IMPLEMENTATION GUIDE V2G

RESEARCHING AND TESTING SMART AND SUSTAINABLE CHARGING

ElaadNL | November 2025 | Version 1.0

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1. INTRODUCTION

Bidirectional charging is an emerging technology, allowing an electric vehicle to both charge from the grid and supply energy back to other loads or the power grid. Bidirectional charging can provide financial benefits to end consumers and will add flexibility to the power grid.

By adjusting the (dis)charging process of the electric vehicle, a number of flexible energy services can be achieved:

- Reduce grid congestion by discharging during high electricity demand (peak shaving) and charging during off-peak hours (valley filling);
- Increase self-consumption of solar production;
- Aid in balancing supply and demand of electricity.

The large scale adoption of bidirectional charging is partly held back by a complex set of requirements related to grid interconnection, interoperability and the installation process for bidirectional chargers. This V2G installation guide serves as a resource for all parties interested in the development and deployment of bidirectional charging, by describing the requirements to be considered 'V2G ready' in the Dutch EV market from a grid operator's perspective.

This guide is divided into three sections. Chapter 1 describes the different types of bidirectional charging and specifies which specific bidirectional charging solutions are within the scope of this document. Chapter 2 describes the implementation process for both private and public V2G and provides recommendations to end users and site owners on how to prepare their grid connection to fully unlock the potential of bidirectional charging. Furthermore, this guide includes appendices describing technical requirements to perform V2G, policy recommendations and potential use cases of V2G in alleviating grid congestion

SCOPE

Depending on the application that bidirectional charging is used for, different rules and regulations may apply. This section describes the different applications of bidirectional charging and commonly used definitions.

From a systems perspective, the most important distinction between bidirectional charging applications is the connection with the wider power grid. Islanded – or off-grid – bidirectional charging allows vehicles to supply electricity to other loads while being disconnected from the grid. With Vehicle-to-Load (V2L), the vehicle is equipped with an AC outlet that can power a single (portable) device. Common applications include camping, charging another electric vehicle (Vehicle-to-Vehicle) and powering tools such as vacuum cleaners. Furthermore, bidirectional vehicles can be used to power a building in case of a power outage. In this case, the electric vehicle and charging station act as a grid forming module, which allows power transfer behind the customer meter without a connection to the wider grid. This application is also known as islanded or off-grid Vehicle-to-Home (V2H).

Islanded bidirectional applications are generally easier to implement than grid connected applications. Because there is no connection with the power grid, there is no need for an interconnection agreement with the grid operator. However, due to the lack of a grid connection, the potential use cases for islanded bidirectional charging are limited. For instance, it is not possible for the customer to trade their 'flexible' energy on energy markets to save or earn money. Islanded bidirectional charging is excluded from the scope of this report because of the limited potential use cases in the Netherlands.

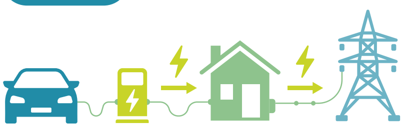
The second category of bidirectional charging applications is interconnected bidirectional charging. Interconnected devices, such as solar panels and batteries, are able to discharge energy to the power grid. A precondition of being interconnected is that the device should be grid synchronized, which includes measuring and following certain aspects of the power grid, such as frequency, voltage and phase angle. Before an interconnected device can be connected and allowed to discharge energy to the grid, an interconnection agreement between the consumer and grid operator should be made. Chapter 3 describes the interconnection process and requirements for interconnection in more detail.

Vehicle-to-Grid (V2G) encompasses all applications where a bidirectional vehicle and charging station are grid-synchronized and able to discharge energy to the power grid. Confusingly, Vehicle-to-Home (V2H) can both refer to islanded (off-grid) and interconnected (grid-synchronized) applications. With the latter, the consumer's home is treated as the primary load, while any energy surpluses and deficits are exported to or imported from the power grid. To avoid confusion, this report uses the term V2G to refer to any interconnected bidirectional charging application.

Scope of the V2G Installation Report

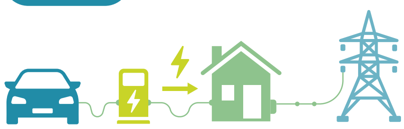
Within scope:

V2G



V2G refers to all applications where a bidirectionel vehicle can discharge power directly to the grid.

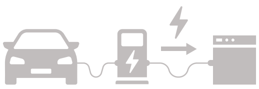
V2H (Interconnected)



Interconnected V2H is a variant of V2G where the consumer's home is treated as the primary load.

Outside of scope:

V2L



With V2L, the vehicle is equipped with an AC outlet that can power a single device.

V2H (Islanded)

With islanded V2H, the vehicle and charging station act as a grid forming module. The vehicle can power the household without a connection to the grid.

Graphic adapted from the Center for Community Energy

2. IMPLEMENTATION

This chapter outlines the requirements for installing a V2G module. A V2G module can either refer to an individual DC V2G charging station or a combination of an AC V2G electric vehicle and an AC V2G charging station. The technical requirements for connecting a V2G module are described in Chapter 3.

This chapter serves as a practical guideline for consumers, site owners and installers by describing the necessary steps to correctly install a V2G charging station and connect a V2G vehicle in compliance with the Dutch grid code and the guidelines set by grid operators. The requirements and recommendations described in this chapter are applicable to both public and private V2G implementations.

GRID CONNECTION

The Dutch grid code requires all devices with a rated power of more than 5,75 kVA to be three-phase connected.[1] A single-phase connected charging station should therefore limit its maximum power to a maximum of 5,75 kVA (1x25A). As most V2G vehicles and charging stations are able to discharge with a maximum power up to 11 kW (3x16A) and may in some cases only support three-phase bidirectional charging, a three-phase connection of a V2G charging station is highly recommended.[2] Households with a single-phase grid connection should reinforce their connection to accommodate for three-phase power transfer. Grid reinforcement for installations up to 55,2 kVA (3x80A) can be requested at www.mijnaansluiting.nl.

SMART METER

Smart meters are a tool which help consumers access the benefits of flexible energy usage. Unlike traditional meters, which only record overall consumption, smart meters provide insight into consumer behavior by measuring energy usage near real-time. Smart meters are essential for unlocking flexibility of V2G with multiple potential use cases:

- Self-consumption of local solar PV by charging during production surplus and discharging during consumption surplus;
- Charge when prices are low and discharge when prices are high with a dynamic energy contract;
- Allow trade on markets for ancillary services, such as imbalance and congestion markets.

The specifications of smart meters are described in Dutch Smart Meter Requirements (DSMR). The most commonly used smart meters versions are DSMR v4 and DSMR v5. These smart meters contain a P1 connection point which can be used to communicate electricity meter readings to the consumer. Using a DSMR v5 smart meter is recommended for flexibility purposes due to the higher frequency of real-time measurements (every second as opposed to every 10 seconds for DSMR v4). The higher frequency of DSMR v5 is important in conjunction with a home energy management system (HEMS) to prevent local issues such as the tripping of fuses due to overproduction (e.g. if both solar PV and the V2G charging station discharge simultaneously). An upgrade of the electricity meter to a DSMR v5 smart meter can be requested at the grid operator.

Public charging stations have a separate, direct connection to the power grid. In these cases, the grid operator is responsible for installing the smart meter in the charging station. Since 2018, DSMR v5 is used

[1] Dutch grid code, Article 2.33 (2)

[2] A three-phase connection of a charging station is also recommended from a grid operator's perspective to minimize phase imbalance: https://youtu.be/qpcsGS42KPE?si=02pQ0HqmwXQVdG-p

for all charging stations. This also applies to semi-public charging stations that have a separate grid connection.

MANAGEMENT SYSTEM

The installation of a V2G charging station adds a significant load and reinjection potential to the grid connection. Coordination between a V2G charging station and other devices is necessary to match supply and demand and thereby preventing overloading of the grid connection. Rudimentary communication between a charging station and the smart meter can be accomplished by connecting a P1 meter to the P1 port of the smart meter. Additional value can be achieved by integrating multiple flexible devices in a (Home) Energy Mangement System, or (H)EMS. An (H)EMS is a central control unit that manages and coordinates flexible energy-producing and energy-consuming devices. An (H)EMS provides multiple benefits to end consumers:

- It optimizes self-consumption of local solar energy;
- It prevents that the contracted power of the grid connection is exceeded, either by overconsumption or overproduction. By extension, this prevents that the consumer or site owner requires an increase in their grid connection;
- It increases the potential financial benefits of flexible energy usage. For instance, by scheduling the (dis)charging of the vehicle based on a dynamic energy contract. Additionally, it enables the consumer or site owner to participate in markets for ancillary services like imbalance settlement;
- It enables identifying the origins of power flows. By distinguishing between self-consumption and grid usage, double taxation of consumed energy can be prevented.

The (H)EMS can control smart devices either directly or indirectly after receiving a signal from a third party requesting flexibility. This requires interoperability between different devices: they should be able to exchange information with the (H)EMS regardless of the manufacturer. One of the key challenges in developing the (H)EMS lies in the absence of standardized communication protocols between flexible devices and (H)EMS. Furthermore, there is no uniform interface for an (H)EMS to interact with external systems. The development of interoperable energy management systems is ongoing.

REGISTRATION (INTERCONNECTION AGREEMENT)

The Dutch grid code mandates that an interconnection agreement must be established between a consumer or site owner and grid operator for any production or storage device with a rated power of at least 0,8 kW. The agreement proves that the connected device complies with the Dutch grid code requirements and provides grid operators with valuable insights on the location and capacity of installed production and storage units. The grid code requirements are described in detail in Chapter 3 of this report.

Registration is mandatory and can be done unilaterally by the consumer or site owner by registering the V2G module at energieleveren.nl. To complete registration, the consumer or site owner shall provide technical information about the V2G module to the grid operator. The manufacturer of the vehicle and/or charging station should therefore be aware that the following information is clear to the consumer:

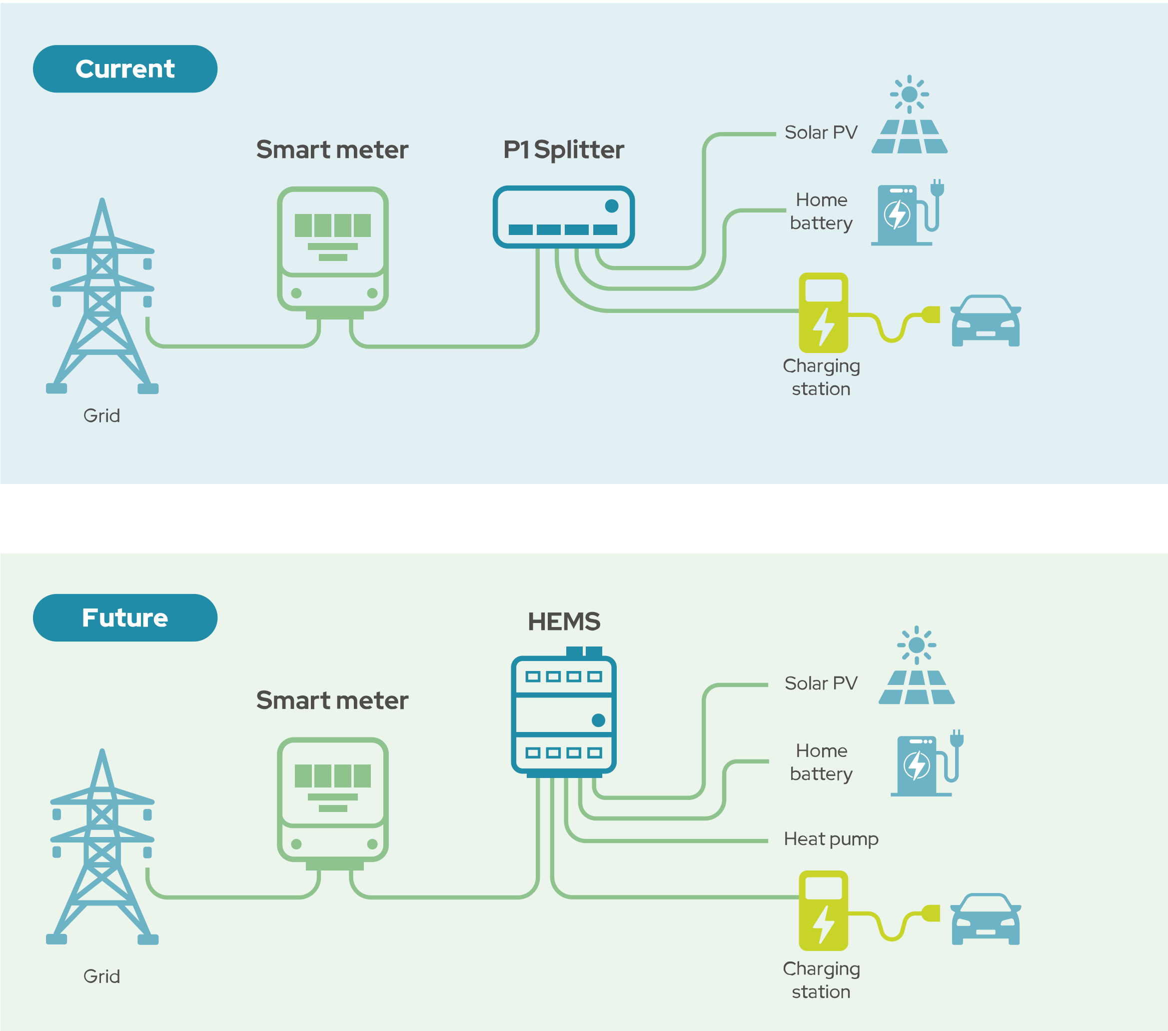
- The brand and type of inverter
- The maximum rated power of the inverter (in kW)
- The storage capacity of the electric vehicle (in kWh)
- Commissioning date

The detailed registration process is described at https://www.energieleveren.nl/faq.

For public charging stations, questions remain regarding tender procedures and registration. Some tenders include provisions that prescribe that charging stations should be prepared for V2G. However, a clear definition of what constitutes 'V2G ready' is missing. To bridge this gap, Elaad is drafting a compliancy credential, which includes the requirements to be considered V2G ready. A registration process for public V2G charging stations is under development.

INSTALLATION

Smart Meter



3. TECHNICAL REQUIREMENTS (INTERCONNECTION)

ElaadNL published a guideline on technical requirements for smart and bidirectional charging infrastructure in March 2025.[3] This chapter provides an in-depth overview of the technical requirements for interconnection based on the guideline, which can be applied to both bidirectional vehicles and charging stations. It also offers a guideline on how compliance with the aforementioned requirements shall be verified.

INTERCONNECTION

Devices connected to the power grid affect and are affected by certain grid aspects such as frequency, voltage and harmonics. These devices should minimize distortions to the grid and contribute to fixing power quality issues. A number of requirements have been described in national and international regulations and standards. The requirements described in this chapter are related to maintaining the system stability as a whole. Other aspects, like how a V2G vehicle and charging station should respond to signals of local grid congestion, are outside the scope of interconnection requirements.

Requirements for Generators

The Requirements for Generators (RfG) is a network code published in 2016 that describes the behavior of grid-synchronized production units. Small production units (i.e. rated power below 1 MW) shall comply with the 'Type A' requirements, which are described in Article 13 of the RfG. The RfG is adopted in the Dutch grid code (Articles 2.16 and 3.13). In the Netherlands, the RfG is also applied to storage units and therefore mandatory for V2G installations.

The Dutch grid code contains an additional requirement related to the active power response to underfrequency (LFSM-U). Storage units shall adjust their active power during periods of underfrequency, which is not required for Type A units according to the RfG. LFSM-U is a must-have requirement for storage units to ensure system stability during emergency situations. The specifical technical requirements of the Dutch grid code are described in Appendix 4 of this report.

Interface protection settings

Interface protection refers to safety mechanisms of the inverter. The interface protection disconnects an interconnected unit from the grid when the voltage and frequency deviates too much from normal operation limits (i.e. 50 Hz or 230 V). The interface protection prevents damage to electrical equipment as they are not designed to operate outside the normal operation ranges. Furthermore, the interface protection serves an important role for the stability of the grid by disconnecting production units during overvoltage and overfrequency events. Interface protection settings are established on the national level rather than in the RfG. The Dutch grid code specifies the parameters in Article 3.8 (for units with a maximum rated power of 11 kW or less) and Article 3.14 (for units with a maximum rated power of more than 11 kW).

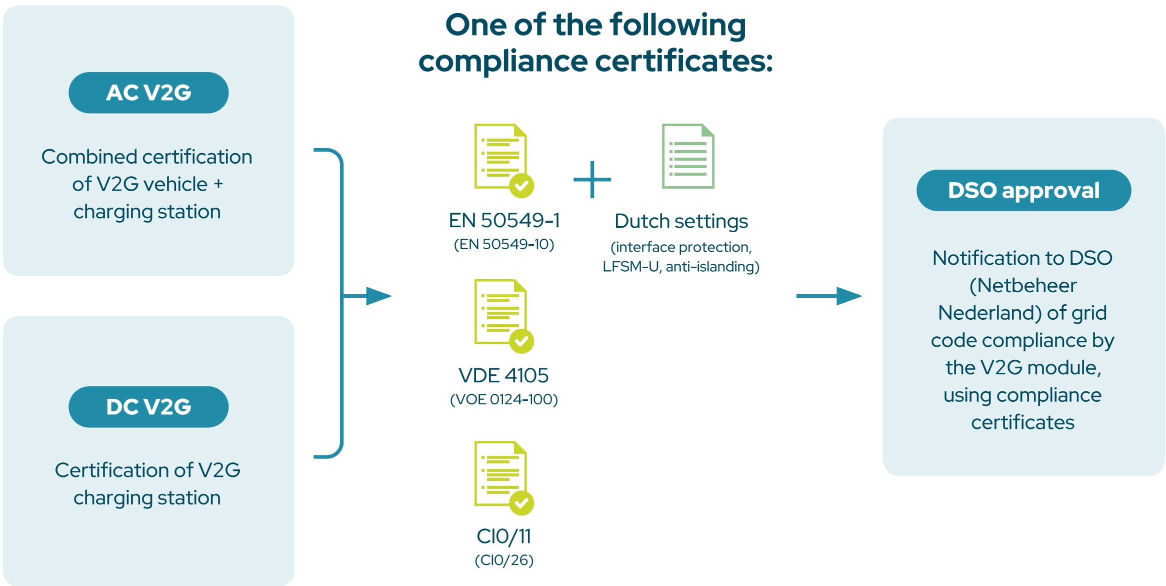
The interface protection shall also include a mechanism that automatically disconnects the charging station from the grid in case of a power failure. This feature, known as anti-islanding, prevents that the

[3] https://elaad.nl/nieuwe-technische-richtlijn-voor-slimme-en-bi-directionele-laadinfrastructuur

charging station continues to power local loads in case of a power failure. The detection of unintentional island situations is important to ensure the safety of maintenance workers during a power outage.

Certification

An interconnection agreement between a grid operator and consumer can only be made if the consumer can prove that the V2G vehicle and charging station is compliant with the Dutch grid code. Grid code compliance can most easily be proven to the grid operator using certificates. A certificate will be provided by an accredited certification body after grid code compliance has been proven. Manufacturers of the V2G vehicle or charging station generally conduct a compliance test prior to market release.



The difference between AC V2G and DC V2G should also be taken into account. When charging an electric vehicle, alternating current (AC) from the grid has to be converted to direct current (DC) to be stored in the battery. The conversion of AC to DC can either be done via the inverter in the on-board charger in the EV (AC charging) or via the inverter in the charging station (DC charging). Likewise, the conversion from DC to AC with V2G can either be done by the inverter in the EV or the inverter in the charging station.

With AC V2G, ensuring grid code compliance is more complex because there is no fixed, permanent connection between the inverter and the power grid. Since vehicles are mobile and can cross borders, grid operators face challenges in verifying whether a particular electric vehicle meets the local technical requirements for interconnection. It is therefore currently not possible to certify an electric vehicle for grid code compliance on its own. Instead, certification must be based on a combination of a V2G vehicle and charging station. Only these integrated modules (where the electric vehicle and charging station have been tested and certified together) can be submitted for an interconnection agreement. The combined certification of EVs and charging stations is considered a barrier to an interoperable V2G system. A proposed solution to remove this barrier is described in Appendix 5.

With DC V2G it is only required that the charging station is certified, as the inverter has a fixed location and permanent grid connection. In the context of DC V2G, a V2G module only refers to the DC charging station.

The Dutch grid code does not specify how compliance should be verified and tested. To bridge the gap between legislation and practical implementation, internationally recognized technical standards are used. The most commonly used standard for this purpose is EN 50549. The German standard VDE 4105 and the Belgian standard C10/11 are also accepted to prove compliance. Though there are some minor difference between these standards and the Dutch grid code (for instance, different interface protection settings), no additional test reports are needed to bridge this gap. Once certified, the V2G module can be registered with the grid operator via rfg@netbeheernederland.nl.[4]

[4] A detailed description on how certificates can be submitted can be found at https://www.netbeheernederland.nl/requirements-generators

APPENDICES

APPENDIX 1 – TECHNICAL REQUIREMENTS (COMMUNICATION)

Communication protocols are essential in the context of V2G because they enable reliable, secure and standardized data exchange between electric vehicles, charging stations, grid operators and e-mobility stakeholders. This section provides an overview of the commonly used communication protocols across the communication chain that should be implemented in order to enable bidirectional power transfer.

ISO 15118-20

ISO 15118 is a communication protocol that enables high level communication between an electric vehicle and a charging station. ISO 15118-20, published in 2022, provides the basis for bidirectional charging and will be mandatory for all new public and private (Mode 3) charging stations from January 2027 onwards. ISO 15118-20 adds detailed negotiation between the electric vehicle and charging station, which includes signals for dynamic pricing and grid congestion.

For AC V2G, another important aspect of negotiation is the communication of local grid code settings between the electric vehicle and charging station. As technical requirements differ between countries, different grid codes and local settings may apply. Even if the electric vehicle is certified in accordance with the process outlined in paragraph 2.1, the electric vehicle receives information about which local grid code settings apply. The most recent version of ISO 15118-20 does not allow the communication of local grid code settings from the charging station to the electric vehicle. For this purpose, an amendment to ISO 15118-20 has been proposed and is expected to be published in early 2026.

The amendment introduces a new function known as AC_BPT_DER. The possible range of grid code settings (for instance as described in standards such as EN 50549) should be implemented in the on-board charger of the electric vehicle. The charging station uses the function to communicate which local grid code settings apply. If all settings communicated by the charging station are supported by the electric vehicle, it is ensured that the V2G module complies with the relevant technical requirements. Without AC_BPT_DER it is only possible to implement static grid code settings and therefore the inverter of the electric vehicle cannot be controlled. As a result, each on-board charger needs to have a different configuration for each different local grid code setting. The implementation of amendment 1 of ISO 15118-20 is highly recommended to enable the scale-up of V2G modules across the entire European market, but is not a necessity from a grid operator's perspective.

OCPP (IEC 63584)

The Open Charge Point Protocol (OCPP) is the industry standard for communication between a charging station and a charging station management system. OCPP was approved as an IEC international standard IEC 63584 in 2024. OCPP allows charge point operators to manage and control a large number of charging stations from a single platform. It facilitates essential functions such as user authentication, charging session management and remote control. The most recent version of OCPP, version 2.1, introduces new functionalities that are key to enabling V2G. It includes native support for ISO 15118-20, Bidirectional Power Transfer (BPT) and DER control. The latter allows the grid operator to communicate specific parameters related to power quality and grid code support. This way, changes in grid code parameters can be communicated easily without the need to modify the inverter of the vehicle. In addition to these functionalities, a charging station should also support the core, advanced security and smart charging services of OCPP in order to fully support V2G.

AC V2G	Requirements	Implementation in EV	Negotiation between EV and EVSE	Local differences in grid codes	Changes in grid codes
Static grid code support	ISO 15118-20 OCPP 2.0.1	EV implements local grid code settings	No negotiation between EV and EVSE for grid code settings	Each different local grid code requires a new configuration in the EV OBC	Changes in grid code parameters require an update of the EV OBC
Dynamic grid code support	ISO 15118-20 Amendment 1 to ISO 15118-20 (AC_BPT_DER) OCPP 2.1	EV implements a range of all possible grid code settings	Negotiation between EV and EVSE which specific grid code settings apply (via ISO 15118-20 Amd. 1)	Only one configuration is required in the EV (OBC) for all local grid codes	Changes in grid code parameters can be communicated to the EVSE via OCPP 2.1

OCPI

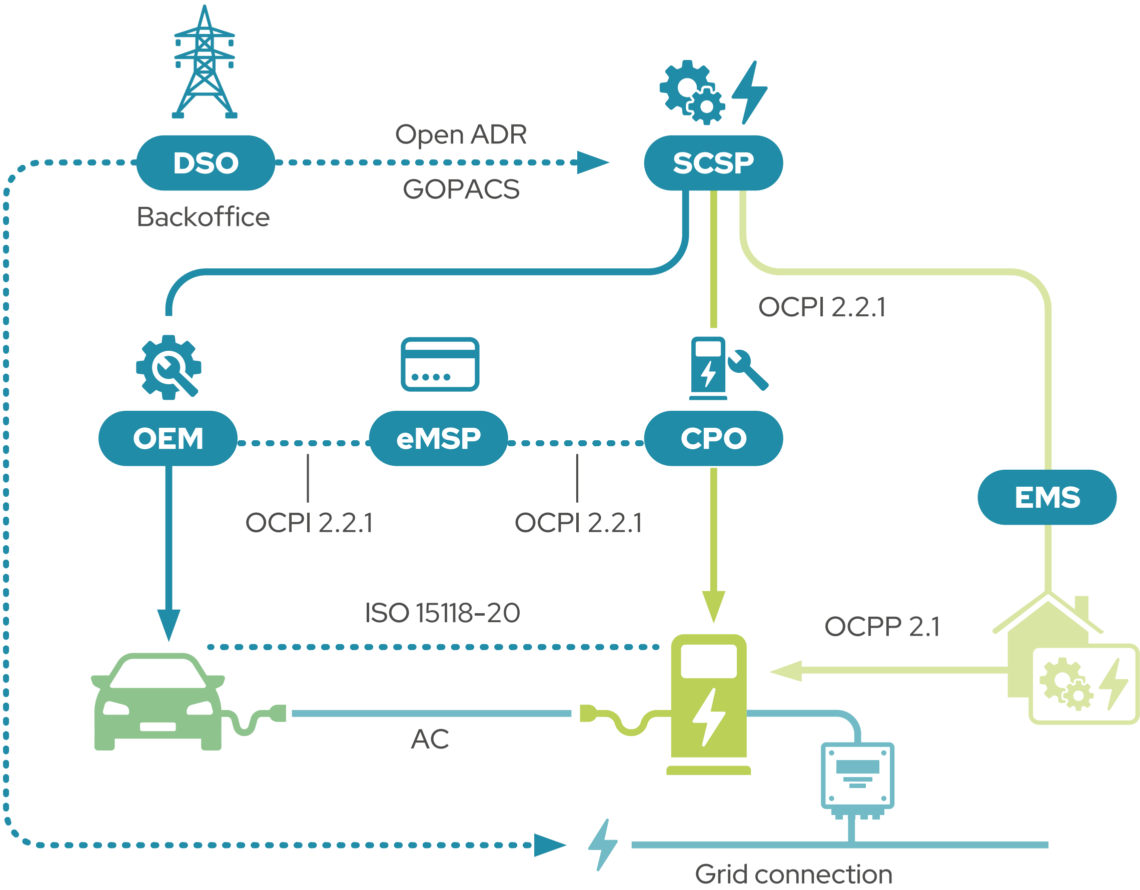
OCPI (Open Charge Point Interface) is an open protocol between charging point operators and service providers. OCPI enables electric vehicle users to initiate a charging session on nearly every charging station using a single charging card. Similar to 'roaming' with your mobile phone, OCPI allows you to use all charging networks through a single provider. Besides convenience, OCPI offers additional benefits: the protocol helps consumers gain insight into important data such as location, accessibility, and pricing. The most recent version of OCPI (v2.3) does not include support for specific V2G functionalities like discharge tariffs. OCPI 3.0, expected to be released in late 2025, adds support to complex scenarios and integration with OCPP 2.1, enabling V2G transactions.

Certification

Certification of dynamic grid code support based on ISO 15118-20 and OCPP 2.1 is not yet available. Test cases for ISO 15118-20 are defined in ISO 15118-21. However, this does not yet include a test case for the AC_BPT_DER function. Compliance with OCPP can be tested with the OCPP Compliance Test Tool (OCTT), but is only available for OCPP 2.0.1. There is no confirmed release date for a test tool for AC_BPT_DER and OCPP 2.1.

ElaadNL is currently discussing a temporary solution to enable V2G before publication of ISO 15118-21 and OCTT 2.1. V2G will be allowed via a temporary compliance credential. The aim of the credential is to prove that the EV and charging station models comply with the Dutch grid code and additional functional requirements. However, this solution is not considered future-proof, as it only enables V2G via a proprietary route, without the desired interoperability.

V2G Charging management



APPENDIX 2 – V2G COMPLIANCE CHECKLIST

Aspect	Explanation	Requirement	Notes
General requirements	General requirements for all smart charging stations. Includes requirements for measuring devices, cyber security, safe installation and integration with Energy Management Systems	Charging station complies with NTA 8043	Currently, no compliance verification is available yet From Q1 2026 onwards, compliance with NTA 8043 can be proven with a certification based on a to be published test standard
		Charging station is installed according to NEN 1010 (clause 722)	General requirement for all charging stations
Visual indicators	Show to EV drivers that the charging point is suitable for bidirectional charging	On the charging station it should be clearly visible that the charging station is suitable for bidirectional charging. The status indicators provides indication when the EV supplies energy to the grid.	N/A
Certification	Certification proves that the V2G module complies with the Dutch grid code	V2G module complies with NEN-EN 50549-1	Compliance verification with a test report based on EN 50549-10
		Alternatives to prove grid code compliance: V2G module complies with VDE 4105	Alternatives to prove grid code compliance: Test report based on VDE 0124-100
		V2G module complies with C10/11	Test report based on C10/26
		V2G module implemented Dutch settings for interface protection (Grid Code §3.8 and §3.14)	If EN 50549-1 is used, compliance verification with a test report based on EN 50549-10 If VDE 4105 or C10/11 is used, compliance verification with a test report based on VDE 0124-100 or C10/26. The German/Belgian settings for interface protection may be used
		V2G module contains means to detect unintentional islanding	Compliance verification with a test report based on IEC 62116
		V2G module implemented Dutch setting for LFSM-U droop (Grid Code §2.16)	Compliance verification with a test report based on EN 50549-10, VDE 0124-100 or C10/26

Communication	High-level communication between EV and charging station is required to enable bidirectional power transfer	EV supports ISO 15118-20 including AC_BPT_DER Charging station supports ISO 15118-20 including AC_BPT_DER	Currently, no compliance verification is available yet From 2026 onwards, compliance with ISO 15118-20 can be proven with a certification based on ISO 15118-21
	High-level communication between a charging station and a charging station management system is required to enable integration with ISO 15118-20 and communication of grid code settings	Charging station supports OCPP 2.1	Currently, no compliance verification is available yet From 2026 onwards, compliance with OCPP 2.1 can be proven with a certification based on the OCPP Certification Test Tool (OCTT)
	Communication between charge point operators and mobility service providers to enable V2X transactions	The backend of the Charge Point Operator supports OCPI 2.3 or higher	OCPI 3.0 is under development and expected to be released in late 2025. The implementation period for OCPI 3.0 is to be determined.
Registration (private V2G)	Registration gives the grid operators information on the location V2G charging stations are installed. During registration process, the consumer can prove that the V2G module is certified	V2G module is registered at energieleveren.nl	The registration process is described in detail in Appendix 4.
Registration (public V2G)	Registration gives the grid operators information on the location V2G charging stations are installed. During registration process, the consumer can prove that the V2G module is certified	To be determined	Registration most like to be done via energieleveren.nl
Grid connection	Improve the business case of V2G by enabling three-phase power transfer	Grid connection should be at least 3x25A	Optional requirement
Smart meter	Enable real-time production and consumption measurement	Smart meter of the main grid connection complies with DSMR 5 requirements	N/A
Management system	Enable coordination between charging stations and other devices	V2G charging station is connected to and able to communicate with an EMS	Optional requirement

APPENDIX 3 – DESCRIPTION OF TECHNICAL REQUIREMENTS

While substantial technical differences between countries exist, the grid codes for interconnection are fundamentally based on the same overarching principles. The following technical requirements are typically included in grid codes worldwide.

Requirement	Explanation	Implementation in Europe (RfG and EN 50549)
Voltage and frequency operating ranges	Operating ranges prevent cascading effects by preventing that production units disconnect from the grid too quickly. Production units should stay connected during temporary frequency and voltage deviations	Frequency ride through Voltage ride through RoCoF ride through
Frequency control	Frequency control helps restore the grid to normal operating ranges by prescribing production units to adjust their active power output, e.g. during large frequency deviations	LFSM-O LFSM-U
Voltage control	Voltage control helps restore the grid to normal operating ranges by prescribing production units to provide reactive power with different control schemes	Included, but not relevant for V2G in the Netherlands Q setpoint mode Q (U) Cos φ setpoint mode Cos φ (P)
Post-fault behaviour	Post-fault behaviour prevents cascading effects by preventing that production units concurrently reconnect to the grid after a grid fault has been cleared	Starting to generate electrical power Automatic reconnection after tripping
Protection	Protection requirements help to protect both the grid and the equipment itself by automatically disconnecting the production unit during abnormal conditions	Interface protection Anti-islanding
Active power control	Active power control allows production units to be controlled remotely. It can, for example, be used to prevent grid congestion issues	Logic interface
Power quality	Prevent energy losses and damage to equipment due to power quality issues	Not included in RfG Included in EN 50549 and other international standard (e.g. EN 50160, IEC 61000)

The following table provides a detailed explanation of grid code requirements in the European grid code.

Reference in Dutch grid code	Reference in RfG	Reference in EN 50549-1	Requirement	Explanation
2.16(f)	N/A	4.6.2 Power response to underfrequency	LFSM-U	Limited Frequency Sensitivity Mode – Underfrequency describes the behavior of a storage unit during periods of underfrequency During underfrequency, a storage unit shall increase its active power output proportionally to the frequency dip Lower frequency threshold is configurable between 49.5 and 49.8 Hz. The default threshold is 49.8 Hz The droop setting is set at 2%, i.e. 100% per Hz. For every frequency drop of 0.1 Hz below the lower frequency threshold, the storage unit shall increase its active power with 10% of its maximum rated power
3.8	N/A	4.9.2 Requirements on voltage and frequency protection	Interface protection	The interface protection describes the behavior of a production or storage unit during large voltage and frequency deviations. The production or storage unit shall automatically disconnect from the grid within a certain time period if frequency and/or voltage exceeds certain limits For units with a rated power between 0.8 and 11 kW • UV1 – 80% of Un – 2 seconds • OV1 – 110% of Un – 2 seconds • UF1 – 47.5 Hz – 2 seconds • UF2 – 51.5 Hz – 2 seconds For units with a rated power above 11 kW • UV1 – 80% of Un – 2 seconds • UV2 – 70% of Un – 0.2 seconds • OV1 – 110% of Un – 2 seconds • UF1 – 47.5 Hz – 2 seconds • UF2 – 51.5 Hz – 2 seconds
N/A	N/A	5.8.6 Islanding	Anti-islanding	The production or storage unit is equipped with a device that detects unintentional island situations and automatically disconnects the production or storage unit from the grid. It is allowed to use the relay for this disconnection.

				A test report according to IEC 62116:2014 must be available
3.13(1)	13(1)(a)	4.4.2 Operating Frequency Range	Frequency ride through	Frequency ride through describes the behavior of a production or storage unit during frequency deviations. The production or storage unit shall be able of operating on different grid frequencies without automatically disconnecting from the grid for a defined time period • At least 30 minutes in the frequency range of 47.5 – 48.5 Hz • At least 30 minutes in the frequency range of 48.5 – 49.0 Hz • Indefinitely in the frequency range of 49.0 – 51.0 Hz • At least 30 minutes in the frequency range of 51.0 – 51.5 Hz
3.13(2)	13(1)(b)	4.5.2 ROCOF withstand capability	RoCoF ride through	RoCoF ride through describes the behavior of a production or storage unit during sudden, quick changes of the nominal frequency The production or storage unit shall be able of operating for at least 0.5 seconds during frequency deviations of 2 Hz per second
3.13(4)	13(2)	4.6.1 Power response to overfrequency	LFSM-O	Limited Frequency Sensitivity Mode – Overfrequency describes the behavior of a production or storage unit during periods of overfrequency During overfrequency, a production or storage unit shall decrease its active power output proportionally to the frequency spike Upper frequency threshold is configurable between 50.2 and 50.5 Hz. The default threshold is 50.2 Hz The droop setting is configurable between 4% and 12%. The default droop setting is 5%, i.e. 40% per Hz. For every frequency spike of 0.1 Hz above the upper frequency threshold, the production or storage unit shall decrease its active power with 4% of its maximum rated power
3.13(5)	13(4)	4.4.3 Minimal requirement for active power	Admissible power reduction	Admissible power reduction describes the behavior of a production or storage unit during periods of underfrequency

		delivery at underfrequency		The production or storage unit – when operating on its maximum active power output – may reduce its active power during underfrequency The reduction threshold is set at 49.5 Hz. The maximum reduction rate is set at 10%. A production or storage unit operating below the maximum active power output when the reduction threshold is reached, shall operate according to the LFSM-U requirement
3.13(6)	13(6)	4.11.2 Reduction of active power on set point	Logic interface	The production or storage unit shall be equipped with a logic interface in order to cease active power output within five seconds following an instruction received at the input port The specifications of the logic interface are not described in the Dutch grid code. Reducing active power output on set point is available via OCPP Ceasing active power output is available via digital interface of the smart meter. Implementation is currently not required
3.13(7)	13(7)	4.10.2 Automatic reconnection after tripping 4.10.3 Starting to generate electrical power	Automatic (re)connection	Automatic (re)connection requirements describe the behavior of a production or storage unit after tripping of the interface protection or after an initial reinjection event (starting to generate electrical power) The production or storage unit may only connect with the grid if the frequency and voltage are within normal operating limits for a certain time period. The production or storage unit may only increase its power output following an active power gradient The following conditions must be met: • Voltage is between 90% and 110% of Un • Frequency is between 49.9 and 50.1 Hz • Minimal observation time is 60 seconds • Active power output may increase by 20% of maximum rated power per minute

APPENDIX 4 – CERTIFICATION AND REGISTRATION PROCESS

Process Step	Responsible Party	Description / Requirements
Compliance verification	Manufacturer	The inverter used in the generating / storage module shall first be certified via the following process: • The inverter shall comply with the Dutch grid code ('Netcode Elektriciteit'), which is based on the European grid code 'Requirements for Generators'. • Compliance verification with the Dutch and European grid codes is described in Netbeheer Nederland – ESM Compliance Verification. In short, the inverter / storage module (Type A) shall comply with the following requirements: • Netcode §3.4 (RfG Type A requirements) • Netcode Article 2.16 (additional requirements for storage units) • Netcode Article 3.14 and EN 50549-1, Article 4.9.3 (Interface protection settings) The manufacturer shall contact the Dutch DSOs via rfg@netbeheernederland.nl and provide the necessary equipment certificate(s). Once all required information is provided, the inverter will be listed on the *'Goedegekeurde omvormers opslag type A'* list, available at energieleveren.nl/faq ('Hoe moet ik registreren?').
Registration at energieleveren.nl	Consumer / installer / site operator	The storage module shall be registered on energieleveren.nl. The registration can be submitted by the consumer, the installation technician or indirectly via the grid operator. It is common practice that the consumer or installer submits the registration. The registration process is described at energieleveren.nl/faq. Note*:* There is currently no formal process to register EVs and charging stations at energieleveren.nl. ElaadNL is currently working together with the Dutch grid operators to include bidirectional EVs and charging stations.

APPENDIX 5 – POLICY RECOMMENDATIONS

Grid codes

One of the main barriers to the large scale deployment of V2G is the lack of harmonization of technical requirements across Europe. Differences in national grid codes make it difficult for manufacturers to design a single product for the European market. As discussed in Appendix 1, this barrier is especially problematic for AC V2G. Complex communication between the vehicle, charging station and central management systems is required to bridge the differences in grid codes.

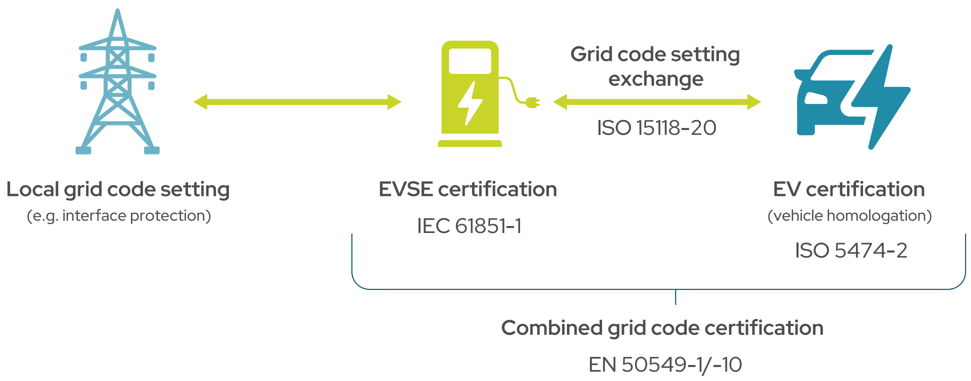
An important step towards an interoperable V2G ecosystem is the establishment of a new European grid code. The Requirements for Generators (RfG) is currently being reevaluated and a revision is expected to be published in early 2026. The draft of the new RfG contains requirements specifically related to V2G vehicles and charging stations. These requirements no longer prescribe possible ranges to be implemented by each individual member state, but rather have fully harmonized requirements that do not differ between member states. As the grid code requirements for V2G modules will be uniform across the European Union, the free movement of V2G electric vehicles can be maintained.

Function split

To guarantee interoperability for electric vehicles and charging stations in the case of AC V2G the certification process should be split. The proposed solution is to split the grid code requirements between the mobile component (i.e. the electric vehicle) and the stationary component (i.e. the charging station). The electric vehicle will be responsible for fulfilling the requirements related to restoring grid issues, such as active power response to frequency deviations. The charging station will be responsible for fulfilling the requirements related to the protection of the grid, such as the interface protection settings.

Requirement	Certification of mobile component (EV)	Certification of stationary component (EVSE)
LFSM-U		
Interface protection		
Anti-islanding		
Frequency Ride Through		
RoCoF Ride Through		
LFSM-O		
Logic interface		
Automatic (re)connection		

The main advantage of the function split is that manufacturers can assure that every possible combination of certified vehicles and charging stations comply with the relevant grid code, even if compliance is proven independently from one another, thereby ensuring an open market, freedom of consumer choice, and interoperability. To ensure individual compliance, a separate certification process should be defined for both electric vehicles and charging stations, referencing existing product standards: ISO 5474-2, IEC 61851-1 and ISO 15118-20.



Financial incentives

Energy taxation

The existing tax structure and the lack of access to flexibility markets are major financial barriers to the scale up of V2G. The current tax structure does not define storage as a separate activity and there is no distinction between self-consumption and grid usage. Rather, taxation is aimed at increasing demand-side efficiency. Double taxation occurs when an electric vehicle reinjects energy during a charging session. The initial consumed energy will be taxed. If the vehicle discharges energy to the grid and then recharges for mobility purposes, the consumed energy will be taxed again.

For residential V2G, double energy taxation can largely be avoided because of the net metering rule, as only the net consumed energy is subject to taxation. However, as of 2027, the net metering rule will be discontinued and a different taxation approach is needed to prevent double taxation. Two approaches were identified in a 2024 report by PWC[5]:

- Monthly or yearly tax reimbursement
- Tax exemption by only taxing the net consumed energy per charging session

Either solution requires the installation of an extra MID-meter to distinguish between energy exported from the EV and from other devices, such as solar panels or home batteries. The requirements for the MID-meter are outlined in Chapter 2 and are also included in NTA 8043.

[5] strategy& - Unlocking EV smart charging to reduce grid congestion – lessons from the Netherlands, March 2024

Flexibility markets

V2G can provide significant benefits by alleviating grid congestion problems in low voltage grids. However, existing financial incentives for flexible usage of storage devices mainly focus on portfolio balancing of energy suppliers and imbalance settlements of TSOs. From 2027 onwards, after ending of the net metering rule, there will be an additional incentive to directly consume local solar energy behind the meter. With the latter, the EV battery can act as a buffer by storing excess solar energy in the afternoon and supplying the home with energy during evening peak hours.

To fully unlock the potential of V2G, especially in the context of congestion management, certain flexibility models need to be developed further.

- An adjustment of the tariff system based on time of use grid tariffs. The costs of electricity can be differentiated based on the time and day the electricity is consumed. During peak hours, the grid tariff will be higher than during off-peak hours, which encourages consumption during off-peak hours. With V2G, the EV can be charged cheaper during off-peak hours and can be used to feed back energy to the household during peak hours, thereby avoiding higher grid tariffs.

- The establishment of a congestion market for grid congestion in low-voltage grids. Current congestion management models are primarily aimed at avoiding congestion at the high-voltage grid. Grid operators forecast grid congestion in low-voltage grids as early as late 2025. V2G can alleviate congestion by directly supplying a household with energy stored in the EV battery. Market parties such as CPOs and flexibility service providers can act as aggregators in these congestion markets by offering the flexibility of a large number of EVs and charging stations in a certain area.

A prioritization of flexibility models is needed to prevent a mismatch between congestion management and other flexibility incentives. Currently, the primary use case for storage units is to offer balancing services to the transmission system operator. However, deploying V2G for balancing services can increase local congestion and power quality issues, for instance when multiple V2G EVs feed back electricity at the same time as rooftop solar. Clear rules need to be established to prevent that V2G increases local power quality and congestion issues.

APPENDIX 6 – USE CASE – CONGESTION MANAGEMENT

One of the primary use cases for V2G is to alleviate grid congestion. The control of V2G EVs and charging stations for congestion management can be implemented in various ways.

One use case that is currently being developed in the Netherlands is grid-aware charging. Based on day ahead forecasts, the grid operator can send a signal to a CPO. The signal includes power limits for certain time periods in specific clusters. The CPO, taking into account EV driver preferences, can decide which charging stations within the cluster should temporarily reduce their power. In April 2025, Open Automated Demand Response (OpenADR) 3.0 was selected as the standard to be used as the interface between grid operators and CPOs to enable grid-aware charging. OpenADR 3.0 was selected because of the ability to automatically send signals for the available grid capacity. Furthermore, it is widely applicable to demand response use cases in general, beyond grid-aware charging. For instance, OpenADR 3.0 can be expanded to send signals directly to charging stations or energy management systems, rather than indirectly to a CPO.

In the context of grid-aware charging, OpenADR 3.0 is used to send capacity limits for import (consumption) in certain areas, but can theoretically also be used to send directional preferences for both import and export. For instance, a grid operator can signal a need for export during peak consumption hours. V2G can provide benefits to grid operators and CPOs with OpenADR 3.0 in two ways. First, it is easier to remain below capacity limits for import because V2G EVs and charging stations essentially act as a negative load. Second, directional preferences for import can be satisfied by EVs and charging stations discharging to the grid. V2G charging profiles via OpenADR 3.0 are currently being developed and tested by ElaadNL.

Market-based congestion management (redispatch) offers an alternative solution, allowing a DSO to declare congestion and evaluate bids via the GOPACS platform. Redispatch differs from grid-aware charging because it allows flexibility service providers to determine the price they receive from their flexibility. Therefore, the financial benefits for end users can potentially be higher using redispatch rather than grid-aware charging via OpenADR 3.0. The participation of V2G EVs and charging stations is currently being developed in the FlexSynX project.

Once these platforms have been developed, consumers and site owners will be able to participate with congestion management through an aggregator or Smart Charging Service Provider (SCSP).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