

Individual tariff							
Price model id	Tariff id	Start Time	End Time	Price type	Time unit	Price unit	Price value
GridTariff1	TimeOfUseWinter1	20201101T000000	20210228T235959	Price per kWh		EUR	xx.xx
GridTariff1	TimeOfUseSummer1	20210301T000000	20210930T235959	Price per kWh		EUR	xx.xx
GridTariff1	TimeOfUseAutumn1	20211001T000000	20211231T235959	Price per kWh		EUR	xx.xx
GridTariff1	FeesSurch1	20200101T000000		Price per kWh		EUR	xx.xx
PowerTariff1	HighestPerMonth1	20200101T000000		Price per highest kWh	Month	EUR	xx.xx
FixedGridTariff1	FixedPrice1	20200101T000000		Fixed price	Year	EUR	xx.xx

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

A.2 Prices paid to electricity retailer

The payment to the electricity retailer may have components of two types

1. A variable price component
   - Market price – Varying energy price per kWh. It varies over time.
2. A selection of static price components (one or more may be combined)
   - Energy fee - Fixed price per kWh to be paid in addition to the market price
   - Monthly fee - Fixed price per month to be paid in addition to the market price
   - Fees and surcharges – Additional price per kWh to be paid in addition to the market price
   - VAT – Percentage of the total cost to be paid in addition to the market price

Both types are identified by the metadata specified in 4.3.4.3. The actual prices are however represented in different ways:

1. The variable price component is described in log entries following the metadata, as specified in 4.3.4.3.
2. The static price components are described in an individual price model (see 4.2.10) and associated individual tariffs (see 4.2.11). The metadata entry in in 4.3.4.3 refers to the price model.

The table below show examples of data entries for the energy cost metadata described in 4.3.4.3.

Location id	… (misc. attributes)	Price unit	Static prices
Location id		EUR	StaticEnergyPrices1
Log entries with market price			

The table below show examples of the individual price models (see 4.2.10).

Individual price model entries						
Price model id	… (misc. attributes)	Entry Time	Exit Time	Payer	Receiver	Tariffs id
StaticEnergyPrices1		20200101T000000		Building owner	Retailer	EnergyFee1
						MonthlyFee1
						FeesSurch1
						VAT1

The table below show corresponding data entries for the individual tariff (all data elements are not included).

Individual tariff							
Price model id	Tariff id	Start Time	End Time	Price type	Time unit	Price unit	Price value
StaticEnergyPrices1	EnergyFee1	20200101T000000	-	Price per kWh	-	EUR	xx.xx
StaticEnergyPrices1	MonthlyFee1	20200101T000000	-	Price per time unit	Month	EUR	xx.xx
StaticEnergyPrices1	FeesSurch1	20200101T000000	-	Price per kWh	-	EUR	xx.xx
StaticEnergyPrices1	VAT1	20200101T000000	-	Percentage added to total	-	percentage	xx.xx

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

A.3 Charging service prices

The table below show examples of s data entries for the individual price models for charging services.

Individual price model entries						
Price model id	… (misc. attributes)	Entry Time	Exit Time	Payer	Receiver	Tariffs id
Charging1		20200101T000000		EV user	EMP	ChrPrice1
						PriorityFee1
						BlockingFee1
						FlexibilityReward1
ChrSubscription1		20200101T000000		EV user	EMP	SubscrFee1

The table below show corresponding example of data entries for the individual tariff.

Individual tariff							
Price model id	Tariff id	Start Time	End Time	Price type	Time unit	Price unit	Price value
Charging1	ChrPrice1	20200101T000000	-	Price per kWh	-	EUR	xx.xx
Charging1	PriorityFee1	20200101T000000	-	Price per kWh	.	EUR	xx.xx
Charging1	BlockingFee1	20200101T000000	-	Price per time unit	Minute	EUR	xx.xx
Charging1	FlexibilityReward1	20200101T000000	-	Price per kWh	.	EUR	-xx. xx
ChrSubscription1	SubscrFee1	20200101T000000	-	Price per time unit	Month	EUR	xx.xx

A.4 EV rental prices

The table below show examples of s data entries for the individual price models for Erzic sharing services.

Individual price model entries						
Price model id	… (misc. attributes)	Entry Time	Exit Time	Payer	Receiver	Tariffs id
EVRental1	…	20200101T000000		EV user	Fleet operator	Insurance1
						Distance1
						Discount1
						…

The table below show corresponding example of data entries for the individual tariff.

Individual tariff							
Price model id	Tariff id	Entry Time	Exit Time	Price type	Time unit	Price unit	Price value
EVRental1	Insurance1	20200101T000000		Price per kWh	-	EUR	xx.xx
EVRental1	Distance1	20200101T000000		Price per kWh	.	EUR	xx.xx
EVRental1	Discount1	20200101T000000		Fixed price	…	EUR	-xx. xx
EVRental1	…	20200101T000000		…	…	EUR	xx.xx

A.5 Price paid to CPO

The table below show examples of data entries for the individual price models for Erzic sharing services.

Individual price model entries						
Price model id	… (misc. attributes)	Entry Time	ExitTime	Payer	Receiver	Tariffs id
CPOPayment	…	20200101T000000		Building owner	CPO	ServiceFee …

The table below show corresponding example of data entries for the individual tariff.

Individual tariff							
Price model id	Tariff id	Entry Time	Exit Time	Price type	Time unit	Price unit	Price value
CPOPayment	ServiceFee	20200101T000000		Price per kWh	-	EUR	xx.xx

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Members of the GreenCharge consortium

SINTEF	SINTEF AS (SINTEF) NO-7465 Trondheim Norway www.sintef.com	**Project Coordinator:** Jacqueline Floch, Jacqueline.Floch@sintef.no **Technical Manager:** Shanshan Jiang Shanshan.Jiang@sintef.no
eSmart Systems	eSmart Systems AS (ESMART) NO-1783 Halden Norway www.esmartsystems.com	**Contact:** Susann Kjellin Eriksen susann.kjellin.eriksen@esmartsystems.com
HUBJECT	Hubject GmbH (HUBJ) DE-10829 Berlin Germany www.hubject.com	**Contact:** Jürgen Werneke juergen.werneke@hubject.com
eurecat Centre Tecnològic de Catalunya	Fundacio Eurecat (EUT) ES-08290 Barcelona Spain www.eurecat.org	**Contact:** Regina Enrich regina.enrich@eurecat.org
ATLANTIS TRACKING YOUR WORLD	Atlantis IT S.L.U. (ATLAN) ES-08013 Barcelona Spain http://www.atlantisit.eu/	**Contact:** Ricard Soler rsoler@atlantis-technology.com
enchufing	Millor Energy Solutions SL (ENCH) ES-08223 Terrassa Spain www.millorbattery.com	**Contact:** Baltasar López blopez@enchufing.com
motit www.motitworld.com	Motit World SL (MOTIT) ES-28037 Madrid Spain www.motitworld.com	**Contact:** Valentin Porta valentin.porta@goinggreen.es
Freie Hansestadt Bremen	Freie Hansestadt Bremen (BREMEN) DE-28195 Bremen Germany	**Contact:** Michael Glotz-Richter michael.glotz-richter@umwelt.bremen.de
ZET zero emission transportation	ZET GmbH (MOVA) DE-28209 Bremen Germany http://www.zet.technology	**Contact:** Dennis Look dennis@zet.technology

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

	Personal Mobility Center Nordwest eG (PMC) DE-28359 Bremen Germany www.pmc-nordwest.de	**Contact:** Bernd Günther b.guenther@pmc-nordwest.de
	Oslo kommune (OSLO) NO-0037 Oslo Norway www.oslo.kommune.no	**Contact:** Patrycjusz Bubilek patrycjusz.bubilek@bym.oslo.kommune.no
	Fortum OYJ (FORTUM) FI-02150 Espoo Finland www.fortum.com	**Contact:** Jan Ihle jan.haugen@fortum.com
	PNO Consultants BV (PNO) NL.2289 DC Rijswijk Netherlands www.pnoconsultants.com	**Contact:** Francesca Boscolo Bibi Francesca.boscolo@pnoconsultants.com
	Universita Deglo Studi Della Campania Luigi Vanvitelli (SUN) IT-81100 Caserta Italy www.unicampania.it	**Contact:** Salvatore Venticinque salvatore.venticinque@unicampania.it
	University of Oslo (UiO) NO-0313 Oslo Norway www.uio.no	**Contact:** Geir Horn geir.horn@mn.uio.no
	ICLEI European Secretariat GmbH (ICLEI) DE-79098 Freiburg Germany www.iclei-europe.org	**Contact:** Stefan Kuhn stefan.kuhn@iclei.org **Innovation Manager:** Reggie Tricker reggie.tricker@iclei.org
	EGEN B.V. NL.2289 DC Rijswijk Netherlands www.egen.green	**Contact:** Simone Zwijnenberg Simone.zwijnenberg@egen.green

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.