European Commission

Preparatory Study for Ecodesign of Electric Vehicles Chargers

Draft report (tasks 4 to 6)

implementing the Ecodesign Working Plan 2022 -2024

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List of abbreviations and acronym

AC	Alternating Current
AFIR	Alternative Fuel Infrastructure Regulation
AI	Artificial Intelligence
AP	Acidification Potential
avg	Average
BAT	Best Available Technology
BAU	Business As Usual
B2B	Business-to-Business
BC	Base Case
BNAT	Best Not yet Available Technology
BOM	Bill of Materials
BPT	Bidirectional Power Transfer
CA	Control Accuracy
CAPEX	Capital Expenditure
CEN	European Committee for Normalisation
CENELEC	European Committee for Electro technical Standardization
CO_2	Carbon Dioxide
CS	(Re-)charging Station
CSMS	Charging Station Management System
DER	Distributed Energy Resources
ED	Ecodesign Directive
EE	Energy Efficiency
EED	Energy Efficiency Directive
Elec	Electricity
ELR	Energy Labelling Regulation
EMS	Energy management system
EN	European Norm
Epac	Electrically pedal assisted cycle
EoL	End of Life
ErP	Energy related Products
EU	European Union
EV	Electrical Vehicle
EVSE	Electric Vehicle Supply Equipment
FU	Functional Unit
GER	Gross Energy Requirement
GDP	Gross Domestic Product
GPP	Green Public Procurement
GWP	Global Warming Potential
HDV	Heavy duty vehicle
HH	Household
HPC	High Power Charging
IA	Impact Assessment
I/F	Interface
I/O	Input/Output
IC-CPD	In-Cable Control and Protection Device
IoT	Internet of Things
IP	Internet Protocol
ISO	International Organization for Standardization
KPI	Key Performance Indicators
kWh	Kilowatt hour
kWp	kilowatt peak (power output of PV panels)
lBAC	local building controls
LCA	Life Cycle Assessment
LCC	Life Cycle Cost

LDV	Light duty vehicle
LLCC	Least Life Cycle Costs
LED	Light emitting diode
LMT	Light Means of Transport
MEErP	Methodology for Ecodesign of Energy-related Products
MEPS	minimum energy efficiency performance standard
n.e.c.	not elsewhere classified
NM	Not modelled
NPV	Net Present Value
OBC	On-board charger
OCPP	Open Charge Point Protocol
OFBC	Off-board charger
O&M	Operation and Maintenance
OPEX	Operational Expenditure
OPS	On-shore Power Supply
PE	Primary energy
PEF	Primary energy factor
PEP	Profil Environnemental Produit
PID	proportional–integral–derivative controller
PLC	Power-Line Communication
PO	Policy Option
PRODCOM	Production Communautaire
PSR	Product Specific Rules
PV	Photo-voltaic panels (solar panels)
PWM	pulse width modulation
RCCB	Residual Current Circuit Breaker
RCD	Residual Current Device
RES	Renewable Energy Sources
SG	Smart Grid
SPI	Sustainable Product Initiative
SRI	Smart Readiness Indicator
SRT	Smart Readiness Technologies
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TEN-T	Trans-European Transport Network
TOR	Terms of Reference
TP	Twisted Pair
TS	Technical Specification
UMC	Universal Mobile Connector (Tesla Mode 2 charging cable)
V2G	Vehicle to grid
VA	Volt-ampere
WAN	Wide Area Network
WEEE	Waste Electrical & Electronic Equipment

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List of BAT and sensitivity analysis cases

EFF	Increasing energy efficiency for stand-by loss for EVSE mode 2/3/4
AC/DC	Increasing energy efficiency for conversion loss for EVSE mode 4
UP	Increasing material efficiency with upgradeability
LIFE	Increasing material efficiency with repair
PLUG	Increasing material efficiency by maximizing the use of mode 2
RES	Decreasing impact by using Renewable Energy Sources
TR	Decreasing impact by local end-manufacturing
REP-	*D*ecreasing material efficiency with less repair possibility

Colour codes used in this draft document:

Text in blue background will be updated in the final version.

Text in green background needs special attention from the stakeholder.

Text in yellow background is for internal review only.

Executive summary

These are draft Task 4 to 6 reports only for discussion at the stakeholder meeting.

For the context and more information please read draft Task 1-3 report on the project website, see: https://ecodesign-ev-charger.eu/ecodesign/documents/

An executive summary overarching all tasks will be elaborated in the final version.

This document is a draft version for discussion in the stakeholder meeting.

4 Technologies

4.0 Introduction

The aim of this Task is to identify, retrieve and analyse data working towards the definition of Base Cases (BC) for Task 5 and finally evaluating the improvement options in Task 6. Standard improvement or options, Best Available Technology BAT and Best Not yet Available Technology BNAT (best of products in field tests, labs, etc.) will be considered.

The data collected serves for further Life Cycle Analysis (LCA) and Life Cycle Cost (LCC) calculation in Tasks 5 and 6. Therefore, both the Bill-Of-Material (BoM) and cost data associated with the improvement options is collected which will be further processed with the MEErP tool.

There is however a broad range of EVSE on the market and the MEErP foresees so called Base Cases (BC). BCs encompass the challenge to model the diverse range of recharging equipment. In total 4 BCs were used to streamline and collect data.

In brief, data is collected for the following improvement options with the acronyms between brackets:

- Increasing energy efficiency for stand-by loss for EVSE mode 2/3/4 and conversion for EVSE mode 4 (BAT EFF, BAT AC/DC)
- Increasing material efficiency with upgradeability and/or repair (BAT UP, BAT LIFE)
- Increasing material efficiency by maximizing the use of mode 2 (BAT PLUG)
- *De*creasing material efficiency with less repair possibility (BAT REP-)

This data will be further processed in Task 5 & 6.

Given that this is a relative new product group with frequent changes in products brought to the market it turned out to be difficult to collect reliable and accurate BAT data. Also, few input was received on a manufacturing enquiry.

Regarding mode 4, data collection is particularly difficult and if one wants to proceed with a policy measure then defining a standard and starting with the obligation to supply data will be a first step.

This task also identified and discussed BNAT: V2G/Bidirectional charging, Plug And Charge, Megawatt Charging System (MCS), Wireless EV charging and DC grid solutions for EVSE. It can be concluded that EVSE is still in part under development and significant changes in products supplied can be expected. It turned out to be complicated to collect BAT data, but for BNAT this is even more complicated. That is an aspect that will have to be considered when proposing policy measures in Task 7.

This is a first working draft version of the Task 4 for review and commenting in the stakeholder meeting. A summary will be added in the draft final version.

4.1 AC EV recharging with IEC mode 2 or 3 EVSE

4.1.1 Introduction to AC recharging IEC mode 2 and 3 EVSE

Mode 2 and Mode 3 are only AC voltage supply equipment. Mode 2 can rely on a standard socket and has the necessary protection and communication functions incorporated in the cable. Apart from the cabling there is no technical difference between mode 2 and 3 but mode 2 is a mobile station and does not need to be installed.

The AC into DC current conversion and control of the charging current is done by the onboard charger (OBC).

Note that this study is focused on the 'IEC modes (1-4)' defined in the IEC 61851-1 standard EV for conducting charging systems as explained in the scoping Task 1.

4.1.2 IEC 61851 Mode 2 mobile AC charging

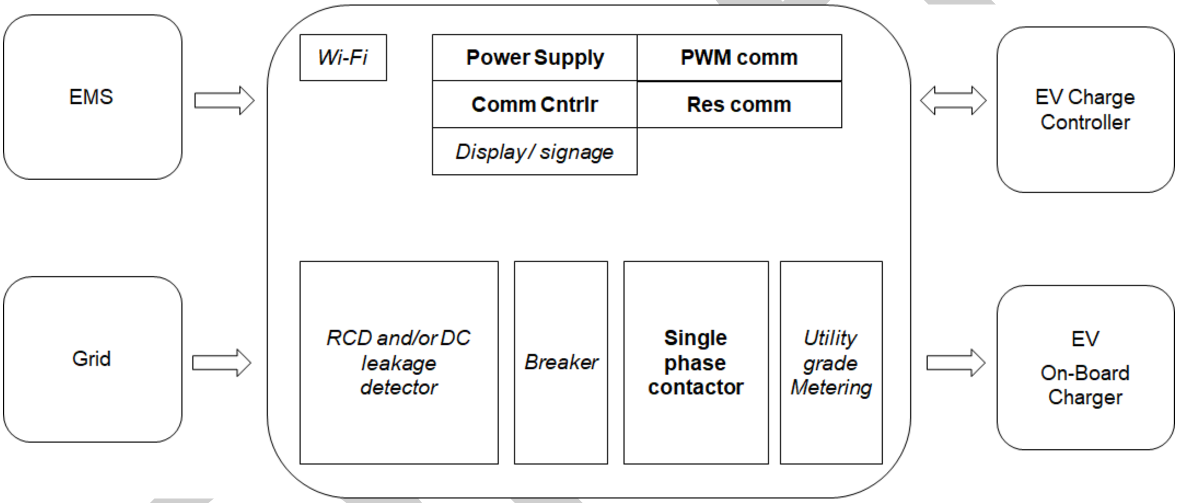

Figure 4-1 Mode 2 Charging Cable Block Diagram

To allow EV owners to charge even without dedicated recharging points around, many EV manufacturers provide a Charging Cable, also named "Mobile Charging Adapter". Sometimes it is also referred to as "Granny charger", since it can be used to charge an EV from any normal power socket e.g. during family visits. As shown in the block diagram (Figure 4-1Figure 4-1) this cable contains the necessary hardware to enable communication with an EV on-board charger (OBC).

A Mode 2 Charging Cable therefore consists of the following parts:

- Communication controller
- Control Pilot hardware
- PWM hardware
- Power supply (AC to DC)
- Single phase contactor
- Residual Current Detection and/or DC leakage detector

Optionally these Mobile Charging solutions can also include:

- Wi-Fi and/or Bluetooth for additional connectivity such as remote control of charging, remote firmware updates, mobile phone app via backend, display, …
- Switch to allow selection of different charging currents

Every mode 2 to 4 IEC 61851-1 EVSE operates the same EV socket. To enable this, 8 operation states are defined in the standard (A1, A2, B1, B2 analogue, B2 digital, C1, C2 analogue, C2 digital). This is based on the signal on the control pilot (CP) and proximity pilot (PP). A CCS2 plug/socket (see Task 1) includes the supply lines, earthing and CP and PP. The basic hardware components are included in Figure 4-2. Every mode 2 to 4 EVSE is a state machine and can run into 8 different modes depending on the CP and PP signals, see Table 4-1.

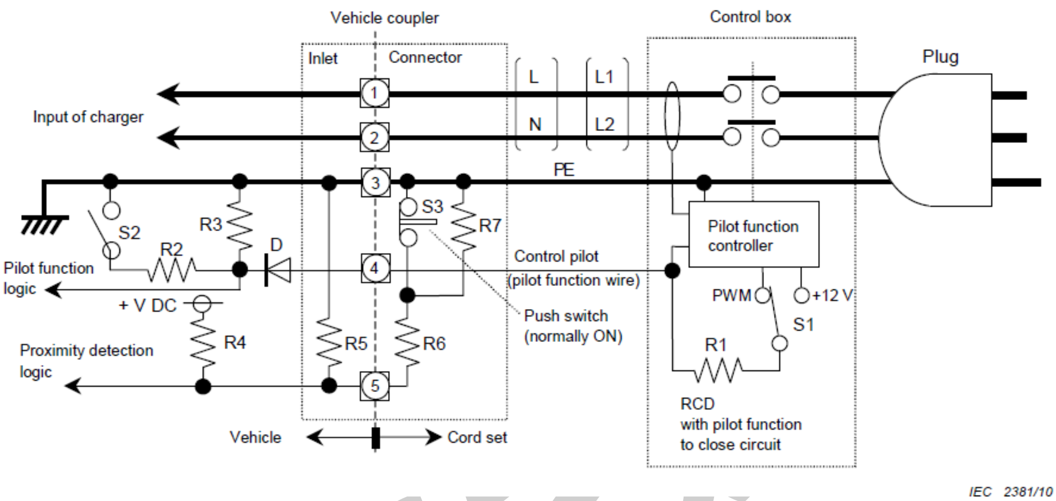

Figure 4-2 Basic components of a mode 2 EVSE using the basic single phase vehicle coupler (source IEC 61851-1)

Table 4-1 IEC 61851-1 EV conducting charging system operating states

IEC 61851-1 EV conducting charging system						
IEC 61851-1 states EV		IEC 61851-1states EVSE		PWM	S2 relais in EV	Va nominal V
A	N/A	1	not connected	Off	N/A	12
A	N/A	2	not connected	On	N/A	12
B	EV not ready to receive energy	1	EVSE not ready	0%	open	10
B	EV not ready to receive energy	2 analogue	EVSE ready - analogue PWM communication (AC only)	≥10%	open	10
B	EV not ready to receive energy	2 digital	EVSE ready - with digital communication	=5%	open	10
C	EV ready to receive energy	1	EVSE not ready	0%	close	7
C	EV ready to receive energy	2 analogue	EVSE ready - analogue PWM communication (AC only)	≥10%	close	7
C	EV ready to receive energy	2 digital	EVSE ready- with digital communication	=5%	close	7

Notes:

A car who reached its user defined maximum SOC (e.g. 80 %) will typically change from state C to B.

Digital communication mode is needed for mode 4 DC charging and/or bidirectional charging.

Important note:

Very recently we see the availability of smart Mode 2 chargers[1] that have Energy Management System (EMS) functionality integrated. They can indirectly read data from the grid electricity meter. This is useful when the EV owner has a solar installation because the

[1] Powerbaas Smart Granny Charger | Powerbaas.nl

digital meter will indicate when there is a surplus of solar energy and then the smart mode 2 charger will be activated to self-consume the excess solar energy.

As a conclusion, EVSE with integrated EMS can be implemented both in IEC mode 2 and 3 EVSE.

4.1.3 Use of mode 2 EVSE with industrial sockets

Different types of Mode 2 may be available in different EU countries, depending on national legislation:

- Mode 2 on domestic socket: 230V/10A, 2.3kW
- Mode 2 on reinforced domestic socket that can stand 16A load for long periods: 230V/16A, 3.7kW (IEC 60309-2 (16 A single Phase)) or up to 32A (7,4 kW) (Figure 4-3 shows the cable with connector) on an industrial IEC 60309-style socket (Figure 4-4).

Figure 4-3 Mercedes Flexible Pro Charging Unit

Figure 4-4 Single Phase industrial socket 3-poles 230V 32A IP44 (source: Schneider)

Examples:

- Mercedes Flexible Charging Pro:
  - WLAN
  - Up to 22 kW charging power
  - Different wall socket adapters available
- Tesla Mobile Connector
  - In the EU up to 7.3 kW charging power

Note: the “Tesla Mobile Connector” can even allow larger currents than 32A. However, in the EU high power is mostly achieved with tri-phase 230V chargers.

4.1.4 IEC 61851 Mode 3 EVSE common functionalities and primary function

A Mode 3 Recharging Point is permanently connected to an AC supply network and therefore is often referred to as a “wall box charger”. Technically an IEC mode 3 EVSE is identical to a mode 2 EVSE apart from that mode 3 is designed for a fixed installation while mode 2 is for mobile use. This means that most technical requirements and basic functionality is identical to section 4.1.2.

4.1.5 Introduction to mode 3 EVSE optional functionalities and secondary functions

Additional hardware functionality that is very often supplied:

- LAN and/or WLAN (WIFI), sometimes a wired RS485 Modbus connection
- Display or signage lighting: for user feedback.
- RFID card reader: for authentication
- Fixed charging cable attached or charging socket
- Residual Current Detection and/or DC leakage detection
- Breaker
- Utility Grade Metering (MID – Measurement Instrument Directive)

Possible other features:

- Bluetooth: for nearby interfacing with e.g. smartphone
- Power Line Communication module (PLC). The ISO 15118-20 (2022) standard specifies that the Control Pilot can also be used for additional functionality for AC chargers, see also section 1.6.2 ‘Communication with EV’ is the Task 1 report. These new features are:
    - Bidirectional charging: the Power Line communication over the Control Pilot signal can also be used to control the bidirectional On-Board Chargers in EVs.
    - Allowing the utilization of EV batteries for storage of renewable energy
    - Plug And Charge: automatic authentication and payment when connecting an EV to a recharging station using Power Line Communication over the Control Pilot signal.

This optional hardware can allow:

- User authentication
- Smart Charging / load balancing

- Plug And Charge
- Bidirectional charging
- Grid code support features

4.1.6 Mode 3 EVSE brought on the market as a product versus an installed system

Because a mode 3 EVSE is an installed product the installer can also assemble onsite any other electrical installation composed of its components (breaker, contactor, controllers, leakage current detector, wiring). This might be an important consideration for any future product regulation because a mode 3 EVSE is not always brought as a product with an accountable manufacturer on the market.

Note that in Article 2 of the ESPR (EU) 2024/1781, the following definitions apply:

(1) ‘product’ means any physical goods that are placed on the market or put into service.

(2) component’ means a product intended to be incorporated into another product.

(3) ‘Intermediate product’ means a product that requires further manufacturing or transformation such as mixing, coating or assembling to make it suitable for end-users.

Conclusion:

When setting ‘product’ performance requirements Article 6 of the ESPR (EU) 2024/1781 circumvention might be straightforward by procuring components and on-site assembly.

4.2 DC EV recharging with mode 4 EVSE

When charging an EV battery using an AC charger the AC power must be converted by the On-Board Charger of the EV. The Onboard Charger has a limited conversion power (often 11kW, sometimes up to 22kW).

DC fast recharging stations create a High-Power DC connection to the EV. The conversion from AC to DC takes place in the recharging station. The EV battery can directly be charged using this DC current without any additional conversion in the EV.

Two types of DC recharging station architecture can be distinguished:

- standalone and
- split.

The standalone architecture consists of one single entity containing all necessary hardware for fast charging like the AC/DC converter, control electronics, user interface etc. The output power of a standalone DC Fast Charger typically ranges from 50kW to 400kW.

With the split architecture different units are needed: they can be named as “power units” and “user units”. The user unit provides the physical connection with a large cable (possibly liquid-cooled for very high power) and the DC plug.

The Power unit can be installed at a distance from the user units and contains sufficient AC/DC conversion for multiple user units. Since the location of these power units can be at a distance from the user units, the size can be larger to accommodate high power electronics, cooling installation etc.

Also, mode 4 EVSE can be procured as components and installed onsite, meaning what is discussed for mode 3 in section 4.1.6 will also apply here.

4.3 BNAT trends

4.3.1 V2G/Bidirectional charging

When the adoption of EVs will increase, the risk of grid congestion will also rise. Smart charging and bidirectional charging can be used to counter grid congestion. Smart charging and load balancing are already possible with most available recharging stations.

The ISO15118-20 standard describes the implementation of bidirectional charging. Bidirectional charging will be implemented in many new charging stations either directly or via an upgrade using a plug-in module. [cfr. Base Case BAT-UP]

4.3.2 Renewable Energy charging

The ISO15118-20 standard allows the utilization of EV batteries for storage of renewable energy. This makes it easier for e.g. house-owners to profit from their PV installation.

4.3.3 Plug And Charge option

The multitude of payment options in public recharging stations is not a benefit for the adoption of EVs. The AFIR addresses this issue. A new method is the optional Plug And Charge protocol that allows to an EV to authenticate automatically to a charging network without the needs for RFID cards etc.

4.3.4 OCPI – EV roaming

The Open Charge Point Interface protocol allows CPOs (Charge Point Operators) to interconnect with EMSPs (Electro-Mobility Service Providers). This will allow easy roaming of EV users between different recharging point networks.

The implementation of OCPI would increase affordability and accessibility of charging infrastructure for EV owner.

4.3.5 Megawatt Charging System (MCS)

The Charin organisation is developing the so-called Megawatt Charging System (MCS) to satisfy the market demand of the trucks, buses, industrial or heavy-duty vehicles within a reasonable time and therefore charging stations of up to 3 MW (“Mega chargers”) are being developed with new standards[2].

4.3.6 Wireless EV charging

Recently revised standards are supporting the implementation of wireless charging:

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[2] https://www.charin.global/technology/mcs/

- SAE J2954 “Wireless Power Transfer for Light-Duty Plug-in/Electric Vehicles and Alignment Methodology” [3]
- ISO15118-20 Wireless charging (WPT): the definition of messages to exchange the necessary information between the vehicle and the wireless charger as a supplement of the IEC 61980 protocol. [4]

Prototype technology:

Wireless charging can be an interesting solution for autonomous vehicles with driverless recharging because there is no need for a robot to connect the charging cable. The main challenges are efficiency and to contain electromagnetic radiation. [5, 6]

4.3.7 BNAT: DC grid solutions for EVSE

In principle any power electronic conversion step from AC to DC introduces losses and when integrating recharging with renewable energy or storage an integrated DC microgrid can save conversions and thus losses and material, see Figure 4-5. This can also support the modularity and standardization of split architecture mode 4 EVSE, see section 4.2. Several EU standardization initiatives for DC grids that can host EV recharging are ongoing [7,8].

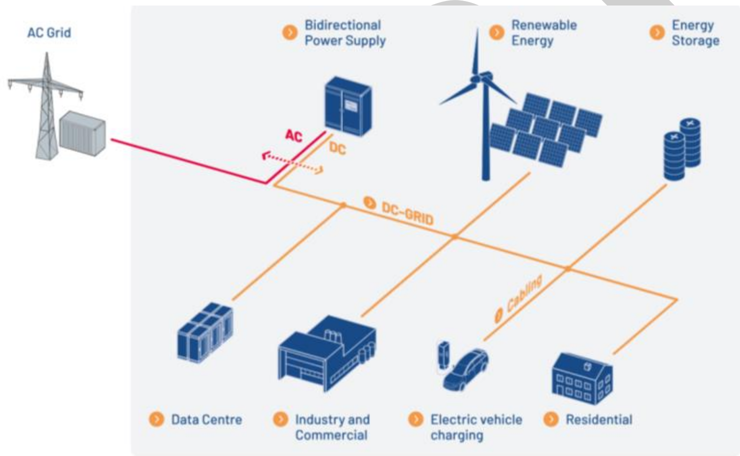

Figure 4-5: DC microgrid with electric vehicle charging (source: ZVEI ODCA[9])

[3] https://www.sae.org/standards/content/j2954_202408/
[4] https://www.iso.org/standard/77845.html
[5] https://electrek.co/2024/10/18/tesla-releases-closer-look-at-its-upcoming-wireless-ev-charger/
[6] https://witricity.com/
[7] https://odca.zvei.org/
[8] https://currentos.foundation/
[9] https://experience.odca.zvei.org/

4.4 Technical aspects affecting environmental performance of AC EV recharging of mode 2-3 EVSE

4.4.1 Base cases and data sourcing

An enquiry was sent to the stakeholders to obtain disaggregated energy consumption data and Best Available Technology (BAT) impact, see section 7.This enquiry asked for disaggregated data per type of secondary function (see Task 1) and operational states. The aim was to aggregate data and preserve anonymity of the manufacturers. Unfortunately, this enquiry did only generate one incomplete response. In order to fill this data gap VITO proceeded to some teardowns and measurements on a set of 5 EVSE available, see section.9 These measurements were contractually not foreseen and only done in the limited extent possible. This means that in the future more data gathering might be needed as well as defining the method.

Note that the Energy Star US ® program offers a method to evaluate the energy consumption of recharging stations and has a product database[10], see Task 1. Energy Star US ® data is not representative for the EU27 market given the differences in available grid voltage, grid frequency, the number of phases and there are other brands and players on the market. Consequently, for this study we had to collect our own data and could not rely simply on US data. Also, this method has some allowances for secondary functions but does not disclose detailed disaggregated data. Nevertheless, where deemed useful we've consulted Energy Star. More information is also in section 8 on Energy Star methods.

There is a broad range of EVSE on the market and the MEErP foresees so called Base Cases (BC). BCs encompass the challenge to model the diverse range of recharging equipment and allow to streamline and collect data. The base-case's characteristics must allow for the multiplication of its LCA and LCC impacts during the use phase, production and distribution, and end-of-life stages based on the MEErP tool.

Given that this is a relative new product group with frequent changes in products brought to the market, it turned out to be difficult to collect reliable, comparable and accurate BAT data. Also, very few input was received on a manufacturing enquiry. Regarding mode 3, it is difficult to compare market data because several products are on the market with different add-on functionality for displays, signage lighting, identification, energy management, payment, etc. The Energy Star data[11] is for the US grid which has different line voltage, frequency and suppliers and was not directly considered representative for the European market. Therefore, we have made the collected data as simple as possible and focus on defining a realistic range of efficiency data for quantifying the potential range of impact of any policy measure in future. Consequently, if one wants to proceed with a minimum energy efficiency performance standard (MEPS) policy the first step will be defining a standard and starting with the obligation to supply data accordingly.

Based on the market and user data the following 3 BCs are proposed, their distinctive properties can be found in table 4.2.

Herein:

- BC1: is an IEC mode 2 mobile charger ("mobile charging adapter") that usually comes with the car and plugged into a standard national (IEC 60083) or industrial (IEC 60309) socket.

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[10] https://www.energystar.gov/productfinder/product/certified-evse-ac-output/results

[11] https://www.energystar.gov/productfinder/product/certified-evse-ac-output/results

- BC2: is a basic IEC mode 3 fixed installed charger fitted with charging cable usually installed at the car owners parking ("home wall box charging adapter").
- BC3: is a fully functional IEC mode 3 public (maybe with limited operating hours) charger typically with two CCS socket outlets.

Table 4-2 Base Cases for Mode 2 and 3 EVSE: distinctive properties

	Base Case 1	**Base Case 2**	**Base Case 3**
Typ. IEC mode	**2**	3	3
Accessibility	Private	Private	Limited Public or Public
Location	At a closed or semi public car park close to home	At home	At workplace parking lot or on the street
Primary application	M1 (Passenger Cars)	M1 (Passenger Cars)	M1 (Passenger Cars) or N1 (Truck or Van <3,5T)
Secondary functions	Features on communication and accessibility	Communication functions: e.g. LAN	WiFi, LTE, RFID, Display, MID Meter but no advanced payment/control system OPCC support and no SIM card(= external system)
Typ. Connection to EV	Socket	EVSE with cable & plug	Socket
Typ. Charging Power	*Normal power (7,4kW-1ph)*	*Normal power (7,4 kW-1ph)*	*Medium power (22 kW - 3ph)*

In Table 4.3 all physical properties of the EVSE are specified for easy comparison between BAU (Business As Usual) and BAT (Best Available Technique) approaches.

Table 4-3 Mode 2 and 3 Base Cases: properties overview

				BC1 BAU	BC2 BAU
Location			Private/public	private	private
Current			AC/DC	AC	AC
Application			LDV,HDV	LDV	LDV
IEC Charging Mode			[-]	2	3
Maximum power output (per EVSE)			[kW]	7.4	7.4
Number of outlets (per EVSE)			[-]	1	1
Standalone/Split architecture			[-]	NA	NA
Charging cable total hose length			[m]	7	5
Useable hose length			[m]		
Cable cooling (y/n)			[y,n]	n	n
Power electronic cooling system			[air/ liquid/ NA]	NA	NA
WIFI/LAN			[y,n]	n	n
Display or signage lighting			[y,n]	n	y
RFID system (e.g. NFC payment system, other, ..)			[y,n]	n	n
Power line digital communication (e.g. mode 4, bidirectional charging, Pn			[y,n]	n	n
Utility grade (MID) meter			[y,n]	n	n
Others (Camera, speakers occupancy sensor,..)		if any specify here	[y,n]	n	n
load balancing between multiple outlets (multiple controllers)			[y,n]	n	n
Modular design			[y,n]	n	n
"	modular/retrofitable PSU		[y,n,NA]	NA	n
	solderless contactor replacement		[y,n]	n	n
	option for power line digital communication		[y,n]	n	n
	any other	if any specify		n	n

4.4.1.1 Base Case 1: Mode 2 Charger

As an average reference product, we consider a mobile charger for mode 2 charging using a domestic plug on the grid side and a Mode 2 plug on the EV side.

This mobile charger will have signage lighting as a bare minimum user interface.

Optionally, such a mobile charger can have a display, WLAN or Bluetooth for connection with a smart phone app, and/or other auxiliary features.

The spreadsheet (Table 4-3) allows to list the optional features and their power consumption separately.

Note that cable losses were excluded from the base case reference data set, because:

- In general, this improvement potential has already been part of a preparatory study[12] and can easily be calculated.

[12] https://erp4cables.net/

- For BC1-3 they are mostly relevant for the cable external losses within the longer cabling inside the building or parking but far less in the last flexible cable section 5-7 m. See also section
- BC3 hasn't a cable but uses socket and thus neglected for simplification and streamlining data between BC1-3.
- For the sake of completeness cables losses will be discussed at system level in section 4.4.6 and at product level in section 4.4.2.
- BAU was the worst case measured in the laboratory from a set of 3 devices tested, see Annex 8.

4.4.1.2 Base Case 2: Mode 3 AC Charger for Home Use

In Base Case 2 we observe a wall box charger for EV charging at home via Mode 3.

For the Base Case these chargers will have a network interface for interaction with a smartphone app (either via cloud or directly).

Optional features for home use are e.g. a display and RFID card reader. See also Task 1 report on the secondary functions (§ 1.4.3).

Note that cable losses were excluded from the base case reference data set for the reasons mentioned in BC2.

BAU for stand by power consumption was the worst case measured in the lab, see Annex 8. The Bill of Material data used for BC2 is included in Table 4-6 was sourced from PEP_LGRP-01620-V01.01-EN[13].

4.4.1.3 Base Case 3: Mode 3 AC Charger for Public Use

In Base Case 3 we observe a wall box charger for EV charging in public spaces (that may have limited operating hours) via Mode 3 charging.

These chargers need a network interface, a display and an RFID card reader for user authentication and billing. Also, Utility Grade Metering is considered as required for the Base Case 3.

An important difference between BC2 and BC3 are sockets with cable locks that could contribute to significant losses in active stand by or on mode when the car is connected. Tests were performed to evaluate the operation and energy consumption of cable locks. Several devices under test showed no savings in standby indicating that bistable cable locks may already be BAU and therefore will not necessarily provide energy savings as BAT.

In BC3 no cables are used and thus cables losses are not considered.

The purpose of this study is not to compare brands and therefore data has been aggregated and anonymised.

The Bill of Material data used for BC3 is based on twice BC2 with a negative correction for the cable which is not part of BC3.

[13] https://assets.legrand.com/pim/DOCUMENT/LGRP-01620-V01.01-EN.pdf

4.4.2 Increased conversion efficiency and lower stand-by power

Acronym: BC1 BAT EFF1, BC1 BAT EFF2, BC2 BAT EFF, BC3 BAT EFF

The comparison of these Best Available Techniques on efficiency with the Base Cases is given in Table 4-5.

The data sources show differences in standby power of over 100% in standby power consumption for EV Recharging equipment with the same functionality.

The base cases are selected to have an average performance with regards to power consumption.

The Best Available techniques will then be applied to these base cases.

Mode 2 chargers have a very limited functionality. Also because of waterproofing, they are not built to be opened or repaired. Therefore, the assumption is made that the differences in efficiency will be originating from the power supply and the control electronics.

This will be studied in [BAT BC1 EFF1].

Each EVSE requires a contactor to switch the AC current path between Recharging Point and the On-Board Charger [OBC] of the EV. A standard contactor will require a hold current. As a second step an additional efficiency gain can be made by replacing the contactor by a bistable contactor. Since a bistable contactor requires no hold current, it is assumed that the power consumption for the contactor is zero. This additional improvement is evaluated in [BAT BC1 EFF2].

In Base Case 2 we consider a basic Home Wall-Box Charger with an attached charging cable. Again, large differences in power consumption are observed. Similar efficiency gains as in [BC1 EFF2] will be applied and studied in [BAT BC2 EFF].

In [BC3 EFF] the most efficient technology is taken into account for Base Case 3.

Notes about the cable losses in BC1 and BC2:

- As mentioned before in section 4.4.1 these losses are not included in the tables of collected BC1&2 data. BC3 has no cable and uses sockets.
- Cable losses are of course only present in the ‘on mode’ while recharging.
- Cable losses are proportional to the cables cross sectional area (CSA)[14] and simply the losses will decrease with the amount of copper used.
- The standard EN 50620 on charging cables for electric vehicles and cable applies and cable designation is H07BZ5-F and maximum cable power, and losses are included in Table 4-4.
- These cable losses are still insignificant compared to system losses in the electrical installation itself because of longer cables, see section 4.4.6.

Table 4-4 charging cables for electric vehicles (EN50620) with maximum power resistance and losses

cable type	Max. Power	Max. current (A)	R (Ohm/m) @ 20°C	typ. cable length(m)	Max. loss (W)
3G2,5 + 1 x 0,5	4,7	20	0,00798	7	44,7
3G6,0 + 1 x 0,5	7,4	32	0,00330	5	33,8
5G6,0 + 1 x 0,5	22	32	0,00330	5	50,7

[14] https://erp4cables.net/

Table 4-5: Comparison of these Best Available Techniques on efficiency with the Base Cases

Description				**BC 1 & BAT**			**BC2**		**BC3**	
				BAU	**BAT**	**BAT**	**BAU**	**BAT**	**BAU**	**BAT**
				BC1 BAU	**BAT EFF1**	**BC1 EFF2**	**BC2 BAU**	**BC2 EFF**	**BC3 BAU**	**BC3 EFF**
WIFI/LAN			[y,n]	n	n	n	n	n	y	y
Display or signage lighting			[y,n]	n	n	n	y	y	y	y
RFID system			[y,n]	n	n	n	n	n	y	y
Power line digital communication (e.g. mode 4, bidirectional charging, Pn			[y,n]	n	n	n	n	n	n	n
Utility grade (MID) meter			[y,n]	n	n	n	n	n	y	y
Others (Camera, speakers occupancy sensor,..)	if any specify here		[y,n]	n	n	n	n	n	n	n
load balancing between multiple outlets (multiple controllers)			[y,n]	n	n	n	n	n	y	y
Modular design			[y,n]	n			n	n	y	y
"	modular/retrofitable PSU		[y,n,NA]	NA	NA	NA	n	n	y	y
	solderless contactor replacement		[y,n]	n	n	n	n	n	y	y
	option for power line digital communication		[y,n]	n	n	n	n	n	y	y
	any other	if any specify		n	n	n	n	n	Y (credit card)	n
Power "passive standby" total (no vehicle connected)			[W]	3.9	2.4	0.7	4.3	0.8	25	10
Power "passive standby" total (no vehicle connected)		disaggregated	calculated	-	0.0	0.0	3.9	3.9	10.5	0.0
Power "active standby mode" total (EV is not ready to receive enery or supply interrupted due to DRM)			[W]	3.9	2.4	0.7	7.8	0.8	25.0	10.0
Power "active standby mode" total (EV is not ready to receive enery or supply interrupted due to DRM)		disaggregated	calculated	-	0.0	0.0	6.0	4.0	15.0	0.0
Power "Active mode" total (charging or interrupted supply due to load management)			calculated [W]	3.9	2.4	0.7	7.8	0.8	32	10
CAPEX (excl. VAT)			euro	165	165.29	173.55	600.00	630.00	3200.00	3360.00
Extra cost for BAT			%		0%	5%	0%	5%	0%	5%
Installation cost (excl. VAT)			euro	0.00	0.00	0.00	800.00	800.00	3000.00	3000.00

4.4.3 Increased material efficiency

Acronyms: BC2 UP, BC2 PLUG, BC3 LIFE, BC3 REP-

The comparison of these Best Available Techniques on efficiency with the Base Cases is given in Table 4-6.

A modular design allows easy installation and makes repairs easier. It allows to share hardware modules between different product lines.

It can also allow upgrading the functionality of an existing installation at a later time. For example: for the implementation of Plug-To-Charge support and V2G support the chargers will require powerline communication [PLC]. Having this feature available as a pluggable hardware module allows the client to decide when this feature will be useful and therefore worth the investment.

In the Best Available Technique [BC2 UP] the assumption is made that the EVSE is built in a modular way. All functional modules can easily be replaced in case of defect. This leads to an increase in lifetime of 5 years.

The Best Available Technique [BC2 PLUG] is replacing the complete standard wall-box home charger with a simple 16A reinforced wall plug socket. It is assumed that an EV by default has a mode 2 charger supplied with it.

By allowing mode 2 chargers to be connected using an industrial plug (IEC 60309-2 (16 A / 32A single Phase)) at home, the charging power of Mode 2 charging cables can be significantly increased. Having increased charging power would decrease the need for the installation of a full mode 3 EVSE recharging point.

Note: installing a reinforced 16A socket is not allowed in all EU member states, see also the report on task 1.

In [BC3 LIFE] the assumption is made that the Base Case 3 EVSE is built in a modular way for excellent repairability. An additional lifetime of 5 years is taken as a result.

In [BC3 REP-] the assumption is made that the Base Case 3 EVSE is built in an integrated manner. As much functionality as possible is integrated on a single printed circuit board. This makes repairs time consuming, costly and often not worthwhile. A decrease of lifetime of 5 years is taken as a result. *NOTE: REP- is considered as a sensitivity analysis* [SEN-REP-].

Table 4-6: Material efficiency options

	Unit	BC1 BAU	BC2 BAU	BC2 UP	BC2 PLUG	BC3 BAU	BC3 LIFE	BC3 REP-
reference life time (RLT)	[years]	10	10	15	10	10	15	5
Functional Unit over the RLT	[kWh]	28 174	28 174	42 261	28 174	554 800	832 200	277 400
Power supply Unit (PSU) technology mix production mix	[g]		242.99	242.99		606.06	1326.06	606.06
Electronic Controller board (3,08 kg/m²)	[m^2]	0.010	0.009	0.011		0.02	0.02	0.02
Polycarbonate (PC) granulate Technology mix,	[g]	600.0	1959.36	1959.36	8.05	4886.99	8326.99	4886.99
Nylon /PA	[g]	0.0	485.98	485.98	73.85	1212.13	1212.13	1212.13
Polyethylene terephthalate (PET)	[g]	0.0	61.71	61.71		153.92	153.92	153.92
Rubber or PBT	[g]	800.0	54.00	54.00		134.68	134.68	134.68
Styrene acrylonitrile (SAN)	[g]	0.0	0.00	0.00		0.00	0.00	0.00
Polypropylene (PP)	[g]	0.0	46.28	46.28	78.40	115.44	115.44	115.44
Epoxy plastic or resin or any other	[g]	0.0	269.99	269.99	17.50	673.40	673.40	673.40
Copper production mix	[g]	990.0	339.42	339.42	7.00	846.56	846.56	846.56
Brass	[g]	0.0		0.00		0.00	0.00	0.00
Cable (60 g/m)	[g]	0.0	1596.80	1596.80		3982.70	3982.70	3982.70
PVC	[g]	0.0		0.00		0.00	0.00	0.00
Fiberglass	[g]	0.0		0.00		0.00	0.00	0.00
Galvanized Steel	[g]	0.0	1157.10	1157.10		2886.02	2886.02	2886.02
Stainless Steel	[g]	0.0		0.00	4.20	0.00	0.00	0.00
Aluminium	[g]	0.0		0.00	3.50	0.00	0.00	0.00
display	[m^2]	0.0	0.00	0.00		0.02	0.02	0.02
wood	[g]	0.0	601.69	601.69		2477.56	2477.56	2477.56
cardboard	[g]	0.0	1103.10	1103.10	280.00	4542.18	4542.18	4542.18
glass	[g]	0.0		0.00		0.00	0.00	0.00
PE	[g]	0.0	15.43	15.43		38.48	38.48	38.48
CAPEX (excl. VAT)	euro	165	600.00	660.00	60.00	3200.00	3360.00	3360.00
Extra cost for BAT	%		0%	10%	-90%	0%	5%	5%
Installation cost (excl. VAT)	euro	0.00	800.00	800.00	140.00	3000.00	3000.00	3000.00

4.4.4 Reducing the impact from energy use by renewable energy sources

Acronym: BC2 RES

Obviously, the environmental impact during the use phase can be reduced by using Renewable Energy Sources (RES), such as photovoltaic or wind energy. Modelling this impact is very simple with the MEErP tool that relies on the EF 3.1 LCA Ecoreport tool database[15] and the following assumptions will be made:

- By default, in the BAU the 'Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV - 60kV (ID 243)' is used in Task 6.
- In BC2 RES the 'Electricity from wind power technology mix of onshore and offshore production mix, at plant 1kV - 60kV (ID 242)' will be used.

NOTE: RES is considered as a sensitivity analysis [SEN-RES*] in Task 6 and not a product related BAT option*

4.4.5 Reducing the impact from distribution by local manufacturing

Acronym: BC2 TR

Obviously, the environmental impact during distribution can be reduced by local manufacturing.

By default, we have assumed local manufacturing as we do not expect large impact. However, as a sensitivity analysis in Task 6 we will assume manufacturing in China, thus:

- 'Transoceanic ship, bulk heavy fuel oil driven, cargo consumption mix, to consumer 100.000- 200.000 dwt payload capacity ocean going (ID 269)' with shipping distance 26000 km.
- 'Articulated lorry transport, Euro 5, Total weight 12-14 t diesel driven, Euro 5, cargo consumption mix, to consumer 12-14t gross weight / 9,3t payload capacity (ID 260)' with shipping distance 1000 km.

NOTE: TR is considered as a sensitivity analysis [SEN-TR] *in Task 6 and not a product related BAT option*

4.4.6 Other system level improvement options for mode 2 and 3 EVSE

Between the electricity distribution grid and the battery in the EV there are more possible losses than the EVSE only. This has been published by ADAC in Germany [16]. Part of their findings is given below.

4.4.6.1 Mode 2 system losses for recharging at 2.3kW

The Mode 2 overall system losses beyond the EVSE are given in Figure 4-6 A.

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[15] Supporting information on environmental impacts - European Commission

[16] https://www.adac.de/rund-ums-fahrzeug/elektromobilitaet/laden/ladeverluste-elektroauto-studie/

The findings are:

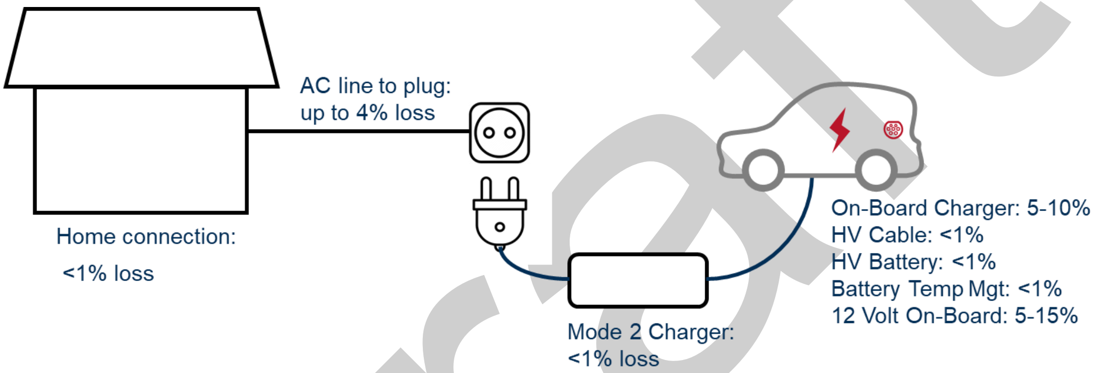
- AC line to plug: a significant loss of energy is already appearing in many homes.
- On-Board Chargers are not very efficient, particularly when running at low power levels, as it is the case with Mode 2 Chargers.
- During the longer charging time, the 12V of the vehicle remains active. This adds to the efficiency loss.

The total losses can vary from 10% to 30%.

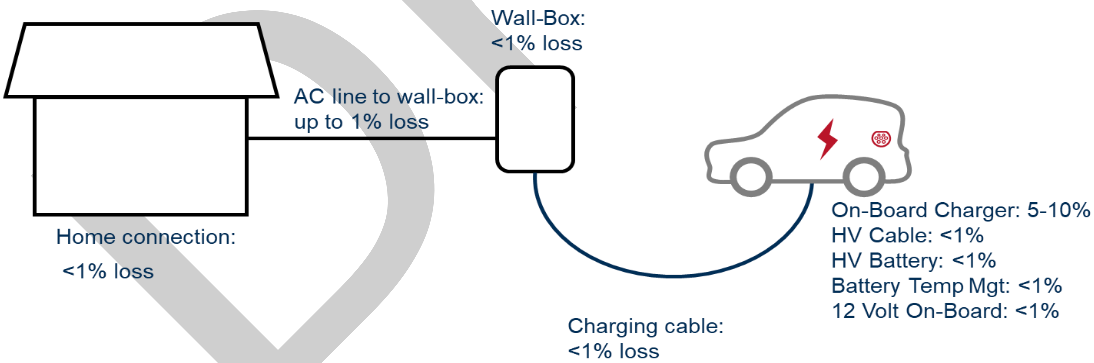
4.4.6.2 Mode 3 system losses for recharging at 11kW

The Mode 3 overall losses beyond the EVSE are given in Figure 4-6 B. The findings are:

- Most of the losses are in the on-board charger.



A



B

Figure 4-6: The losses as measured by ADAC between the home and the EV battery (own drawings, based on footnote 16). A shows Mode 2 charging and B shows Mode 3 charging.

Stakeholder questions related to mode 2 and 3 EVSE Task 4 data collection:

- Are those BAT assumption on energy efficiency impact, correct? If not, do you have any other data you want to share with us?
- Are those BAT assumption on cost impact, correct? If not, do you have any other data you want to share with us?
- TBD?
- Other remarks?

4.5 Technical aspects affecting environmental performance of DC EV recharging of mode 4 EVSE

4.5.1 Base case and data sourcing

There is a broad range of mode 4 EVSE on the market and the MEErP foresees so called Base Cases (BC). BCs encompass the challenge to model the diverse range of recharging equipment and allow to streamline and collect data. The base-case's characteristics must allow for the multiplication of its LCA and LCC impacts during the use phase, production and distribution, and end-of-life stages based on the MEErP tool.

Given that this is a relative new product group with frequent changes in products brought to the market it turned out to be difficult to collect reliable, comparable and accurate BAT data. Also, very few input was received on a manufacturing enquiry. Regarding mode 4, data collection is particularly difficult because there is no European standard and manufacturers report ad hoc in different metrics. Also, this study has foreseen a budget neither to procure nor to test any mode 4 EVSE meaning that the energy data used is based in declared performance but not validated by a standard neither standardized laboratory.

For mode 4 one base case will be elaborated (BC4). We have selected a recent product with a 2022 published Product Environmental Profile (PEP) from a 180 kW fast charger (INGE-00001-V01.01-EN)[17] as BAU BC4. Based on catalogue data, it was judged that this product has similar performance as several other products on the market today (2025). The key benefit of selecting this product was that it has a complete LCA data set that can be entered in the MEErP LCA tool and it can be compared with.

This is a first working draft version of the Task 4 for review and commenting in the stakeholder meeting, after the meeting this LCA/LCC data will be updated and finalized. A summary will be added in the draft final version.
An enquiry was launched to collect data, and this was used in combination with literature and catalogue data, the enquiry is included in section 8.

Important notice:

During this study we remain careful with collecting mode 4 energy efficiency data because a European standard for measuring mode 4 EVSE is missing, more specifically:

[17] https://register.pep-ecopassport.org/

- The Energy Star data[18] is for the US grid which has different line voltage, frequency and suppliers and was not directly considered representative for the European market.
- The Energy Star US ® published for this purpose a Final Test Method for DC-output EVSE (rev. January – 2021)[19] and in principle this method could be used in the EU as well (400 VAC/50Hz). On-mode measurements are done at -7°C, 20°C and 40°C. Standby losses aren't measured at -7°C meaning that defrosting and de-icing losses might be overlooked. Load conditions are 50&150kW and 25%, 50%, 75% and 100 % of the maximum power output available. Therefore, we've also asked in our enquiry for efficiency at 25%, 50%, 75% and 100 % of the maximum power output available.
- There has not been done any comparative for products on the EU market.
- The European mode 4 suppliers include different statements and/or metrics to specify energy efficiency making it impossible to compare products based on catalogue declared data such as peak efficiency, minimum efficiency, typical efficiency, maximum stand-by loss, difference in decimals (95% or 95,0%).
- The typical load profiles (kW vs time) are not publicly available but are important to know how often lower and potentially less efficient loading occurs, e.g. above 80% SOC.
- Most or maybe all today's products work with power converter modules or bricks, ranging from 40 kW to 85 kW each.
- Under 10% load the efficiency of the power converter decreases sharply. However, this range hardly happens since the EV is considered sufficiently charged at the moment that the power lowers. Also, due to the modular design of the power supplies, some units are disabled at lower loads.

As a conclusion, we have kept the collected data as simple as possible and focus on defining a realistic range of efficiency data for quantifying the 'range of impact' of any policy measure in future. As a consequence, if one wants to proceed with a policy option with regard to efficiency the first step will be defining a measurement standard and afterwards introduce the obligation to supply data.

[18] https://www.energystar.gov/productfinder/product/certified-evse-ac-output/results

[19] https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%201.1%20DC%20EVSE%20Final%20Test%20Method.pdf

Table 4-7 Base Case 4 mode 4 EVSE DC fast charger general product specifications and functions

					BC4 BAU
General product information	Location			Private/public	public
	Current			AC/DC	DC
	Application			LDV,HDV	LDV
	IEC Charging Mode			[-]	4
	Maximum power output (per EVSE)			[kW]	180
	Number of outlets (per EVSE)			[-]	2
	Standalone/Split architecture			[-]	Standalone
	Charging cable total hose length			[m]	7
	Useable hose length			[m]	4,6
	Cable cooling (y/n)			[y,n]	n
	Power electronic cooling system			[air/ liquid/ NA]	air
Secondary functions or features	WIFI/LAN			[y,n]	y
	Display or signage lighting			[y,n]	y
	RFID system			[y,n]	y
	Power line digital communication (e.g. mode 4, bidirectional charging, PnC,..)			[y,n]	y
	Utility grade (MID) meter			[y,n]	y
	Others (Camera, speakers occupancy sensor,..)	if any specify here		[y,n]	n
	load balancing between multiple outlets (multiple controllers)			[y,n]	y
	Modular design			[y,n]	y
	"	modular/retrofitable PSU		[y,n,NA]	y
	"	solderless contactor replacement		[y,n]	n
	"	option for power line digital communication		[y,n]	y
	"	any other	if any specify		
	Power "passive standby" total (no vehicle connected)			[W]	80
	Power "Active mode" total (charging or interrupted supply due to load management)			calculated [W]	NA

4.5.2 BC 4 increased conversion efficiency and lower stand by power

Acronym: BC4 BAT AC/DC

In consultation with stakeholders and own experience with converters, the following aspects have been identified that can increase AC/DC conversion efficiency:

- Use of wide band gap semiconductors such as SiC[20] to reduce both so-called conducting and switching losses.
- Use of low loss magnetics and copper conductors.
- Optimization of the power electronic converters losses by redesign and EMC testing considering product lifetime and reliability. For power converters this is complex due to the interactive effects between semiconductors, passive magnetics components, conductors and the cooling systems. It means that for example lower switching losses in a semiconductor part could result in higher losses in another magnetic filter part etc. Also, the copper conductor resistance increases with temperature as opposed to the semiconductor resistance which decreases with temperature meaning that thermal design and optimization matters. Moreover, when increasing the temperature of semiconductors, the

[20] https://www.iea-4e.org/pecta/publications/wide-band-gap-technology-timing-of-most-beneficial-policy-measures-4e-power/

impact on lifetime needs to be considered as well and some design trade-offs might be needed. Also switching frequency, PCB design, compactness and EMC compliance needs to be optimized.

- Keep the flexible supply cable with the vehicle connector as short as possible.
- Use of a modular power supply with a load management system to achieve a constant high efficiency over a wide range of loads (10%-100%).
- Use load profile statistics and forecasts for load balancing the available supply over multiple charging outlets.
- Larger copper section and cable cooling for high power operation to decrease copper losses.
- Variable speed cooling system or fans.

The following aspects are identified to reduce stand by losses:

- Efficient display and touch screen including heating for anti-condensation/frost.
- Efficient modular power supply design, control circuits and idle mode management of auxiliary features.
- Management of the cooling and heating system

Although the BC BAU is already efficient (94,2%) we assume that the following improvement is possible, see Table 4-8. The efficiency loss of 5.8% can be reduced with 2.5%.

Table 4-8 BC4 BAT assumptions for increased conversion efficiency and stand by power

				BC	BAT
				BC4 BAU	BC4 AC/DC
				15	16
Energy performance parameters	Power "passive standby" total (no vehicle connected)		[W]	80,0	50,0
	Power "active standby mode" total (EV is not ready to receive enery or supply interrupted due to DRM)		[W]	80,0	50,0
	Active mode: Efficiency (average) = Pout/Pin		[%]	94,2%	96,7%
Cost	CAPEX (excl. VAT)		euro	70000,00	77000,00
	Extra cost for BAT		%	0%	10%
	Installation cost (excl. VAT)		euro	20000,00	20000,00

4.5.3 BC4 material efficiency improvement option

Acronym: BC4 REP-

There are some stakeholder concerns about reduced lifetime due to availability of spare parts and/or software updates for mode 4 fast chargers. Note that this is a concern but not a pending practice and most EU vendors today have excellent after-sales support.

The following repair parts are reported:

- Cable breaks are common
- Failed displays but sometimes also upgrades to more attractive displays
- Chillers (if any) for liquid cooled cables
- Fuses and contactors

- Air filters for air cooling are a consumable and regularly replaced
- AC/DC power converter module (less frequent)

Because those products are very new and reliable and accurate failure statistics are missing, this study will use as a negative proxy a lifetime reduction relative to the BC4 BAU data, see Table 4-9. It is a negative assumption that can be used to quantify the impact for back-stop policy in Task 7 (if any).

NOTE: REP- is considered as a sensitivity analysis [SEN-REP-]

Table 4-9 BC4 BAT assumptions for material efficiency improvement options

	Description		BC	BAT
			BC4 BAU	BC4 rep-
			15	18
	reference life time (RLT)	[years]	10	5
Bill of Material for LCA	Power supply Unit (PSU) technology mix production mix	[g]	179198,53	179198,53
	Electronic Controller board (3,08 kg/m²)	[m²]	0,000	0,000
	Polycarbonate (PC) granulate Technology mix,	[g]	3543,91	3543,91
	Nylon /PA	[g]	2722,13	2722,13
	Polyethylene terephthalate (PET)	[g]	2670,77	2670,77
	Rubber or PBT	[g]	1284,03	1284,03
	Styrene acrylonitrile (SAN)	[g]	0,00	0,00
	Polypropylene (PP)	[g]	0,00	0,00
	Epoxy plastic or resin or any other	[g]	0,00	0,00
	Copper production mix	[g]	5495,63	5495,63
	Brass	[g]	1027,22	1027,22
	Cable (60 g/m)	[g]	0,00	0,00
	PVC	[g]	16692,33	16692,33
	Fiberglass	[g]	308,17	308,17
	Galvanized Steel	[g]	42886,44	42886,44
	Stainless Steel	[g]	194915,00	194915,00
	Aluminium	[g]	1027,22	1027,22
	display	[m²]	0,02	0,02
	wood	[g]	28402,63	28402,63
	cardboard	[g]	410,89	410,89
	glass	[g]	0,00	0,00
	PE	[g]	0,00	0,00
	Any other? specify	[g]	0,00	0,00
Cost	CAPEX (excl. VAT)	euro	70000,00	70000,00
	Extra cost for BAT	%	0%	0%
	Installation cost (excl. VAT)	euro	20000,00	20000,00

4.5.4 System level improvement potential for mode 4 EVSE

Although outside the direct product scope of mode 4 EVSE recharging equipment the following system level improvement potential is identified:

- To keep the charging cables short, it would be beneficial of all cars have their charging ports at the same location.
- To influence user behaviour discouraging EV DC fast charging above 80 % SOC to avoid low efficiency operation in the charger.

- Mode 4 EVSE need an isolated IT or unearthed grid, one could rely in the MV/LV transformer for this and use a transformerless converter for charging since transformers have an inherent efficiency loss.
- No-load losses in MV/LV transformers are relatively high compared to stand-by power of the EVSE and low-loss specific rectifier transformers could be considered.
- A roof above the charging station can reduce screen illumination power but can also be beneficial for defrosting/de-icing due to radiative cooling at night.
- Signage lighting intensity should match with the outdoor illumination or street lighting.

A short description of other options but not modelled as being outside the system scope:

A roofed or indoor Mode 4 Recharging Station could be built with less materials since demands on resisting weather conditions etc would be less strict. However, since most Mode 4 will be placed outside in public spaces, an indoor version is considered out of scope.

This system level improvement is outside the scope of product policy for setting minimum product performance requirements and therefore currently no data is collected for the impact modelling.

Stakeholder questions related to EVSE mode 4 Task 4 data collection:

- Are those BAT assumption on energy efficiency impact, correct? If not, do you have any other data you want to share with us?
- Are those BAT assumption on material efficiency impact, acceptable? If not, do you have any other more accurate data you want to share with us?
- Are those BAT assumption on cost impact, correct? If not, do you have any other data you want to share with us

5 Environment & Economy

5.0 Introduction

This section calculates the environmental and economic impact on the base-case by means of the Ecoreport calculations tool for Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) modelling.

This tool is made available as a spreadsheet on the website of the EC. It can be found on: https://single-market-economy.ec.europa.eu/industry/sustainability/sustainable-product-policy-ecodesign_en

Data was obtained from prior tasks.

Based on the new LCA data tool[23] used it can be concluded that with regards to the climate change metric (CO2eq) the use phase and thus losses are the major contributor (>76 %) for all base cases and thus confirmed the focus on reducing energy losses put forward in the 2022-2024 Ecodesign working plan[23].

5.1 Life Cycle Assessment of the Base Cases

The Life Cycles Analysis (LCA) were done according to the MEErP using the Ecoreport tool[21]. This tool calculates the impacts originated by the Bill-of-Materials (BoM), energy and other resources used during product manufacturing, packaging, distribution, maintenance and repair, and end-of-life (EoL).

The Ecoreport tool uses some key aspects of the Environmental Footprint (EF) method and calculates the 16 EF impact categories, see Figure 5-1. End-of-Life modelling is done according to the EF method by using the Circular Footprint Formula (CFF) and metrics.

[21] Sustainable product policy & ecodesign - European Commission

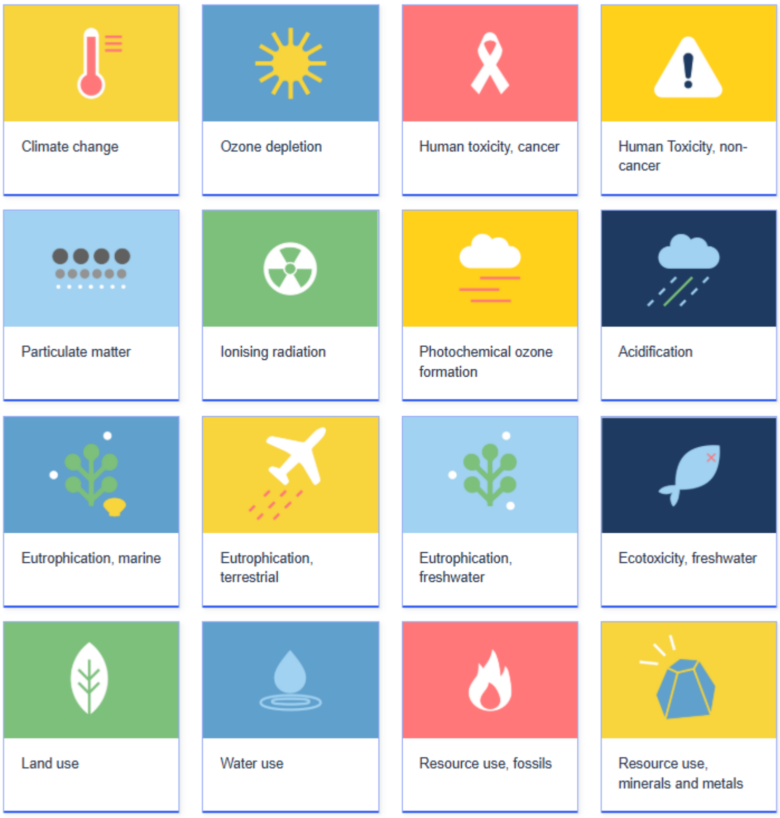


Figure 5-1 The 16 Environmental Impact Categories calculated by the Ecoreport tool (Source: https://green-business.ec.europa.eu/environmental-footprint-methods/life-cycle-assessment-ef-methods_en)

Important notice on simplified use of the new (2024) MEErP tool:

- This product study is based on the previous 2022-2024 working plan[22] based on their energy saving potential, hence this will also be the key focus.
- The revised MEErP tool[23] with new circular economy features based on CFF was not available at the start of this study and currently the tool still needs validation and updates which were ongoing during this study.
- The new circular economy features are related to sophisticated repair/failure statistics and modelling different manufacturing processing steps for LCA combined with CFF and LCC.
- This is a relative new product with relative scarce LCA data and we do not want to overcomplicate LCA with new features but align with the few existing EVSE LCA as they are available.
- These EVSE products are so new that no reliable input data for the complicated CFF metrics exist.

Therefore, as a conclusion, it has been agreed with the EC services that for this study we will use the new MEErP tool in a simplified manner. This means that we will use its LCA EF data but will simplify the CFF modelling .

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[22] C_2022182EN.01000101.xml

[23] Sustainable product policy & ecodesign - European Commission

LCA Ecoreport tools are shared with the EC services and with the respective manufacturers who supplied data. The computed results are included in this task report.

This allows to review and/or update data in case it would be useful in a later stage of policy making (if any).

5.1.1 Base Case 1: AC recharging with Mode 2 EVSE basic

BC1 models the recharging in a Multi Family Home (MFH) or Single-Family Home (SFH) with a IEC Mode 2 mobile charger (“Mobile Charging Adapter”). The results are included in Table 5-1. This is the lowest cost solution. The losses of the AC/DC conversion and battery charger are in mode 2 in the onboard charger (OBC). The OBC is in the car and those losses are scoped out and not included.

Note:

The LCA results included in the Tables (e.g. Table 5-1) are relative (%) to the LCA total and therefore for some LCA indicators values above 100 % can be obtained when there are significant End-of-Life (EoL) credits or benefits, for example due to recycling. Herein BoM or Bill-of-Material represents the manufacturing stage of the product and EoL or End of Life represents the disposal or recycling. EoL credits represent the recycling or reuse benefits, more information can be found in the LCA Ecoreport tool manual[25].

Conclusion:

The use phase dominates the carbon footprint or climate change impact (77%), this is due to the losses and the carbon footprint of electricity.

The carbon footprint (GWP) is 0.007 kgCO2eq/kWh FU energy charged, thus for a car that needs 0.2 kWh/km this top up its carbon footprint with 1.3 g/km. When comparing BC1 to BC4 please note that we’ve discounted car needs to 0.18 kWh/km because they are no OBC losses.

About the other LCA impact indicators apart from carbon footprint (GWP):

- Those are typical for electronic products alike.
- Also, ozone depletion, ionizing ration, eutrophication, water use and fossil fuel use are dominated by the Use phase and related to the electricity mix supplied nuclear power
- Other impact indicators related to the manufacturing. Those are typical due to the use of electronic equipment alike and the improvement is also obtained with the material efficiency improvement options discussed in Task 6.

Table 5-1 LCA results for BC1

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		1,84E+02	22,3%	77,7%	0,0%	-0,1%	**0,007**
Ozone depletion	kg CFC-11 eq		5,40E-08	1,6%	98,4%	0,0%	0,0%	
Human toxicity, cancer	CTUh		4,46E-08	46,9%	53,2%	0,0%	-0,1%	
Human toxicity, non-cancer	CTUh		1,57E-06	69,7%	30,5%	0,0%	-0,3%	
Particulate matter	disease incidence		1,09E-05	58,5%	41,7%	0,0%	-0,2%	
Ionising radiation	kBq U235 eq		6,26E+01	2,9%	97,1%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		3,94E-01	40,6%	59,5%	0,0%	-0,2%	
Acidification	mol H+ eq		1,03E+00	58,1%	42,1%	0,0%	-0,2%	
Eutrophication, terrestrial	mol N eq		1,38E+00	36,9%	63,2%	0,0%	-0,2%	
Eutrophication, freshwater	kg P eq		3,98E-04	26,8%	73,3%	0,0%	0,0%	
Eutrophication, marine	kg N eq		1,30E-01	36,5%	63,7%	0,0%	-0,2%	
Ecotoxicity, freshwater	CTUe		1,02E+03	36,7%	63,9%	0,0%	-0,6%	
Land use	pt		5,60E+04	99,0%	1,1%	0,0%	-0,1%	
Water use	m3 water eq. of deprived water		6,30E+01	22,4%	77,6%	0,0%	0,0%	
Resource use	kg Sb eq		9,18E-03	100,8%	0,4%	0,0%	-1,2%	
Resource use, fossils	MJ		3,09E+03	19,4%	80,6%	0,0%	-0,1%	**BC1 BAU**

5.1.2 Base Case 2: AC recharging with Mode 3 EVSE

BC2 models a Single-Family Home with an EV owner who has installed his own Mode 3 recharging station ("home wall-box charging adapter"). The major convenience is that these recharging stations have a cable and plug connected and can also be connected to the Building Automation and Control System (BACS) (if available). Sometimes part of the energy management system (EMS) of the BACS is integrated within the mode 3 charger itself, but this option is not modelled and included. The losses of the AC/DC conversion and battery charger are in mode 2 in the onboard charger (OBC). The OBC is in the car and those losses are scoped out and not included. The calculation result is shown in Table 5-2.

The LCA results are relative (%) to the LCA total and therefore some LCA indicators' values can rise above 100 % when there are significant End-of-Life (EoL) credits. In this case this is particularly true for the critical resource indicator at manufacturing or BoM(+2021%), meaning that for example the gold content in semiconductors is supposed to be largely recycled at EOL (-1933%).

Conclusion:

The use phase dominates the carbon footprint or climate change impact (78%), this is due to the losses and the carbon footprint of electricity.

See also BC1 most conclusions about other LCA apart from GWP can be reiterated here.

Table 5-2 LCA results for BC2

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	2,23E+02	24,8%	78,8%	0,2%	-3,8%	0,008
Ozone depletion	kg CFC-11 eq	2,08E-07	68,7%	31,4%	0,0%	-0,1%	
Human toxicity, cancer	CTUh	8,12E-08	78,6%	36,0%	0,1%	-14,7%	
Human toxicity, non-cancer	CTUh	4,83E-07	212,1%	122,0%	0,7%	-234,8%	
Particulate matter	disease incidence	1,11E-05	65,1%	50,8%	0,1%	-16,0%	
Ionising radiation	kBq U235 eq	7,74E+01	3,3%	96,8%	0,1%	-0,2%	
Photochemical ozone formation	kg NMVOC eq	4,74E-01	44,7%	60,9%	0,2%	-5,8%	
Acidification	mol H+ eq	1,14E+00	57,8%	46,9%	0,1%	-4,8%	
Eutrophication, terrestrial	mol N eq	1,66E+00	40,7%	65,1%	0,2%	-6,0%	
Eutrophication, freshwater	kg P eq	5,65E-04	47,1%	63,6%	0,1%	-10,8%	
Eutrophication, marine	kg N eq	1,56E-01	40,5%	65,2%	0,2%	-5,9%	
Ecotoxicity, freshwater	CTUe	1,14E+03	44,1%	70,4%	0,1%	-14,6%	
Land use	pt	-5,32E+04	-36,9%	-1,4%	0,0%	138,4%	
Water use	m3 water eq. of deprived water	6,34E+01	21,7%	94,9%	0,3%	-16,8%	
Resource use	kg Sb eq	3,81E-04	2021,1%	11,8%	0,0%	-1932,9%	
Resource use, fossils	MJ	3,81E+03	21,4%	80,5%	0,1%	-2,0%	BC2 BAU

5.1.3 Base Case 3: AC recharging with smart Mode 3 EVSE

BC 3 models a public (maybe with limited operating hours in a shopping centre, etc.) Mode 3 charger with socket connection. The EV user then connects using his own mode 3 cable supplied with the car. The losses of the AC/DC conversion and battery charger are in the onboard charger (OBC). These losses are scoped out and not included.

Conclusion:

The use phase dominates the carbon footprint or climate change impact (68%), this is due to the losses and the carbon footprint of electricity.

See also BC1 most conclusions about other LCA apart from GWP can be reiterated here, however due to the higher losses the use phase is relatively more important.

Table 5-3 LCA results for BC3

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	1,08E+03	13,7%	88,1%	0,1%	-1,9%	0,002
Ozone depletion	kg CFC-11 eq	7,11E-07	50,3%	49,8%	0,0%	-0,1%	
Human toxicity, cancer	CTUh	4,13E-07	68,8%	38,4%	0,0%	-7,2%	
Human toxicity, non-cancer	CTUh	3,01E-06	87,6%	106,0%	0,3%	-93,9%	
Particulate matter	disease incidence	4,51E-05	42,3%	67,4%	0,1%	-9,8%	
Ionising radiation	kBq U235 eq	4,12E+02	1,7%	98,4%	0,0%	-0,1%	
Photochemical ozone formation	kg NMVOC eq	2,07E+00	27,8%	75,4%	0,1%	-3,3%	
Acidification	mol H+ eq	4,52E+00	38,7%	64,3%	0,1%	-3,0%	
Eutrophication, terrestrial	mol N eq	7,42E+00	24,6%	78,7%	0,1%	-3,3%	
Eutrophication, freshwater	kg P eq	2,55E-03	29,7%	76,2%	0,1%	-6,0%	
Eutrophication, marine	kg N eq	7,00E-01	24,5%	78,7%	0,1%	-3,3%	
Ecotoxicity, freshwater	CTUe	5,23E+03	24,8%	83,0%	0,1%	-7,9%	
Land use	pt	-1,30E+05	-38,6%	-3,2%	0,0%	141,8%	
Water use	m3 water eq. of deprived water	3,35E+02	10,6%	97,2%	0,1%	-7,9%	
Resource use	kg Sb eq	1,57E-03	1253,2%	15,4%	0,0%	-1168,6%	
Resource use, fossils	MJ	1,86E+04	11,6%	89,4%	0,1%	-1,0%	BC3 BAU

5.1.4 Base Case 4: DC recharging with Mode 4 EVSE

BC4 models IEC mode 4 EVSE or so-called DC fast chargers. DC fast chargers are typically located in public places (highway parking, shopping centres...). The losses of the charger are included. Therefore, also the carbon footprint per Functional Unit or delivered energy is much higher in BC4 (25 gCO_2eq/kWh) versus BC3 (2 gCO_2eq/kWh), see Table 5-4.

Conclusion:

The use phase dominates the carbon footprint or climate change impact (99%), this is due to the losses and the carbon footprint of electricity.

The carbon footprint (GWP) is 0.025 kgCO2eq/kWh FU energy charged, thus for a car that needs 0.18 kWh/km for DC charging this top up its carbon footprint with 4.5 g/km. When comparing BC1 to BC4 please note that we've discounted car needs to 0.18 kWh/km because they are no OBC losses.

See also BC1 some conclusions about other LCA apart from GWP can be reiterated here, however due to the higher losses the use phase is relatively more important in nearly all indicators.

Table 5-4 LCA results for BC4

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		4,89E+05	1,1%	99,1%	0,0%	-0,3%	0,025
Ozone depletion	kg CFC-11 eq		1,81E-04	0,4%	99,6%	0,0%	0,0%	
Human toxicity, cancer	CTUh		1,49E-04	108,2%	54,0%	0,0%	-62,2%	
Human toxicity, non-cancer	CTUh		1,70E-03	6,2%	95,4%	0,0%	-1,7%	
Particulate matter	disease incidence		1,58E-02	3,8%	97,5%	0,0%	-1,3%	
Ionising radiation	kBq U235 eq		2,06E+05	0,1%	99,9%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		8,06E+02	2,0%	98,5%	0,0%	-0,5%	
Acidification	mol H+ eq		1,51E+03	3,4%	97,6%	0,0%	-1,0%	
Eutrophication, terrestrial	mol N eq		3,01E+03	1,8%	98,6%	0,0%	-0,4%	
Eutrophication, freshwater	kg P eq		1,02E+00	2,9%	97,2%	0,0%	-0,1%	
Eutrophication, marine	kg N eq		2,83E+02	1,7%	98,6%	0,0%	-0,4%	
Ecotoxicity, freshwater	CTUe		2,22E+06	1,4%	99,3%	0,0%	-0,6%	
Land use	pt		1,70E+06	19,1%	122,7%	0,0%	-41,8%	
Water use	m3 water eq. of deprived water		1,66E+05	0,8%	99,4%	0,0%	-0,2%	
Resource use	kg Sb eq		3,79E-01	129,4%	32,5%	0,0%	-61,9%	
Resource use, fossils	MJ		8,48E+06	0,8%	99,3%	0,0%	-0,2%	BC4 BAU

5.1.5 Validation and comparison of results with LCA literature

The results for BC4 BAU (Table 5-4) and BC2 BAU (Table 5-2) can be compared to the respective Ecopassport® results, see Table 5-6 and Table 5-5. In addition, we can compare a DC EVSE power supply unit computed with the MEErP (Table 5-7 with the declared Environmental Footprint (EF 3.0) of a manufacturer[24] (2x1664 kg CO_2eq/PSU).

There is a very good alignment with data calculated in the MEErP and data found in literature as illustrated for the embedded carbon footprint (GWP) in Table 5-8 for Raw Material and manufacturing or Bill of Material (BoM).

When comparing and using the data, one should be aware that:

[24] https://www.phoenixcontact.com/nl-be/producten/dc-vermogensmoduul-charx-ps3ac920dc875kw-1162690

- It is common practice to use the same databases[25] with LCA impact data which can explain the alignment.
- Electronic products manufacturers do not record nor publish accurate impact metrics and generic data from those databases contains proxies and assumptions.
- Also, this study used assumptions and proxies for materials and processes which aligns with common practice.
- None of the databases so far has accurate date for SiC semiconductors (see earlier footnote 20) and thus we must be careful by interpreting the impact in Task 6 because this manufacturing effect is neglected.
- Within the MEErP we have used ‘Electricity grid mix 1kV-60kV technology mix consumption mix’ (ID 243) that has an LCA carbon footprint of 0.419 $kgCO_2eq/kWh$ which is relatively high. Due to this we will also cross-check in Task 6 the impact of using ‘Wind Power’ (ID 242) which only has a carbon footprint of 0.009 $kgCO_2eq/kWh$.

Table 5-5 PEP Ecopassport ® PEP_LGRP-01620-V01.01 per FU or 28174 kWh supplied for comparison to BC2

	Total for Life cycle		Raw material and manufacture		Distribution		Installation		Use		End of life	
Global warming	1,06E-02	$kgCO_2$ eq.	1,99E-03	19 %	1,06E-05	< 1%	1,24E-05	< 1%	8,61E-03	81 %	2,25E-05	< 1%
Ozone depletion	7,44E-10	kgCFC-11 eq.	1,83E-10	25 %	2,15E-14	< 1%	2,45E-14	< 1%	5,61E-10	75 %	5,09E-13	< 1%
Acidification of soils and water	3,90E-05	$kgSO_2$ eq.	2,94E-06	8 %	4,78E-08	< 1%	1,53E-08	< 1%	3,59E-05	92 %	8,72E-08	< 1%
Water eutrophication	3,18E-06	$kg(PO_4)^{3-}$ eq.	8,92E-07	28 %	1,10E-08	< 1%	5,95E-09	< 1%	2,17E-06	68 %	1,07E-07	3 %
Photochemical ozone formation	2,34E-06	kgC_2H_4 eq.	3,60E-07	15 %	3,39E-09	< 1%	1,33E-09	< 1%	1,97E-06	84 %	6,76E-09	< 1%
Depletion of abiotic resources - elements	3,21E-07	kgSb eq.	3,20E-07	100 %	4,25E-13	< 1%	1,22E-13	< 1%	7,48E-10	< 1%	1,37E-12	< 1%
Total use of primary energy	2,07E-01	MJ	3,44E-02	17 %	1,50E-04	< 1%	4,60E-05	< 1%	1,72E-01	83 %	2,51E-04	< 1%
Net use of fresh water	3,13E-02	m^3	9,46E-05	< 1%	9,52E-10	< 1%	1,95E-08	< 1%	3,12E-02	100 %	1,77E-08	< 1%
Depletion of abiotic resources - fossil fuels	1,14E-01	MJ	1,62E-02	14 %	1,49E-04	< 1%	4,49E-05	< 1%	9,77E-02	85 %	2,28E-04	< 1%
Water pollution	9,43E-01	m^3	5,83E-01	62 %	1,75E-03	< 1%	5,94E-04	< 1%	3,55E-01	38 %	2,65E-03	< 1%
Air pollution	6,16E-01	m^3	2,43E-01	39 %	4,36E-04	< 1%	1,87E-04	< 1%	3,71E-01	60 %	2,46E-03	< 1%

[25] https://single-market-economy.ec.europa.eu/industry/sustainability/sustainable-product-policy-ecodesign/supporting-information-environmental-impacts_en

Table 5-6 PEP Ecopassport ® INGE-00001-V01.01-EN per FU or 19710000kWh supplied for comparison to BC4

ENVIRONMENTAL IMPACTS INDICATORS- MANDATORY

Indicator	Units	Raw material and manufacture	Distribution	Installation	Use	End of life	Total
GWP - total	kg CO2e	2,52E-04	2,58E-06	3,44E-07	1,21E-02	1,54E-05	1,24E-02
GWP - fossil	kg CO2e	2,51E-04	2,57E-06	2,83E-07	1,20E-02	1,54E-05	1,23E-02
GWP - biogenic	kg CO2e	7,40E-07	7,42E-10	6,13E-08	5,03E-05	1,81E-08	5,11E-05
GWP - luluc	kg CO2e	4,33E-07	1,05E-09	1,09E-10	9,17E-05	1,11E-08	9,21E-05
ODP	kg CFC 11 eq.	1,99E-11	5,99E-13	6,03E-14	1,28E-09	1,41E-12	1,31E-09
AP	mol H eq.	3,30E-06	1,20E-08	1,30E-09	5,77E-05	4,98E-08	6,11E-05
EP - freshwater	kg P eq.	2,76E-07	1,66E-10	2,21E-11	3,25E-06	3,88E-09	3,53E-06
EP - marine	kg N eq.	4,15E-07	3,53E-09	7,28E-10	1,07E-05	1,40E-08	1,12E-05
EP - terrestrial	mol N eq.	4,08E-06	3,87E-08	4,79E-09	1,08E-04	1,29E-07	1,13E-04
POCP	kg NMVOC eq.	1,11E-06	9,56E-09	1,17E-09	2,70E-05	3,24E-08	2,81E-05
ADPe	kg Sb eq.	6,73E-08	8,92E-12	9,10E-13	2,11E-07	7,47E-11	2,78E-07
ADPf	MJ	3,36E-03	3,91E-05	3,98E-06	4,63E-01	1,53E-04	4,67E-01
WDP	m3	1,19E-04	1,15E-07	2,23E-08	8,32E-03	3,23E-06	8,45E-03

Table 5-7 MEErP results for 2 x PSU CHARX PS/3AC/920DC/87.5KW

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		4,88E+05	0,7%	99,3%	0,0%	0,0%	0,025
Ozone depletion	kg CFC-11 eq		1,80E-04	0,1%	99,9%	0,0%	0,0%	
Human toxicity, cancer	CTUh		9,63E-05	16,6%	83,5%	0,0%	-0,1%	
Human toxicity, non-cancer	CTUh		1,67E-03	3,6%	96,9%	0,0%	-0,6%	
Particulate matter	disease incidence		1,58E-02	2,4%	97,7%	0,0%	-0,1%	
Ionising radiation	kBq U235 eq		2,06E+05	0,1%	99,9%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		8,05E+02	1,4%	98,6%	0,0%	-0,1%	
Acidification	mol H+ eq		1,51E+03	2,7%	97,5%	0,0%	-0,1%	
Eutrophication, terrestrial	mol N eq		3,00E+03	1,3%	98,8%	0,0%	-0,1%	
Eutrophication, freshwater	kg P eq		1,01E+00	1,9%	98,2%	0,0%	0,0%	
Eutrophication, marine	kg N eq		2,83E+02	1,3%	98,8%	0,0%	-0,1%	
Ecotoxicity, freshwater	CTUe		2,22E+06	1,0%	99,3%	0,0%	-0,4%	
Land use	pt		1,65E+06	0,4%	126,7%	0,0%	-27,1%	
Water use	m3 water eq. of deprived water		1,66E+05	0,5%	99,6%	0,0%	-0,1%	
Resource use	kg Sb eq		3,71E-01	89,1%	33,3%	0,0%	-22,4%	
Resource use, fossils	MJ		8,47E+06	0,6%	99,5%	0,0%	0,0%	BC4test

Table 5-8 Comparison of MEErP carbon footprint results from BoM with literature

BC4 versus INGE-00001-V01.01-EN		
GWP BoM per FU	2,52E-04	kg CO2 eq
FU	1,97E+07	kWh
GWP BoM PEP	**4,97E+03**	**kg CO2 eq**
GWP BoM MEErP	**5,60E+03**	**kg CO2 eq**

BC4test versus CHARX PS/3AC/920DC/87.5KW		
GWP BoM per FU	NA	kg CO2 eq
FU	NA	kWh
GWP BoM EF 3.0	**3,33E+03**	**kg CO2 eq**
GWP BoM MEErP	**3,62E+03**	**kg CO2 eq**

BC2 versus PEP_LGRP-01620-V01.01-EN		
GWP BoM per FU	1,99E-03	kg CO2 eq
FU	2,82E+04	kWh
GWP BoM PEP	**5,61E+01**	**kg CO2 eq**
GWP BoM MEErP	**5,53E+01**	**kg CO2 eq**

5.2 Life Cycle Cost for consumers

A life cycle cost (LCC) calculation provides a summation of all the costs incurred for the end-user along the life cycle of the product. This information is relevant to consumers because this cost can then be related to potential savings. It is used in Task 6 to find the Least Life Cycle Cost (LLCC) for the identified design options.

The LCC is a concept that aims to estimate the full cost of a system. Therefore, the Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) are calculated. CAPEXstart is used to indicate EVSE acquisition costs and is mainly comprised of product costs. The cost for decommissioning is expressed as CAPEXeol. The OPEX is the ongoing cost of running the EVSE and consists of costs for replacement services and electricity costs for energy losses.

The purpose of the discount rate in LCC calculations is to convert all life cycle costs to their net present value (NPV) considering OPEX for energy and other consumables.

The LCC in MEErP studies is calculated using the following formula:

$$LCC\,[€] = CAPEX\text{start} + PWF\ x\ OPEX + CAPEXeol\,(1+r)^{N}$$

Where:

- LCC is the life cycle costing,
- CAPEXstart is the total purchase price (including installation) or so-called capital expenditure.
- CAPEXeol is the decommissioning cost at the End-of-Life.
- OPEX are the total operating expenses per year or so-called operational expenditure.
- PWF is the present worth factor with PWF = = $(1 – 1/(1+ r)^{N})/r$ or N if r=0.
- N is the product life in years.

- r is the discount rate which represents the return that could be earned in alternative investments.

Note that for this product CAPEXeol is assumed to be included in the installed product price in line with the extended producer responsibility principle of the WEEE Directive.

The LCC has been calculated in line with the MEErP formulas and economic parameters of Task 2 and results are in Table 5-9.

Table 5-9 LCC calculated for all BCs BAU

			BC1 BAU	BC2 BAU	BC3 BAU	BC4 BAU
CAPEX (excl. VAT)		euro	165	600,00	3200,00	70000,00
Extra cost for BAT		%		0%	0%	0%
Installation cost (excl. VAT)		euro	0,00	800,00	3000,00	20000,00
Discount rate (interest minus inflation)		%	3%	3%	3%	3%
Escalation rate (project annual growth of running costs)		%	2%	2%	2%	2%
Electricity rate		euro/kWh	0,29	0,29	0,19	0,19
PWF			9,48	9,48	9,48	9,48
Life Cycle Cost (LCC)		euro	258,90	1515,22	6603,29	294719,54
LCC/FU		euro/kWh	0,009	0,054	0,012	0,015
CAPEX share in LCC		%	64%	40%	48%	24%

Preliminary conclusions:

- It should be noted that we have selected worst case losses for the base cases which should inflate OPEX, nevertheless for all base cases the CAPEX seems to dominate the LCC cost per functional unit or delivered kWh (LCC/FU). CAPEX is 24 to 64 % of all LCC. This means that for the electrification of transport the challenge is often rather to keep control over the cost of recharging infrastructure compared to controlling its losses.
- The LCC/FU in €/kWh remains low compared to the electricity rate in €/kWh, meaning that for recharging it remains more important to supply low-cost electricity.

5.3 Life Cycle Cost for society

This is an upscaled cost of LCC considering external costs such as GWP or carbon emission. The societal life cycle cost is a sum of direct environmental costs, externalities and other indirect costs. The calculations are based on the following formula:

Societal LCC = LCC consumer + LCC ext.damages

Where:

- LCC ext.damages = PP damages + N* OEdamages+ EoLdamages
- PPdamages = Impacts (GWP in kg CO2 eq., AP in kg SO2 eq., etc.) in Production and Distribution phase x Damage unit value (in €/kg)
- OEdamages = Impacts in Use Phase x Damage unit value
- EoLdamages = Impacts in End-of-Life Phase x Damage unit value
- N is the product life in years.

Applying this on BC3, results in LCC as reported in Table 5-10 versus societal LCC in Table 5-11. As can be concluded 673 euro is little more compared to 660 euro and therefore for this product group, we can further neglect societal LCC. Moreover, the societal cost did not cover the indirect benefits of transport electrification and therefore also we suggest to not consider this societal cost anymore further within this study.

Table 5-10 LCC for BC3 BAU as reported in the Ecodesign calculation template

Table . Life Cycle Costs per product and Total annual expenditure (2005) in the EU-27

	Products Item	LCC new product
D	Product price	3.200
E	Installation/ acquisition costs (if any)	3.000
F	Fuel (gas, oil, wood)	0
F	Electricity	40
G	Water	0
H	Auxiliary material 1	0
I	Auxiliary material 2	0
J	Auxiliary material 3	0
K	Auxiliary material 4	0
L	Auxiliary material 5	0
M	Repair & maintenance costs	0
	Total	**660**

Table 5-11Societal LCC for BC3 BAU as reported in the Ecodesign calculation template

Table . Societal Life Cycle Costs per product and Total annual expenditure (2005) in the EU-27

	Item	LCC new product
D	Product price	3.200
E	Installation/ acquisition costs (if any)	3.000
F	Fuel (gas, oil, wood)	0
F	Electricity	40
G	Water	0
H	Auxiliary material 1	0
I	Auxiliary material 2	0
J	Auxiliary material 3	0
K	Auxiliary material 4	0
L	Auxiliary material 5	0
M	Repair & maintenance costs	0
N	**External damages total, of which**	**129,19**
	- production PPext	42,21
	- lifetime operating expense N*OEext	127,80
	- end-of-life OELext	-40,82
	Total	**673**

5.4 EU27 totals and conclusion

This will be elaborated later after concluding on the market data. Preliminary data is included in Table 5-12. To have a notion of impact the values in the table can be compared to the 2022 gross electricity production in the EU which was 2824 TWh. From this data it can be concluded that the sales and stock of BC3 and 4 are likely overestimated as the forecasted energy demand for EV recharging for 2030 and 2040 exceeds the current total EU electricity production.

Table 5-12 EU27 Totals in terms of units recharging points sold and losses (GWh/y) and functional unit (FU) supplied to EV

					BC1 BAU	BC2 BAU	BC3 BAU	BC4 BAU
	Sales in 2030	[million recharging points]			1,65	1,75	3,95	0,12
	Stock in 2030	[million recharging points]			15,50	17,50	11,50	0,70
	Sales in 2040	[million recharging points]			3,15	3,40	7,20	0,40
	Stock in 2040	[million recharging points]			31,50	34,00	23,50	4,25
			Stock 2030	TWh/y	0,53	0,74	2,62	80,96
			Stock 2040	TWh/y	1,08	1,43	5,35	491,52
			Charged FU in 2030	TWh/y	43,67	49,30	638,02	1379,70
			Charged FU in 2040	TWh/y	88,75	95,79	1303,78	8376,75

6 Design Options

6.0 Introduction

The purpose of Task 6 is also to support Art. 5/6/7 of the new ESPR and more specifically:

- Article 5 specifies which types of Ecodesign Requirements can be proposed.
- Article 6 specifies how to set performance requirements, for example minimum energy performance requirements (MEPS) and refers herein to Annex II. Annex II is a procedure for defining performance requirements based on a technical, environmental and economic analysis shall select a number of representative models and this is what we are doing in Task 6.
- Article 7 specifies that also information requirements can be set, this is compared to Article 6 less invasive and therefore does not need the detailed analysis included in Annex II.

Therefore, according to the MEErP we are calculating LCA and LCC based on the improvement options listed in Task 4 and wrap up Least Life Cycle Costs which improves LCA.

This is a 1st working draft version of the Task 6 for review and commenting in the stakeholder meeting, after the meeting this LCA/LCC data for design options will be updated and finalized.

In this version for a summary on MEPS policy options, please consult section 6.5.

6.1 BAT LCA and LCC improvement options

6.1.1 BC1 BAT and LCC

BC1 is an IEC mode 2 mobile charger that usually comes with the car and plugged into a domestic or industrial socket (“mobile charger adapter”).

The calculated LCA results of BC1 options are in Table 6-1 and Table 6-2 and their LCC results in Table 6-3 with their GWP carbon footprint per FU (kg CO_2eq/kWh) for comparison and EU27 totals (TWh/y).

Note that all options result in lowering their GWP carbon footprint.

Table 6-1 LCA BC1 BAT EFF1 option

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		1,28E+02	31,5%	68,5%	0,0%	-0,1%	0,005
Ozone depletion	kg CFC-11 eq		3,36E-08	2,6%	97,4%	0,0%	0,0%	
Human toxicity, cancer	CTUh		3,53E-08	58,7%	41,4%	0,0%	-0,1%	
Human toxicity, non-cancer	CTUh		1,38E-06	78,9%	21,4%	0,0%	-0,3%	
Particulate matter	disease incidence		9,08E-06	69,3%	30,9%	0,0%	-0,2%	
Ionising radiation	kBq U235 eq		3,92E+01	4,6%	95,4%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		3,01E-01	52,3%	47,9%	0,0%	-0,2%	
Acidification	mol H+ eq		8,56E-01	69,0%	31,3%	0,0%	-0,3%	
Eutrophication, terrestrial	mol N eq		1,04E+00	48,4%	51,8%	0,0%	-0,2%	
Eutrophication, freshwater	kg P eq		2,85E-04	37,0%	63,0%	0,0%	-0,1%	
Eutrophication, marine	kg N eq		9,71E-02	47,9%	52,3%	0,0%	-0,2%	
Ecotoxicity, freshwater	CTUe		7,65E+02	48,4%	52,4%	0,0%	-0,8%	
Land use	pt		5,57E+04	99,4%	0,7%	0,0%	-0,1%	
Water use	m3 water eq. of deprived water		4,41E+01	31,8%	68,2%	0,0%	0,0%	
Resource use	kg Sb eq		9,09E-03	100,9%	0,2%	0,0%	-1,1%	
Resource use, fossils	MJ		2,12E+03	27,9%	72,2%	0,0%	-0,1%	BAT EFF1

Table 6-2 LCA BC1 BAT EFF2 option

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		6,61E+01	61,3%	38,9%	0,0%	-0,2%	0,002
Ozone depletion	kg CFC-11 eq		1,04E-08	8,4%	91,6%	0,0%	0,0%	
Human toxicity, cancer	CTUh		2,50E-08	83,1%	17,1%	0,0%	-0,2%	
Human toxicity, non-cancer	CTUh		1,17E-06	92,9%	7,3%	0,1%	-0,3%	
Particulate matter	disease incidence		7,09E-06	88,7%	11,5%	0,0%	-0,3%	
Ionising radiation	kBq U235 eq		1,27E+01	14,1%	85,9%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		1,99E-01	79,2%	21,2%	0,0%	-0,3%	
Acidification	mol H+ eq		6,67E-01	88,6%	11,7%	0,0%	-0,3%	
Eutrophication, terrestrial	mol N eq		6,58E-01	76,5%	23,9%	0,0%	-0,3%	
Eutrophication, freshwater	kg P eq		1,58E-04	66,9%	33,2%	0,0%	-0,1%	
Eutrophication, marine	kg N eq		6,11E-02	76,1%	24,2%	0,0%	-0,3%	
Ecotoxicity, freshwater	CTUe		4,81E+02	76,9%	24,3%	0,0%	-1,2%	
Land use	pt		5,55E+04	99,9%	0,2%	0,0%	-0,1%	
Water use	m3 water eq. of deprived water		2,28E+01	61,5%	38,5%	0,0%	-0,1%	
Resource use	kg Sb eq		9,07E-03	101,1%	0,1%	0,0%	-1,1%	
Resource use, fossils	MJ		1,04E+03	57,0%	43,1%	0,0%	-0,2%	BC1 EFF2

Table 6-3 LCC BC1 BAT EFF1 and EFF2 options with GWP per FU for comparison and EU27 totals (TWh/y)

					BC1 BAU	BAT EFF1	BC1 EFF2
		Discount rate (interest minus inflation)	%		3%	3%	3%
		Escalation rate (project annual growth of running costs)	%		2%	2%	2%
		Electricity rate	euro/kWh		0,29	0,29	0,29
		PWF			9,48	9,48	9,48
		Life Cycle Cost (LCC)	euro		258,90	222,90	190,36
		LCC/FU	euro/kWh		0,009	0,008	0,007
		CAPEX share in LCC	%		64%	74%	91%
		GWP per FU [kg CO2 eq/kWh]	kg/kWh		0,0065	0,0046	0,0023
Sales in 2030	[million recharging points]			T2	1,65	1,65	1,65
Stock in 2030	[million recharging points]			T2	15,50	15,50	15,50
Sales in 2040	[million recharging points]			T2	3,15	3,15	3,15
Stock in 2040	[million recharging points]			T2	31,50	31,50	31,50
		Stock 2030	TWh/y		0,53	0,33	0,10
		Stock 2040	TWh/y		1,08	0,66	0,19
		Charged FU in 2030	TWh/y		43,67	43,67	43,67
		Charged FU in 2040	TWh/y		88,75	88,75	88,75

6.1.2 BC2 BAT and LCC

BC2 is a basic IEC mode 3 fixed installed charger fitted with charging cable usually installed at the car owners parking ("home wall-box charging adapter").

The calculated LCA results of BC1 options are in Table 6-4 to Table 6-6 and their LCC results in Table 6-7with their GWP carbon footprint per FU (kg CO_2eq/kWh) for comparison and EU27 totals (TWh/y).

Note that all options result in lowering their GWP carbon footprint.

Table 6-4 LCA BC2 BAT EFF option

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		7,70E+01	72,2%	38,1%	0,6%	-11,0%	**0,003**
Ozone depletion	kg CFC-11 eq		1,54E-07	93,0%	7,1%	0,0%	-0,2%	
Human toxicity, cancer	CTUh		5,85E-08	112,0%	8,3%	0,1%	-20,4%	
Human toxicity, non-cancer	CTUh		-3,68E-09	-27979,2%	-2668,3%	-90,7%	30838,1%	
Particulate matter	disease incidence		6,40E-06	112,8%	14,6%	0,2%	-27,6%	
Ionising radiation	kBq U235 eq		1,50E+01	17,2%	83,1%	0,5%	-0,9%	
Photochemical ozone formation	kg NMVOC eq		2,34E-01	90,8%	20,5%	0,4%	-11,7%	
Acidification	mol H+ eq		6,99E-01	94,9%	12,8%	0,2%	-7,8%	
Eutrophication, terrestrial	mol N eq		7,60E-01	89,0%	23,6%	0,5%	-13,1%	
Eutrophication, freshwater	kg P eq		2,67E-04	100,2%	22,4%	0,3%	-22,9%	
Eutrophication, marine	kg N eq		7,14E-02	88,6%	23,7%	0,5%	-12,8%	
Ecotoxicity, freshwater	CTUe		4,72E+02	106,8%	28,3%	0,3%	-35,4%	
Land use	pt		-5,39E+04	-36,5%	-0,2%	0,0%	136,7%	
Water use	m3 water eq. of deprived water		1,33E+01	103,7%	75,2%	1,2%	-80,1%	
Resource use	kg Sb eq		3,56E-04	2172,7%	2,1%	0,0%	-2074,8%	
Resource use, fossils	MJ		1,26E+03	65,2%	40,6%	0,3%	-6,1%	**BC2 EFF**

Table 6-5 LCA BC2 BAT UP option

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	3,08E+02	20,5%	82,1%	0,2%	-2,8%	0,007
Ozone depletion	kg CFC-11 eq	2,37E-07	60,5%	39,6%	0,0%	-0,1%	
Human toxicity, cancer	CTUh	9,61E-08	68,7%	43,6%	0,1%	-12,4%	
Human toxicity, non-cancer	CTUh	8,09E-07	135,5%	104,5%	0,4%	-140,4%	
Particulate matter	disease incidence	1,47E-05	57,3%	54,7%	0,1%	-12,0%	
Ionising radiation	kBq U235 eq	1,10E+02	2,7%	97,4%	0,1%	-0,1%	
Photochemical ozone formation	kg NMVOC eq	6,31E-01	38,7%	65,5%	0,1%	-4,4%	
Acidification	mol H+ eq	1,51E+00	52,8%	50,8%	0,1%	-3,6%	
Eutrophication, terrestrial	mol N eq	2,22E+00	34,8%	69,5%	0,2%	-4,5%	
Eutrophication, freshwater	kg P eq	7,32E-04	38,0%	70,3%	0,1%	-8,3%	
Eutrophication, marine	kg N eq	2,09E-01	34,6%	69,6%	0,2%	-4,4%	
Ecotoxicity, freshwater	CTUe	1,53E+03	35,8%	75,1%	0,1%	-11,0%	
Land use	pt	-5,29E+04	-37,2%	-2,1%	0,0%	139,2%	
Water use	m3 water eq. of deprived water	9,07E+01	16,6%	95,0%	0,2%	-11,8%	
Resource use	kg Sb eq	1,34E-03	645,4%	4,8%	0,0%	-550,2%	
Resource use, fossils	MJ	5,24E+03	17,6%	83,8%	0,1%	-1,5%	BC2 UP

Table 6-6 LCA BC2 BAT PLUG option

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	1,44E+02	0,5%	99,5%	0,0%	0,0%	0,005
Ozone depletion	kg CFC-11 eq	6,39E-08	16,8%	83,2%	0,0%	0,0%	
Human toxicity, cancer	CTUh	2,54E-08	14,3%	93,5%	0,0%	-7,9%	
Human toxicity, non-cancer	CTUh	4,89E-07	2,2%	97,9%	0,0%	-0,1%	
Particulate matter	disease incidence	4,63E-06	1,6%	98,5%	0,0%	-0,1%	
Ionising radiation	kBq U235 eq	6,09E+01	0,1%	99,9%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq	2,38E-01	1,6%	98,4%	0,0%	0,0%	
Acidification	mol H+ eq	4,40E-01	1,0%	99,1%	0,0%	-0,1%	
Eutrophication, terrestrial	mol N eq	8,87E-01	1,3%	98,7%	0,0%	0,0%	
Eutrophication, freshwater	kg P eq	3,20E-04	8,8%	91,2%	0,0%	0,0%	
Eutrophication, marine	kg N eq	8,38E-02	1,4%	98,6%	0,0%	0,0%	
Ecotoxicity, freshwater	CTUe	6,63E+02	1,9%	98,3%	0,0%	-0,2%	
Land use	pt	1,13E+03	45,4%	54,6%	0,0%	0,0%	
Water use	m3 water eq. of deprived water	4,92E+01	0,7%	99,3%	0,0%	0,0%	
Resource use	kg Sb eq	7,81E-05	56,3%	46,7%	0,0%	-2,9%	
Resource use, fossils	MJ	2,50E+03	0,5%	99,5%	0,0%	0,0%	BC2 PLUG

Table 6-7 LCC BC2 BAT EFF, UP and PLUG options with GWP per FU for comparison and EU27 totals (TWh/y)

					BC2 BAU	BC2 EFF	BC2 UP	BC2 PLUG
Discount rate (interest minus inflation)			%		3%	3%	3%	3%
Escalation rate (project annual growth of running costs)			%		2%	2%	2%	2%
Electricity rate			euro/kWh		0,29	0,29	0,29	0,29
PWF					9,48	9,48	13,89	9,48
Life Cycle Cost (LCC)			euro		1515,22	1449,20	1621,21	293,61
LCC/FU			euro/kWh		0,054	0,051	0,038	0,010
CAPEX share in LCC			%		40%	43%	41%	20%
GWP per FU [kg CO2 eq/kWh]			kg/kWh		0,0079	0,0027	0,0073	0,0051
Sales in 2030	[million recharging points]			T2	1,75	1,75	1,75	1,75
Stock in 2030	[million recharging points]			T2	17,50	17,50	17,50	17,50
Sales in 2040	[million recharging points]			T2	3,40	3,40	3,40	3,40
Stock in 2040	[million recharging points]			T2	34,00	34,00	34,00	34,00
		Stock 2030	TWh/y		0,74	0,12	0,70	0,60
		Stock 2040	TWh/y		1,43	0,24	1,37	1,16
		Charged FU in 2030	TWh/y		49,30	49,30	49,30	49,30
		Charged FU in 2040	TWh/y		95,79	95,79	95,79	95,79

6.1.3 BC3 BAT and LCC

BC3 is a fully functional IEC mode 3 public typically with two CCS socket outlets.

The calculated LCA results of BC3 options are in Table 6-8 to Table 6-9 and their LCC results in Table 6-10 with their GWP carbon footprint per FU (kg CO_2eq/kWh) for comparison and EU27 totals (TWh/y).

Note that all options result in lowering their GWP carbon footprint.

Table 6-8 LCA BC3 BAT EFF option

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	4,96E+02	30,1%	73,9%	0,2%	-4,3%	0,001
Ozone depletion	kg CFC-11 eq	4,93E-07	72,5%	27,6%	0,0%	-0,1%	
Human toxicity, cancer	CTUh	3,19E-07	90,2%	19,1%	0,0%	-9,3%	
Human toxicity, non-cancer	CTUh	1,06E-06	250,8%	116,1%	0,8%	-267,7%	
Particulate matter	disease incidence	2,64E-05	72,3%	44,3%	0,1%	-16,7%	
Ionising radiation	kBq U235 eq	1,63E+02	4,2%	95,8%	0,1%	-0,2%	
Photochemical ozone formation	kg NMVOC eq	1,11E+00	51,9%	54,1%	0,2%	-6,1%	
Acidification	mol H+ eq	2,74E+00	64,1%	40,8%	0,1%	-5,0%	
Eutrophication, terrestrial	mol N eq	3,83E+00	47,7%	58,5%	0,2%	-6,5%	
Eutrophication, freshwater	kg P eq	1,36E-03	56,1%	54,9%	0,1%	-11,2%	
Eutrophication, marine	kg N eq	3,62E-01	47,5%	58,6%	0,2%	-6,3%	
Ecotoxicity, freshwater	CTUe	2,56E+03	50,9%	65,2%	0,1%	-16,3%	
Land use	pt	-1,32E+05	-37,8%	-1,2%	0,0%	139,0%	
Water use	m3 water eq. of deprived water	1,35E+02	26,5%	92,9%	0,3%	-19,7%	
Resource use	kg Sb eq	1,45E-03	1360,5%	6,4%	0,0%	-1266,9%	
Resource use, fossils	MJ	8,36E+03	25,8%	76,4%	0,1%	-2,3%	BC3 EFF

Table 6-9 LCA BC3 BAT LIFE option

Impact	unit	Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq	1,59E+03	11,3%	90,0%	0,1%	-1,4%	0,002
Ozone depletion	kg CFC-11 eq	8,89E-07	40,3%	59,8%	0,0%	-0,1%	
Human toxicity, cancer	CTUh	6,07E-07	65,8%	39,2%	0,0%	-5,0%	
Human toxicity, non-cancer	CTUh	4,95E-06	61,4%	96,8%	0,2%	-58,3%	
Particulate matter	disease incidence	6,29E-05	34,6%	72,5%	0,1%	-7,2%	
Ionising radiation	kBq U235 eq	6,16E+02	1,3%	98,7%	0,0%	-0,1%	
Photochemical ozone formation	kg NMVOC eq	2,95E+00	22,9%	79,4%	0,1%	-2,4%	
Acidification	mol H+ eq	6,16E+00	31,6%	70,7%	0,0%	-2,4%	
Eutrophication, terrestrial	mol N eq	1,07E+01	20,3%	82,0%	0,1%	-2,4%	
Eutrophication, freshwater	kg P eq	3,69E-03	25,1%	79,1%	0,1%	-4,2%	
Eutrophication, marine	kg N eq	1,01E+00	20,2%	82,1%	0,1%	-2,3%	
Ecotoxicity, freshwater	CTUe	7,70E+03	21,2%	84,7%	0,0%	-5,9%	
Land use	pt	-1,30E+05	-38,4%	-4,7%	0,0%	143,1%	
Water use	m3 water eq. of deprived water	5,05E+02	8,5%	96,8%	0,1%	-5,4%	
Resource use	kg Sb eq	2,39E-03	874,8%	15,2%	0,0%	-790,1%	
Resource use, fossils	MJ	2,74E+04	9,8%	90,9%	0,0%	-0,7%	BC3 LIFE

Table 6-10 LCC BC3 BAT EFF and LIFE options with GWP per FU for comparison and EU27 totals (TWh/y)

				BC3 BAU	BC3 EFF	BC3 LIFE
Discount rate (interest minus inflation)			%	3%	3%	3%
Escalation rate (project annual growth of running costs)			%	2%	2%	2%
Electricity rate			euro/kWh	0,19	0,19	0,19
PWF				9,48	9,48	13,89
Life Cycle Cost (LCC)			euro	6603,29	6515,07	6950,65
LCC/FU			euro/kWh	0,012	0,012	0,008
CAPEX share in LCC			%	48%	52%	48%
GWP per FU [kg CO2 eq/kWh]			kg/kWh	0,0020	0,0009	0,0019
Sales in 2030	[million recharging points]			3,95	3,95	3,95
Stock in 2030	[million recharging points]			11,50	11,50	11,50
Sales in 2040	[million recharging points]			7,20	7,20	7,20
Stock in 2040	[million recharging points]			23,50	23,50	23,50
		Stock 2030	TWh/y	2,62	1,01	2,62
		Stock 2040	TWh/y	5,35	2,06	5,35
		Charged FU in 2030	TWh/y	638,02	638,02	638,02
		Charged FU in 2040	TWh/y	1303,78	1303,78	1303,78

6.1.4 BC4 BAT and LCC

BC4 is a fully functional IEC mode 4 DC fast charger.

The calculated LCA results of BC4 options are in Table 6-11 and their LCC results in Table 6-12 with their GWP carbon footprint per FU (kg CO_2eq/kWh) for comparison and EU27 totals (TWh/y).

Note that all options result in lowering their GWP carbon footprint. The carbon footprint per FU is clearly higher for BC4 compared to BC1-3. This is due to the charger losses.

Table 6-11 LCA BC4 BAT AC/DC efficiency option

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		2,81E+05	2,0%	98,4%	0,0%	-0,4%	0,014
Ozone depletion	kg CFC-11 eq		1,04E-04	0,7%	99,3%	0,0%	0,0%	
Human toxicity, cancer	CTUh		1,15E-04	140,8%	40,1%	0,0%	-80,9%	
Human toxicity, non-cancer	CTUh		1,00E-03	10,5%	92,3%	0,0%	-2,8%	
Particulate matter	disease incidence		9,23E-03	6,5%	95,7%	0,0%	-2,3%	
Ionising radiation	kBq U235 eq		1,18E+05	0,2%	99,8%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		4,66E+02	3,4%	97,4%	0,0%	-0,8%	
Acidification	mol H+ eq		8,79E+02	5,8%	95,9%	0,0%	-1,8%	
Eutrophication, terrestrial	mol N eq		1,74E+03	3,1%	97,6%	0,0%	-0,7%	
Eutrophication, freshwater	kg P eq		5,93E-01	5,0%	95,3%	0,0%	-0,3%	
Eutrophication, marine	kg N eq		1,64E+02	3,0%	97,6%	0,0%	-0,6%	
Ecotoxicity, freshwater	CTUe		1,28E+06	2,4%	98,7%	0,0%	-1,1%	
Land use	pt		8,06E+05	40,3%	147,9%	0,0%	-88,2%	
Water use	m3 water eq. of deprived water		9,55E+04	1,4%	99,0%	0,0%	-0,4%	
Resource use	kg Sb eq		3,26E-01	150,3%	21,6%	0,0%	-72,0%	
Resource use, fossils	MJ		4,87E+06	1,4%	98,8%	0,0%	-0,3%	BC4 AC/DC

Table 6-12 LCC BC4 BAT AC/DC efficiency option with GWP per FU for comparison and EU27 totals (TWh/y)

				BC4 BAU	BC4 AC/DC
		Discount rate (interest minus inflation)	%	3%	3%
		Escalation rate (project annual growth of running costs)	%	2%	2%
		Electricity rate	euro/kWh	0,19	0,19
		PWF		9,48	9,48
		Life Cycle Cost (LCC)	euro	294719,54	214.030,01 €
		LCC/FU	euro/kWh	0,015	0,011 €
		CAPEX share in LCC	%	24%	36%
		GWP per FU [kg CO2 eq/kWh]	kg/kWh	0,025	0,014
Sales in 2030	[million recharging points]			0,12	0,12
Stock in 2030	[million recharging points]			0,70	0,70
Sales in 2040	[million recharging points]			0,40	0,40
Stock in 2040	[million recharging points]			4,25	4,25
		Stock 2030	TWh/y	80,96	46,28
		Stock 2040	TWh/y	491,52	280,98
		Charged FU in 2030	TWh/y	1379,70	1379,70
		Charged FU in 2040	TWh/y	8376,75	8376,75

6.2 Sensitivity analysis options (TR, RES, REP)

As discussed in Task 4 and 5 a set of sensitivity analyses were done on the BC. The LCA results are in Table 6-13 to Table 6-17 and LCC and GWP carbon footprint per FU (kg CO_2eq/kWh) within Table 6-18.The sensitivity analysis options have acronyms BC2 TR, BC2 RES, BC3 REP-, BC4 REP- and BC4 RES. They model the impact from manufacturing location (TR), use of renewable energy (RES) and lower lifetime (REP-).

This leads to the following conclusions:

- End assembly in China including shipping has relatively modest impact on BC2 TR as the carbon footprint only raises from 7.9 to 8.0 gCO_2eq/kWh.
- The strongest impact on the carbon footprint comes from using renewable energy. This can be explained by the relative high default carbon footprint for EU27 electricity used in the MEErP, see section 4-17.
- Despite using renewable energy in BC4 the use phase remains the largest contributor to GWP (69%), see Table 6-17. This means that for BC4 or DC fast chargers energy efficiency matters irrespective the source of energy supplied.
- The impact from using renewable energy on BC2 RES has a totally different impact compared to BC4, see Table 6-14 and Table 6-17. In BC2 the major GWP impact shifts from the use phase towards manufacturing (BoM) (108,3 %) and the ‘credits’ for recycling (-16.6%). Considering that we expect more low carbon electricity in the EU27 grid by 2035 it means that the improvement potential for BC1-3 AC EVSE should come from material efficiency and circular economy aspects such as extended lifetime, repair and recycling.
- For both BC2 and BC4 shorter lifetime, 10 to 5 years, has an adverse effect on GWP and increases relevance of BoM to 24 % in BC3 and 38 % in BC4. This is not neglectable and back-stop policy to warrant minimum lifetime could be considered.

Table 6-13 BC2 TR sensitivity analysis on transport from China

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		2,25E+02	24,6%	78,3%	0,2%	-3,8%	0,008
Ozone depletion	kg CFC-11 eq		2,08E-07	68,7%	31,4%	0,0%	-0,1%	
Human toxicity, cancer	CTUh		8,16E-08	78,2%	35,9%	0,1%	-14,6%	
Human toxicity, non-cancer	CTUh		4,90E-07	209,0%	120,2%	0,7%	-231,4%	
Particulate matter	disease incidence		1,15E-05	62,7%	48,9%	0,1%	-15,4%	
Ionising radiation	kBq U235 eq		7,74E+01	3,3%	96,7%	0,1%	-0,2%	
Photochemical ozone formation	kg NMVOC eq		4,94E-01	42,9%	58,3%	0,2%	-5,5%	
Acidification	mol H+ eq		1,17E+00	56,5%	45,8%	0,1%	-4,7%	
Eutrophication, terrestrial	mol N eq		1,74E+00	38,7%	61,9%	0,2%	-5,7%	
Eutrophication, freshwater	kg P eq		5,70E-04	46,7%	63,0%	0,1%	-10,7%	
Eutrophication, marine	kg N eq		1,64E-01	38,6%	62,1%	0,2%	-5,6%	
Ecotoxicity, freshwater	CTUe		1,16E+03	43,5%	69,4%	0,1%	-14,4%	
Land use	pt		-5,32E+04	-36,9%	-1,4%	0,0%	138,4%	
Water use	m3 water eq. of deprived water		6,35E+01	21,7%	94,8%	0,3%	-16,8%	
Resource use	kg Sb eq		3,82E-04	2018,3%	11,7%	0,0%	-1930,2%	
Resource use, fossils	MJ		3,83E+03	21,3%	80,1%	0,1%	-2,0%	BC2 TR

Table 6-14 BC2 RES sensitivity analysis on all renewable energy supply from wind

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		5,11E+01	108,3%	7,3%	0,9%	-16,6%	0,002
Ozone depletion	kg CFC-11 eq		1,43E-07	100,1%	0,0%	0,0%	-0,2%	
Human toxicity, cancer	CTUh		1,50E-07	42,6%	65,3%	0,0%	-8,0%	
Human toxicity, non-cancer	CTUh		-7,01E-08	-1461,9%	-51,8%	-4,7%	1618,4%	
Particulate matter	disease incidence		5,57E-06	129,2%	2,3%	0,2%	-31,7%	
Ionising radiation	kBq U235 eq		2,63E+00	97,7%	4,5%	3,0%	-5,2%	
Photochemical ozone formation	kg NMVOC eq		1,93E-01	109,6%	4,0%	0,5%	-14,2%	
Acidification	mol H+ eq		6,19E-01	106,9%	1,7%	0,2%	-8,8%	
Eutrophication, terrestrial	mol N eq		6,08E-01	110,8%	5,0%	0,6%	-16,4%	
Eutrophication, freshwater	kg P eq		2,14E-04	124,6%	3,6%	0,4%	-28,6%	
Eutrophication, marine	kg N eq		5,71E-02	110,5%	4,9%	0,6%	-16,0%	
Ecotoxicity, freshwater	CTUe		3,56E+02	141,3%	5,1%	0,4%	-46,8%	
Land use	pt		-5,40E+04	-36,4%	0,0%	0,0%	136,5%	
Water use	m3 water eq. of deprived water		3,46E+00	397,7%	6,0%	4,7%	-308,4%	
Resource use	kg Sb eq		4,39E-04	1755,5%	23,4%	0,0%	-1678,9%	
Resource use, fossils	MJ		7,88E+02	103,6%	5,6%	0,5%	-9,7%	BC2 RES

Table 6-15 BC3 REP- sensitivity analysis with shorter lifetime

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		6,06E+02	24,5%	78,8%	0,2%	-3,5%	0,002
Ozone depletion	kg CFC-11 eq		5,34E-07	66,9%	33,2%	0,0%	-0,1%	
Human toxicity, cancer	CTUh		3,34E-07	85,1%	23,8%	0,0%	-8,9%	
Human toxicity, non-cancer	CTUh		1,42E-06	186,5%	112,8%	0,6%	-199,9%	
Particulate matter	disease incidence		2,99E-05	63,8%	50,9%	0,1%	-14,7%	
Ionising radiation	kBq U235 eq		2,09E+02	3,3%	96,8%	0,1%	-0,2%	
Photochemical ozone formation	kg NMVOC eq		1,29E+00	44,6%	60,6%	0,2%	-5,3%	
Acidification	mol H+ eq		3,07E+00	57,0%	47,4%	0,1%	-4,4%	
Eutrophication, terrestrial	mol N eq		4,50E+00	40,5%	64,8%	0,2%	-5,5%	
Eutrophication, freshwater	kg P eq		1,58E-03	48,0%	61,5%	0,1%	-9,6%	
Eutrophication, marine	kg N eq		4,25E-01	40,3%	64,8%	0,2%	-5,4%	
Ecotoxicity, freshwater	CTUe		3,06E+03	42,5%	71,0%	0,1%	-13,6%	
Land use	pt		-1,32E+05	-38,0%	-1,6%	0,0%	139,5%	
Water use	m3 water eq. of deprived water		1,72E+02	20,7%	94,5%	0,2%	-15,4%	
Resource use	kg Sb eq		1,45E-03	1358,1%	8,4%	0,0%	-1266,5%	
Resource use, fossils	MJ		1,03E+04	20,9%	80,9%	0,1%	-1,9%	BC3 REP-

Table 6-16 BC4 REP- sensitivity analysis with shorter lifetime

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		2,47E+05	2,3%	98,2%	0,0%	-0,5%	0,025
Ozone depletion	kg CFC-11 eq		9,07E-05	0,8%	99,2%	0,0%	0,0%	
Human toxicity, cancer	CTUh		1,09E-04	148,2%	37,0%	0,0%	-85,2%	
Human toxicity, non-cancer	CTUh		8,88E-04	11,9%	91,3%	0,0%	-3,2%	
Particulate matter	disease incidence		8,12E-03	7,4%	95,1%	0,0%	-2,6%	
Ionising radiation	kBq U235 eq		1,03E+05	0,3%	99,7%	0,0%	0,0%	
Photochemical ozone formation	kg NMVOC eq		4,09E+02	3,9%	97,0%	0,0%	-0,9%	
Acidification	mol H+ eq		7,73E+02	6,6%	95,3%	0,0%	-2,0%	
Eutrophication, terrestrial	mol N eq		1,52E+03	3,5%	97,3%	0,0%	-0,8%	
Eutrophication, freshwater	kg P eq		5,22E-01	5,6%	94,6%	0,0%	-0,3%	
Eutrophication, marine	kg N eq		1,44E+02	3,4%	97,3%	0,0%	-0,7%	
Ecotoxicity, freshwater	CTUe		1,12E+06	2,7%	98,5%	0,0%	-1,3%	
Land use	pt		6,57E+05	49,4%	158,8%	0,0%	-108,3%	
Water use	m3 water eq. of deprived water		8,37E+04	1,5%	98,8%	0,0%	-0,4%	
Resource use	kg Sb eq		3,17E-01	154,5%	19,4%	0,0%	-74,0%	
Resource use, fossils	MJ		4,27E+06	1,6%	98,7%	0,0%	-0,3%	BC4 rep-

Table 6-17 BC4 RES sensitivity analysis on all renewable energy supply from wind

Impact	unit		Total	BOM	Use	EoL impact	EoL credit	kg CO2 eq/kWh per kWh FU
Climate change, total	kg CO2 eq		1,47E+04	38,2%	69,9%	0,5%	-8,6%	0,001
Ozone depletion	kg CFC-11 eq		7,62E-07	98,4%	1,2%	1,7%	-1,2%	
Human toxicity, cancer	CTUh		3,37E-04	47,8%	79,7%	0,0%	-27,5%	
Human toxicity, non-cancer	CTUh		1,77E-04	59,5%	56,3%	0,2%	-15,9%	
Particulate matter	disease incidence		7,46E-04	80,5%	47,0%	0,3%	-27,9%	
Ionising radiation	kBq U235 eq		5,86E+02	45,7%	55,1%	2,6%	-3,4%	
Photochemical ozone formation	kg NMVOC eq		3,38E+01	47,0%	63,7%	0,4%	-11,1%	
Acidification	mol H+ eq		6,53E+01	78,6%	44,8%	0,3%	-23,8%	
Eutrophication, terrestrial	mol N eq		1,26E+02	42,3%	66,7%	0,5%	-9,5%	
Eutrophication, freshwater	kg P eq		4,93E-02	59,7%	43,1%	0,3%	-3,1%	
Eutrophication, marine	kg N eq		1,16E+01	42,2%	66,4%	0,5%	-9,1%	
Ecotoxicity, freshwater	CTUe		6,62E+04	45,7%	75,3%	0,3%	-21,3%	
Land use	pt		-3,32E+05	-97,9%	-16,5%	-0,1%	214,4%	
Water use	m3 water eq. of deprived water		1,55E+03	83,6%	36,7%	1,7%	-22,0%	
Resource use	kg Sb eq		5,38E-01	91,2%	52,5%	0,0%	-43,7%	
Resource use, fossils	MJ		1,77E+05	39,1%	68,2%	0,5%	-7,8%	BC4 RES

Table 6-18 LCC of sensitivity analysis with GWP per FU for comparison

			BC2 BAU	BC2 TR	BC2 RES	BC3 BAU	BC3 REP-	BC4 BAU	BC4 rep-	BC4 RES
Discount rate (interest minus inflation)	%		3%	3%	3%	3%	3%	3%	3%	3%
Escalation rate (project annual growth of running costs)	%		2%	2%	2%	2%	2%	2%	2%	2%
Electricity rate	euro/kWh		0,29	0,29	0,29	0,19	0,19	0,19	0,19	0,19
PWF			9,48	9,48	9,48	9,48	4,86	9,48	4,86	9,48
Life Cycle Cost (LCC)	euro		1515,22	1515,22	1515,22	6603,29	6566,56	294719,54	194.855,87 €	294.719,54 €
LCC/FU	euro/kWh		0,054	0,054	0,054	0,012	0,024	0,015	0,020 €	0,015 €
CAPEX share in LCC	%		40%	40%	40%	48%	51%	24%	36%	24%
GWP per FU [kg CO2 eq/kWh]	kg/kWh		0,0079	0,0080	0,0018	0,0020	0,0022	0,025	0,025	0,001

6.3 LLCC ranking and combined BAT

When ranking Least Life Cycle Costs it is important to note that:

- The study was not able to clearly link the energy efficiency or other improvement options to extra cost for manufacturing, although some own draft assumptions were added in task 4. These products are not like transformers, motors or cables whereby more copper or different magnetic material and costs can simply be traded off and optimised versus losses. This was also confirmed by stakeholder interviews. Cost from making more efficient products is rather related to one-off design and testing.

- For BC4 little market data is available and as mentioned no cost versus efficiency production costs were reported but one-off engineering and testing costs.
- For BC1-3 the focus is on standby and partial standby losses to increase efficiency.

Considering this, we do not think an LLCC ranking makes sense for these product groups neither for BC4.

Regarding combining BAT improvement options, it is important to note that:

- Using renewable energy is the most impactful but in large extent beyond the product scope itself despite being upgradable for new control systems (if any).
- Obviously, all material efficiency options to extend lifetime and/or reduce waste can be combined with energy efficiency options. There is no clear relationship or trade-off between energy efficiency and lifetime of the product and therefore no need to couple policy (if any).

6.4 BNAT and system level improvement options

Most importantly, there are indirect benefits from using electric vehicles compared to combustion engine vehicles. However, the CAPEX for recharging equipment is already significant in the LCC and above 40 % in BC1-3 relative to OPEX, see Table 5-9. Moreover, LCC only included the recharging equipment itself and not yet the full electrical installation (cabling, switchboard, transformer, ...). As a conclusion, one should remain careful when imposing requirements that increase the EVSE CAPEX because increased upfront cost might slow down the electrification of transport and their benefits.

BC1 has lower LCC/FU compared to BC2 and we have also discussed the option BC2 BAT PLUG to switch from BC2 to a BC1 by installing a simple wall plug. However, BC2 remains attractive compared to BC1 because:

- BC2 can be integrated more straightforward with the Home Energy Management System (HEMS) to maximize local produced energy such as PV (if available) and thus indirectly benefits the use of RES.
- BC2 can be fitted with a permanent recharging cable, and this is more convenient because it does not require to take the cable out of the car trunk which can become dirty and/or wet.

BNAT and system level improvement options were listed in Task 4 and will not be reiterated. However, what could be listed here are some product features that have an indirect effect. So far, we have identified the following:

- Allow a product to upgrade for bidirectional charging, in particular IEC mode 3 EVSE (BC2&3).
- For mode 2&3 AC EVSE much of the losses are inside the cabling of the building and this could be included in a monitoring function that calculates loop impedance based on voltage drop during charging (TBC).
- Much of the IEC mode 2/3 losses are inside the car in the On-Board Charger, it is important to know the optimum power range for lowest loss.
- Active standby losses in IEC mode 2/3 can be minimized when the car changes from operational states C to B and the EVSE contactor switches off. Most cars tested changed operational states from C to B when SOC setpoint was reached. However, we could not verify if all cars do this systematically. This is of course an important feature to reduce losses in EVSE.

- The most material efficient and cost-efficient solution for AC recharging at the owner's car park the 'BAT PLUG' option but this needs that the grid code allows to install an industrial or reinforced socket, see Task 1.

6.5 Preliminary conclusion on setting MEPS

EU27 total impact in TWh is reported in previous Table 6-3, Table 6-7, Table 6-10 and Table 6-12. In principle, several TWh/y can be saved by introducing MEPS and/or energy labelling or information requirements.

Regarding mode 2 AC EVSE:

To be considered whether this can be aligned with mode 3 (BC2). Potentially it can be set at short term set close to BC1 BAT EFF1 and for the long term BC1 BAT EFF2.

Also, within BC1 BAT EFF2 we have assumed that bistable relays are used and thus little more power consumption in active stand by or on mode, see section 4.4.2.

Regarding mode 3 AC EVSE:

We must reiterate what has been concluded in Task 4 regarding collecting data, see section 4.4.1. To set a threshold, we miss an EU standard and accordingly disaggregated data which was caused by the broad diversity of secondary functions. Considering the extra functions, it is difficult to find two products alike.

Therefore, if one wants to proceed with a minimum energy efficiency performance standard (MEPS) policy, the first step will be defining a standard and starting with the obligation to supply data accordingly. This could be combined with a minimum functionality requirement to operate in a kind of 'Eco-mode', meaning with all secondary functions switched off and solely with one serial interface for control. Compare it to a dishwasher that also has an 'Eco' mode that corresponds to the rinsing cycle for the energy label. A similar eco-mode will have to be agreed upon, afterwards MEPS and the energy label can be based on this.

According to our analysis the highest class for such an Eco-mode IEC EVSE mode 3 could be BC2 BAT EFF. Also, within BC BAT EFF we've assumed that bistable relays are used and thus little more power consumption in active stand by or on mode, see section 4.4.2.

Regarding mode 4 DC EVSE:

We must reiterate what has been concluded in Task 4 regarding collecting data, see section 4.5.1. To set a threshold, European mode 4 suppliers include different statements and/or metrics to specify energy efficiency making it impossible to compare products based on catalogue declared data. Also, all reported data today is in a very close range even approaching measurement tolerances. Consequently, if one wants to proceed with a policy option regarding efficiency the first step will be defining a measurement standard and afterwards introduce the obligation to supply data.

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7 Annex 1: Stakeholder enquiry for sourcing product data

To be added later, see spreadsheet.

8 Annex 2: Energystar EVSE measurement method for mode 2&3 EVSE (AC)

The ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment Final Test Method (Rev. Apr-2017) can be found here: https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20AC%20EVSE%20Final%20Test%20Method.pdf

This method is for AC supply EVSE, thus IEC mode 2 and 3.

A schematic of the test setup is included hereafter for an AC EVSE, which is in principle a controlled contactor or switch only (for more details consult the document):

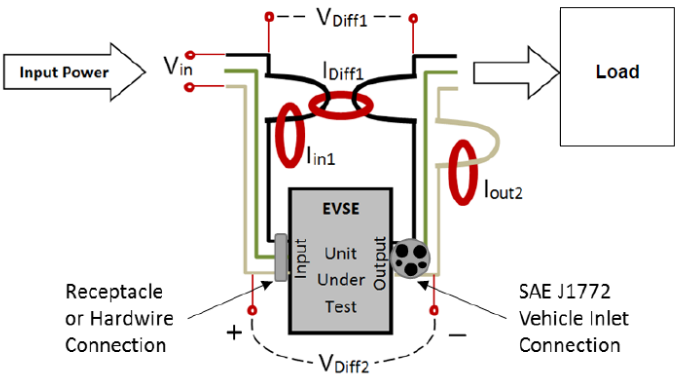

Figure 1b: Schematic of test setup connection

Important properties of this method:

The auxiliary losses in mode 2/3 AC EVSE are very low (e.g. 10 Watt) relative to the AC recharging power (e.g. 10 kW) transferred to the EV or typically only 0.1% losses relative to the recharging power. This means that measuring the losses by only measuring the input power (Iin1) relative to the output power (Iin2) cannot be done easily, unless very accurate power measurements (>>0.1%) would exist. This is not available on the market yet and therefore this method uses a simpler approach and measures for the AC current difference between the input and output and thus losses directly, see IDiff1. In the case of 10 kW 3x400 VAC the recharging current is typically about 16A and the losses of 10-Watt 240 VAC or 0.04A. Idiff1 or 0.04A can only be measured with a very accurate measurement transformers and needs dedicated power measurement equipment.

What are the major limitations to use this method for mode 2/3 EVSE EU chargers:

- Much of European EVSE is 3 phase equipment and therefore 6 voltage measurement and 9 current channels are needed.
- Idiif1 can only be measured with an accurate measurement transformer and not with a measurement shunt resistor. Note that the Idiff1 measurement is relatively low (<1A) for a current measurement transformer and that mostly current shunts are used for such currents.
- Measurement points as indicated on the drawing needs to be accessible, and specific wiring boxes need to be elaborated.

Note that such measurements could be done at the VITO labs would it be necessary and would new budget be available atter this exploratory study.

9 Annex 3: VITO laboratory measurements on mode 2&3 EVSE

Note that VITO did not have the full measurement set up available as described in Annex section 8 for this exploratory study only, missing items were:

- Amount of measurement channels and/or power meters available including calibration to measure 3 phase EVSE.
- Only 1 current transformer available for Idiff1 and it can only fit to a power meter which is in currently in use.
- Only 5 types of EVSE available for non-destructive testing due to budget restrictions.
- Real cars were used instead of car simulator load because we also wanted to verify the electric vehicle behaviour (see note later).
- The differential measurement transformer Idiff1 was not available and thus only input power has been measured (Iin1). Therefore, also the measurement hasn't been done to the full wiring and schematic of section 8.
- Notes on the measurements:
- It was decided to use a real car because we wanted to verify if cars change from state C (IEC 61851-1) to state B when the user defined maximum SOC (e.g. 80 %) was reached. This is important because it means that much of the time the contactor or main switch can be switched off and does not consume activation power which is part of the investigation of this study.
- These indicative measurements were not foreseen in the contract. All measurements were done indicatively and did not aim to provide calibrated reference data.
- The VITO labs could do full measurements in line with section 8 atter this exploratory study, would it turn out to be useful and would there be new budget available.

What has been measured:

- The simplified measurements focused mostly on the passive and active standby mode power which was identified for improvement potential in mode 2&3.
- By tweaking the EVSE power supply phases versus the car recharging phase we could measure for the difference between standby and on mode due to contactor closure with an input measurement only.

Picture of measurement set up:

List of measurement instruments used:

To be added.

Measurement results:

To be added.

List of measurement instruments used:

To be added.

Measurement results:

To be added.

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