



EVALUATION REPORT

TruckZero 2026



Contributors

Editorial

The evaluation report TruckZero Testevent 2026 is published by ElaadNL (The ElaadNL Foundation).
Arnhem, September 2026.

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Thanks to ENI, BMW, RWS, ElaadNL and all participating manufacturers from vehicles, charging stations and battery systems.

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Conclusion and recommendations

During the TruckZero test event, electric trucks and charging stations from different manufacturers were tested in various combinations to assess their interoperability and charging behaviour. The findings below summarise the main observations from these tests and highlight areas where further development or improvement is recommended.

During a regular charging session, the following has been observed:

- During all sessions a **charging session started correctly** and the **cable** locked **correctly**.
- All charging sessions did start within two minutes. An **average** time of **27 [s]** was measured between authorization and current flowing. The **longest** time measured was **63 [s]**, and the **shortest** measured time was **12 [s]**.
- **All chargers and vehicles** do **support DIN70121** and **ISO15118-2**. This is in line with the new AFIR rules that mentions that all newly installed charging stations from January 8th 2026 are mandatory to support EN ISO15118-2:2016.
- **Only one charging station supports ISO15118-20**. None of the vehicles support ISO15118-20. It is recommended to also implement this, as the AFIR states that all newly installed charging stations from January 1st 2027 need to support ISO15118-20.
- The **maximum communicated current** is **always reached**. The **maximum power** is **not always reached** because the **limited factor** is the **maximum current**. As power = current * voltage, the maximum power will only be reached depending on the battery voltage of the vehicle.
- For the customer, the limited charging power is visible on all the tested charging stations. However, the customer does not see whether the limiting factor is the vehicle, charging station, or grid capacity.
- From within all vehicles, it is not visible for the customer if the vehicle, charging station or the grid is the limited factor, once the charging power decreases.
- **It is advised** to implement a function within the charging station and vehicles that shows if the charging station, the vehicle or the grid is the limited factor during a charging session.
- When a charging session is stopped from the vehicle side (if possible) all vehicles correctly unlock the charging cable, and no error messages were observed at the charging station and vehicle side.
- For one of the vehicles, it was not possible to stop the charging session from the vehicle side. **It is advised** to implement this function in case of an error at the charging station side. You should always be able to stop the charging session / unlock the charging cable from the vehicle side.

During a fluctuating charging profile, the following behaviour was observed:

- 30 out of the 36 combinations executed this smart charging profile without observed issues.
- During 2 out of 36 combinations, the charging session stopped when it should not have stopped.
- During a pause in 4 out of the 36 combinations, the session stopped and does not continue.
- All vehicles changed the communicated EVTargetCurrent correctly depending on the set power limit within the charging stations.

During delayed and paused charging, the following behaviour was observed:

- 2 out of the 4 tested charging station did not support a delayed charging session.
- All tested charging stations support a paused charging session.
- During the described delayed and paused test cases it has been observed that most charging stations will keep a power of around 1 [kW] during the charging session to keep the charging session alive. For a charging hub this amount of reactive power is practically negligible. Depending on the energy contract, the utility provider may impose penalties for reactive power. For a next test event it is advised to include a B-C-B/ B-E-B toggle test case if the charging station and vehicle support this functionality.

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1. Introduction

The continued electrification of the logistics sector, by the means of replacing conventional internal combustion engine trucks with electric trucks, requires an accompanying expansion of the charging infrastructure. The required expansion of charging infrastructure, considering the electrification of the Dutch heavy duty vehicle fleet, leaves little room for problems or setbacks.

This expansion creates accompanying challenges for regional governments and local DSOs. In this spirit, Rijkswaterstaat has initiated a Heavy-Duty Charging Hub Living Lab on behalf of the Ministry of Infrastructure and Water Management. The goal of this living lab is to bring together all relevant parties and gather new insights, share data, knowledge and experiences related to the expansion of the Dutch electric truck fleet.

As it turns out, the expansion of this electric truck fleet, and the required charging infrastructure, is not without issues. In the Living Lab interim report^[1] multiple issues were addressed regarding charging electric trucks, such as differences in maximum delivered power per truck-charger combination, charging sessions not reaching their maximum advertised power, disrupted sessions, and more.

To address the issues reported in this interim report, ElaadNL, together with Rijkswaterstaat hosted the very first TruckZero event: a test event where both electric truck OEMs and charging infrastructure OEMs come together on neutral ground to carry out interoperability tests, among others. The goals of this proposed event were:

- Bringing electric truck manufactures and charging station manufacturers together in an effort to accelerate the development of standards and promote collaboration.
- Testing of communication and interoperability between charging stations and electric trucks.
- Identifying bottlenecks in various communication protocols (including ISO15118) that enable interoperability and smart charging, among other things.
- Accelerating standardisation, knowledge sharing, and collaboration within the logistics sector.
- Creating a neutral test environment where manufacturers learn together. Transparency and the mutual sharing of knowledge and insights among stakeholders are central to this event.

This report outlines the key findings from the TruckZero event, hosted at ElaadNL in Arnhem on the 18th and 19th of May 2026. During this two-day event, a total of 36 combinations of electric trucks and charging stations were tested. Many thanks to all accompanying parties, in no particular order: Iveco Group, Terberg, Hedgehog Applications, Voltra Charging, Delta, MAN, Kempower, Renault Trucks, BYD, Van der Sijs and Allego.

2. Participating equipment

2.1 DUT Vehicle

The following vehicles participated during the TruckZero event:

- BYD T8ZA
- Iveco S-way
- MAN eTGS
- Renault E-Tech
- Terberg RT253 EV
- Terberg YT203 EV

2.2 DUT Charging station

The following charging stations participated during the TruckZero event:

- Keysight Testsystem ElaadNL
- Delta UFC500
- Hedgedhog Charge Booster
- Kempower Satellite
- Voltra Charging SEC240
- Van Der Sijs EV Charging Systems 480kW

3. Abbreviations

Abbreviation	Definition
AC	Alternating current
DC	Direct current
DUT	Device under testing
ECU	Electronic Control Unit
EiM	External Identification Means
EV	Electric Vehicle
EV/EVSEMaximumCurrentLimit	Maximum current limit requested by the EV or EVSE during the charge loop
EV/ EVSEMaximumPowerLimit	Maximum power limit requested by the EV or EVSE during the charge loop
EVSE	Electric Vehicle Supply Equipment
EVTARGETCURRENT	Requested target current by the EV during the charge loop
LED	Light Emitting Diode
NA	Not applicable
NOK	Not ok
NT	Not tested
OCPP	Open Charge Point Protocol
PnC	Plug and Charge
PP	Proximity Pilot
PWM	Pulse Width Modulation
RFID	Radio Frequency Identification
SOC	State of charge
SW	Software
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TxDefaultProfile	An OCPP 1.6 Smart Charging profile purpose type. It defines the default charging schedule (power or current limits) applied to new transactions on a specific connector or the entire EVSE.
WebUI	Web User Interface

4. Test plan: Functional

4.1 Test suite: Regular charging

4.1.1 Test case: Regular charging

Functional testing: Regular charging		
Applicable standards:	IEC61851-23, DIN70121 and ISO15118-2 & -20	Estimated test time: 30 min
		Release date : 03/02/2026
PREPARATION		
☐ Connect the equipment according to the set-up drawing		
CONDITION		
☐ Remove all power and or current limits on EVSE and EV side		
TEST CASE		
Functional testing: Regular charging		ID: 1.0
This test will be used to observe if it is possible to start a regular charging session and if any abnormal behaviour will be observed. A regular charging session will be started and the following behaviour will be observed: - Will the cable be locked correctly? - Will the charging session be started? - What is the time it takes between swiping the RFID card and actual power flow? - What communication protocol will be used? - What are the EV/EVSEMaximumCurrentLimit, EV/EVSEMaximumPowerLimit and EVTargetCurrent values? - Will the charging session be stopped according to the protocol when stopped from EV side (if possible)?		
Actions	Expected results	Notes
1. Plug the charging cable in the EV	- The cable will be locked and a regular charging session will be started	
2. Swipe RFID card and start a timer	- The time between authorization and power flow will be under 2 minutes	
3. Stop the timer when the power is more than 10 [kW]	- The EV and EVSE support ISO15118-2, DIN70121 and/ or ISO15118-20	
4. Note down the time it took to start a charging session	- The communicated power and or current limit will be achieved	
5. Check if a charging session is started and analyze the communication between the EVSE and EV	- No error is visible on the EVSE and EV when a session is stopped from EV side	
6. Note down the communication protocol, EV/EVSEMaximumCurrentLimit, EV/EVSEMaximumPowerLimit, EVTargetCurrent and the SOC		
7. Wait for at least 2 minutes		
8. If possible stop the charging session from EV side (if not possible stop from EVSE side)		
9. Note down if the cable will be unlocked at EV side and if any error has been observed at EV (red led) or EVSE side (error notification on screen)		
10. Remove cable from DUT side		

4.1.1.1 Test result: Regular charging

Regular charging and locking mechanism:

- During all sessions a **charging session correctly starts**, and the **cable locked correctly**.

Timing between customer authorisation with charging card and a current flowing:

- All charging sessions will start within 2 minutes. An **average** start time of **27 [s]** has been measured. The **longest** time measured was **63 [s]**, and the **shortest** recorded time was **12 [s]**.

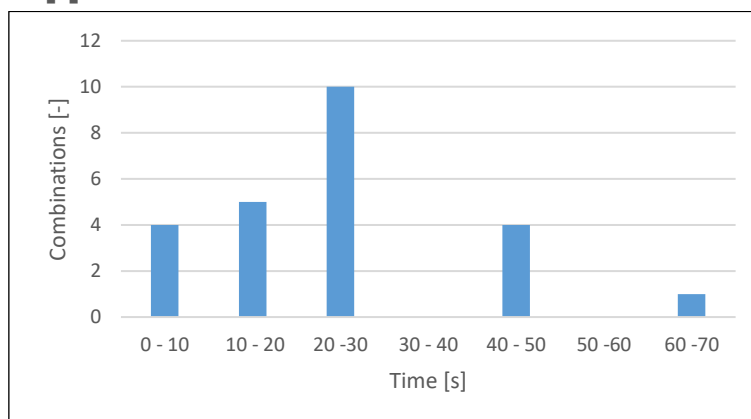


Figure 1 - Measured authorisation timings during the different combinations

- The **maximum communicated current** is **always reached**. The **maximum power** is **not always reached** because the **limited factor** is the **maximum current**. As power = current * voltage, the maximum power will only be reached depending on the battery voltage of the vehicle.
- For the customer, the limited charging power is visible on all the tested charging stations. However, the customer does not see whether the limiting factor is the vehicle, charging station, or grid capacity.
- From within all vehicles, it is not visible for the customer if the vehicle, charging station or the grid is the limited factor, once the charging power decreases. **It is advised** to implement a function within the charging station and vehicles that shows if the charging station, the vehicle or the grid is the limited factor during a charging session.

Stopping a charging session:

- When a charging session is stopped from the vehicle side (if possible) all vehicles correctly unlock the charging cable, and no error messages were observed at the charging station and vehicle side.
- For one of the vehicles, it was not possible to stop the charging session from the vehicle side. **It is advised** to implement this function in case of an error at the charging station side. You should always be able to stop the charging session / unlock the charging cable from the vehicle side.

5. Test plan: Smart charging

5.1 Test suite: Fluctuating charging

5.1.1 Test case: Fluctuating charging

Smart charging: Fluctuating charging profile		
Applicable standards:	IEC61851-1 (2019) & IEC61851-23 (2023)	Estimated test time: 15 minutes
		Release date : 03/02/2026
PREPARATION		
	Connect the equipment according to the set-up drawing	
	Send TxDefaultProfile (see notes below) to the EVSE and check if the EVSE accepts the message	
CONDITION		
	Plug charging cable in the DUT	
TEST CASE		
Smart charging: Fluctuating charging profile		ID:2.0
This test is used to observe the behaviour of the DUT during a fluctuating charging profile set by the EVSE. During this test the charging power/ current will be changed according to the following graph (or otherwise depending on max charging current of the EVSE or as requested by ElaadNL):		
Fluctuating charging profile		
It is expected that the EVSE accepts the profile when send via OCPP and reduce the charging power according to the profile and the EV will follow the profile without stopping the charging session. Optional if data logging is available the EVSEMaximumCurrent, EVSEMaximumPowerLimit and EVTargetCurrent should be logged.		
Actions	Expected results	Notes
1. (if applicable) Start logging with Data acquisition system	- The EVSE accepts the profile (see notes) when send via OCPP and reduces the power according to the profile.	Send following charging profile when using OCPP 1.6: <pre>[2,"ca0a63e4-b307-47a6-ac6f-da4ceb5ec67e","SetChargingProfile",{"connectorId":1,"csChargingProfiles":{"chargingProfileId":471641,"stackLevel":0,"chargingProfilePurpose":"TxDefaultProfile","chargingProfileKind":"Relative","chargingSchedule":{"chargingRateUnit":"W","chargingSchedulePeriod":{"startPeriod":0,"limit":max power er},{ "startPeriod":90,"limit":10000},{ "startPeriod":150,"limit":max power er},{ "startPeriod":210,"limit":0},{ "startPeriod":270,"limit":10000},{ "startPeriod":330,"limit":max power er},{ "startPeriod":420,"limit":0},{ "startPeriod":780,"limit":max power er/2}}]]]</pre>
2. Authorize the charging session and wait until the charging session has been started	- The EV will follow the profile without stopping the charging session.	
3. (If TxDefaultProfile see preparation step is not accepted) change the EVSEMaximumPowerLimit according to above graph	- Optional - The EVSE will change the EVSEMaximumPowerLimit and/ or the EVSEMaximumCurrentLimit according to the charging profile.	
4. Wait until the charging profile is completed	- Optional - The EV will change the EVTargetCurrent according to the charging profile.	
5. Stop charging session via the EVSE and remove the charging cable from the EV		
6. Note down any unexpected behaviour		

5.1.1.1 Test result: Fluctuating charging

Supported communication protocol to send power limits:

- The charging stations used the following protocols to send a fluctuating charging profile during testing:

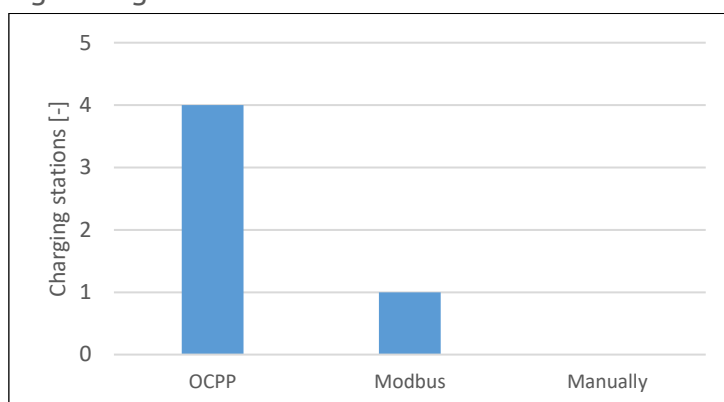


Figure 2 – Communication protocol to send fluctuating charging profile

Fluctuating charging profile:

- During the fluctuating charging profile test case the following behaviour was observed:

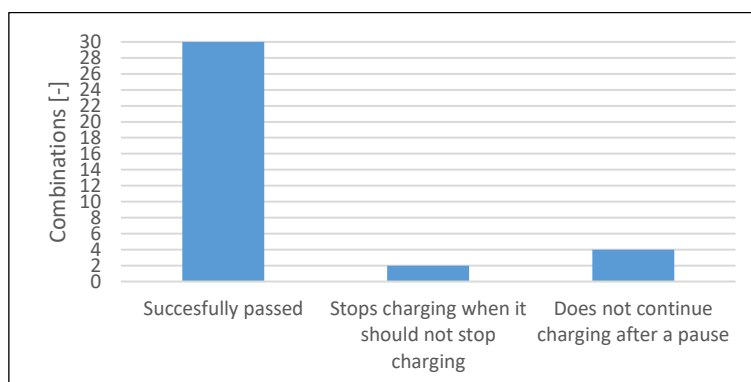


Figure 3 - Results during the fluctuating charging profile

Communicated charging parameters:

- Figure 4 shows the number of charging stations that changed the EVSEMaximumPowerLimit and or EVSEMaximumCurrentLimit according to the charging profile. As the charging profile via OCPP is a power limit it is interesting to see which parameter the charging station will change during the charging loop.
- The vehicles will change the EVTargetCurrent correctly and do not depend on one of the above two EVSE communicated parameters.

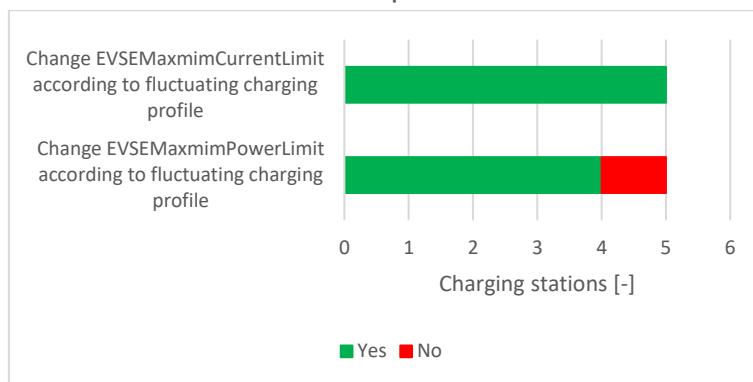


Figure 4 - communicated fluctuating charging parameters within the charging stations

5.2 Test suite: Delayed and paused charging

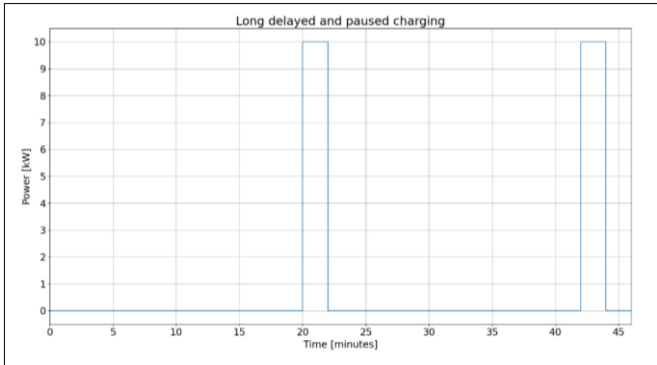
5.2.1 Test case: Short delayed and paused charging

Smart charging: short delay and paused charging		
Applicable standards:	IEC61851-23 & ISO15118-2(0)	Estimated test time: 15 minutes
		Release date : 03/02/2026
PREPARATION		
	Connect the equipment according to the set-up drawing	
	Send TxDefaultProfile (see notes below) to the EVSE and check if the EVSE accepts the message	
CONDITION		
	Plug charging cable in the DUT	
TEST CASE		
Smart charging: short delay and paused charging		ID: 2.1A
This test is used to observe the behaviour of the DUT when a charging session will be delayed and paused for a short time of period. For example a DUT could fall asleep and does not wake up after the commands has been send to start charging especially when all ECU's are asleep. During this test a charging profile (see below graph) is used that first delays the charging session for 5 minutes, starts charging at 10 [kW] for 2 minutes, and pauses the charging session for 5 minutes, after which charging is allowed again for 2 minutes with 10 [kW].		
Short delayed and paused charging		
The advice is to wake up the vehicle and start charging after a delay and pause.		
Actions	Expected results	Notes
1. (if applicable) Start logging with Data acquisition system	- The DUT starts charging after the delay - The DUT starts charging after the pause	Send the following charging profile: [2,"ca0a63e4-b307-47a6-ac6f-da4ceb5ec67e","SetChargingProfile",{"connectorId":1,"csChargingProfiles":[{"chargingProfileId":471641,"stackLevel":0,"chargingProfilePurpose":"TxDefaultProfile","chargingProfileKind":"Relative","chargingSchedule":{"chargingRateUnit":"W","chargingSchedulePeriod":[{"startPeriod":0,"limit":0},{"startPeriod":300,"limit":10000},{"startPeriod":420,"limit":0},{"startPeriod":720,"limit":10000},{"startPeriod":840,"limit":0}]}]}]
2. Connect charging cable and start transaction		
3. (If TxDefaultProfile see preparation step is not accepted) change the EVSEMaximumPowerLimit according to above graph		
4. Wait until the charging profile is completed		
5. Stop the charging session and remove the charging cable from the EV		
6. Stop logging with Data acquisition system		

5.2.1.1 Test result: Short delayed and pause charging

Due to the overnight test this test was not executed. See chapter 5.2.3.1 for the result of the overnight test.

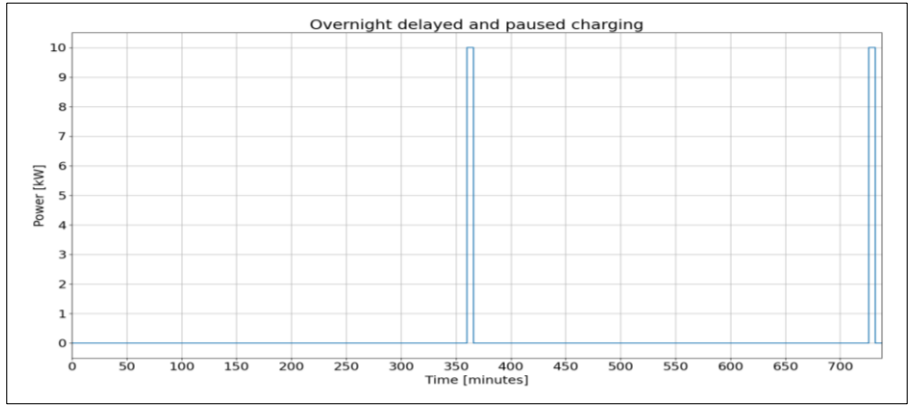
5.2.2 Optional - Test case: Long delayed and paused charging

Smart charging: long delay and paused charging		
Applicable standards: IEC61851-23 & ISO15118-2(0)		Estimated test time: 45 minutes
		Release date : 03/02/2026
PREPARATION		
	Connect the equipment according to the set-up drawing	
	Send TxDefaultProfile (see notes below) to the EVSE and check if the EVSE accepts the message	
CONDITION		
	Plug charging cable in the DUT	
TEST CASE		
Smart charging: long delay and paused charging		ID: 2.1B
This test is used to observe the behaviour of the DUT when a charging session will be delayed and paused for a short time of period. For example a DUT could fall asleep and does not wake up after the commands has been send to start charging especially when all ECU's are asleep. During this test a charging profile (see below graph) is used that first delays the charging session for 20 minutes, starts charging at 10 [kW] for 2 minutes, and pauses the charging session for 20 minutes, after which charging is allowed again for 2 minutes with 10 [kW].		
		
The advice is to wake up the vehicle and start charging after a delay and pause.		
Actions	Expected results	Notes
1. (if applicable) Start logging with Data acquisition system	- The DUT starts charging after the delay	Send the following charging profile: [2,"ca0a63e4-b307-47a6-ac6f-da4ceb5ec67e","SetChargingProfile",{"connectorId":1,"csChargingProfiles":[{"chargingProfileId":471641,"stackLevel":0,"chargingProfilePurpose":"TxDefaultProfile","chargingProfileKind":"Relative","chargingSchedule":{"chargingRateUnit":"W","chargingSchedulePeriod":[{"startPeriod":0,"limit":1200,"limit":10000},{"startPeriod":1320,"limit":0,"limit":2520,"limit":10000},{"startPeriod":2640,"limit":0}}]}]
2. Connect charging cable and start transaction	- The DUT starts charging after the pause	
3. (If TxDefaultProfile see preparation step is not accepted) change the EVSEMaximumPowerLimit according to above graph		
4. Wait until the charging profile is completed		
5. Stop the charging session and remove the charging cable from the EV		
6. Stop logging with Data acquisition system		

5.2.2.1 Test result: Long delayed and pause charging

Due to the overnight test this test was not executed. See chapter 5.2.3.1 for the result of the overnight test.

5.2.3 Optional - Test case: Overnight delayed and paused charging

Smart charging: overnight delay and paused charging		
Applicable standards:	IEC61851-23 & ISO15118-2(0)	Estimated test time: 13 hours
		Release date : 03/02/2026
PREPARATION		
☐	Connect the equipment according to the set-up drawing	
☐	Send TxDefaultProfile (see notes below) to the EVSE and check if the EVSE accepts the message	
CONDITION		
☐	Plug charging cable in the DUT	
TEST CASE		
Smart charging: overnight delay and paused charging		ID: 2.1C
This test is used to observe the behaviour of the DUT when a charging session will be delayed and paused for a short time of period. For example a DUT could fall asleep and does not wake up after the commands has been send to start charging especially when all ECU's are asleep. During this test a charging profile (see below graph) is used that first delays the charging session for 6 hours, starts charging at 10 [kW] for 6 minutes, and pauses the charging session for 6 hours, after which charging is allowed again for 6 minutes with 10 [kW].		
		
The advice is to wake up the vehicle and start charging after a delay and pause.		
Actions	Expected results	Notes
1. (if applicable) Start logging with Data acquisition system	- The DUT starts charging after the delay	Send the following charging profile: <pre>[2,"ca0a63e4-b307-47a6-ac6f-da4ceb5ec67e","SetChargingProfile",{"connectorId":1,"csChargingProfiles":{"chargingProfileId":471641,"stackLevel":0,"chargingProfilePurpose":"TxDefaultProfile","chargingProfileKind":"Relative","chargingSchedule":{"chargingRateUnit":"W","chargingSchedulePeriod":{"startPeriod":0,"limit":0}, {"startPeriod": 21600,"limit":10000}, {"startPeriod": 21960,"limit":0}, {"startPeriod": 43560,"limit":10000}, {"startPeriod": 43920,"limit": 0}}}}]</pre>
2. Send the profile from the notes via OCPP to the EVSE	- The DUT starts charging after the pause	
3. Connect charging cable and start transaction		
4. Wait until the charging profile is completed		
5. Stop the charging session and remove the charging cable from the EV		
6. Stop logging with Data acquisition system		

5.2.3.1 Test result: Overnight delayed and pause charging

Support of a delayed and paused charging session:

- From Monday May 18th at 4:30pm till May 19th 8:30am (CEST time) the overnight delayed and paused charging test has been done. Figure 5 shows the number of combinations supporting the delayed and/ or paused charging session. Two charging stations did not support a delayed charging session. These charging stations did not support a start of a charging session with a limit of 0 [kW].
- During the delayed and paused test cases it has been observed that most charging stations will keep a power of around 1 [kW] during the charging session to keep the charging session alive. For a follow-up test event it is advised to include a B-C-B/ B-E-B toggle test case if the charging station and vehicle support this functionality.

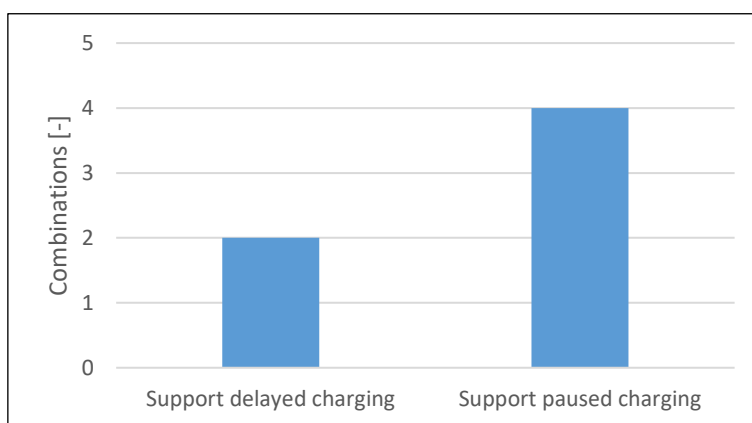


Figure 5 - Combination that support a delayed and/ or paused charging

Reactive power:

Reactive power is the part of electrical energy that is not converted into usable energy, but which does occupy space on the grid. For example, a filter is requesting a reactive power from the grid.

- During the overnight test the reactive power has been measured at the grid side. The measured reactive power is between -3 and 0 [kVAR] with an average of around -1.2 [kVAR]. For a charging hub this amount of reactive power is practically negligible. Depending on the energy contract, the utility provider may impose penalties for reactive power.

6. Optional - Test plan: Interoperability with different protocols ElaadNL

6.1 Test set-up

Figure 6 shows a generic overview of the test set-up where the Keysight COMtester is used to test the interoperability of different charging communication protocols.

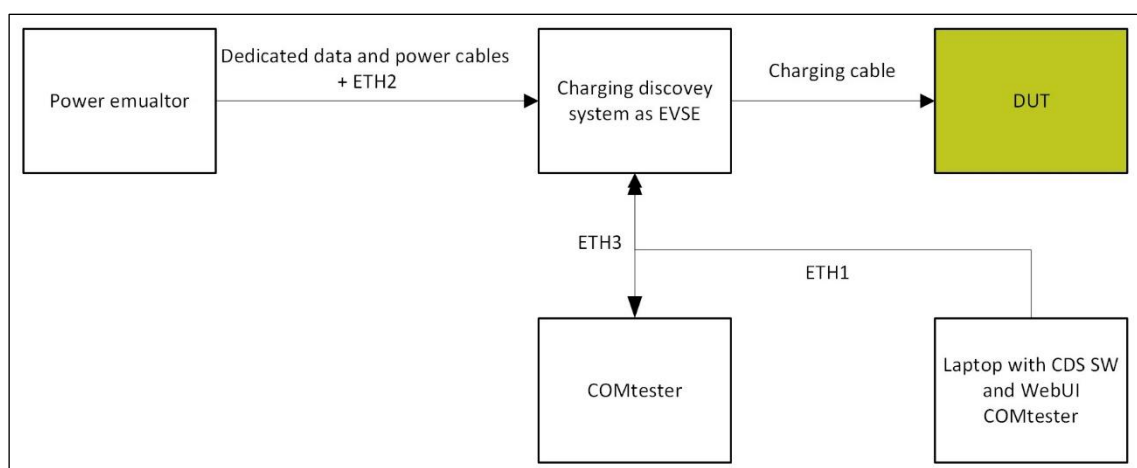


Figure 6 - Test set-up interoperability with different protocols

6.1.1 Test equipment

Name/description	Type
Keysight SL1730A	Power emulator for DC
Keysight SL1200A	Power emulator for AC
Keysight SL1040A	Charging discovery system
Keysight SL1550A	COMtester
Asus NUC 13 pro	Laptop

6.2 Test suite: Interoperability with different protocols

6.2.1 Test case: Interoperability with different protocols

Smart charging laboratory: Interoperability with different protocols		
Applicable standards:	IEC61851, DIN70121, ISO15118-2, ISO15118-20	Estimated test time: 1 hours
		Release date : 30/07/2024
PREPARATION		
☐ ☐ ☐ ☐ ☐	Connect the equipment according to the set-up drawing Place black/ yellow poles around the test area Let the test set-up be checked by someone NEN-3140 VP certified When system is checked and okay turn all equipment on In the back-office delete all smart charging profile of the to be tested EVSE's	
CONDITION		
☐	No condition needed	
TEST CASE		
Smart charging laboratory: Interoperability with different protocols		ID: 3.0
This test will be used to observe how interoperable the DUT will be with different emulated systems on the Keysight system. Per emulated system a regular charging session will be started and will be observed if the communication between the systems is according to specification and if the DUT keeps charging. An overview of the emulated systems can be found in the test results.		
Actions	Expected results	Notes
1. Set the Keysight at the requested emulation parameters	- A regular charging session will start according to the selected communication protocol	
2. Start a regular charging session	- The system keeps charging for at least 2 minutes	
3. Check via the data acquisition system if current is flowing		
4. Wait for at least 2 minutes		
5. Stop charging session via DUT side and check if DUT response according to expected results		
6. Note down the behaviour on the next page		

6.2.1.1 Test result: Interoperability with different protocols

Supported communication protocols:

- **All chargers and vehicles do support DIN70121 and ISO15118-2.** This is in line with the new AFIR rules that mentions that all newly installed charging stations from January 8th 2026 are mandatory to support EN ISO15118-2:2016.
- **Only one charging station supports ISO15118-20.** None of the vehicles support ISO15118-20. The vehicle is leading in which communication protocols should be used during a charging session. It is recommended to implement ISO15118-20, as the AFIR states that all newly installed charging stations from January 1st 2027 need to support ISO15118-20.
- Below relation can be made between the prioritization of the communication protocols within the vehicles (right graph in Figure 7).

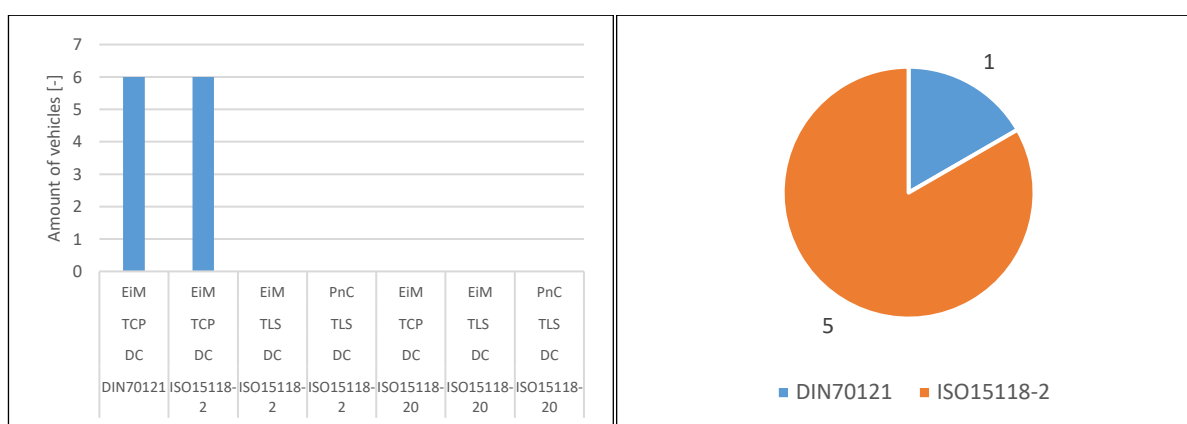


Figure 7 – Supported communication protocols within the vehicles (left graph) and prioritisation of communication protocol within the vehicles (right side).