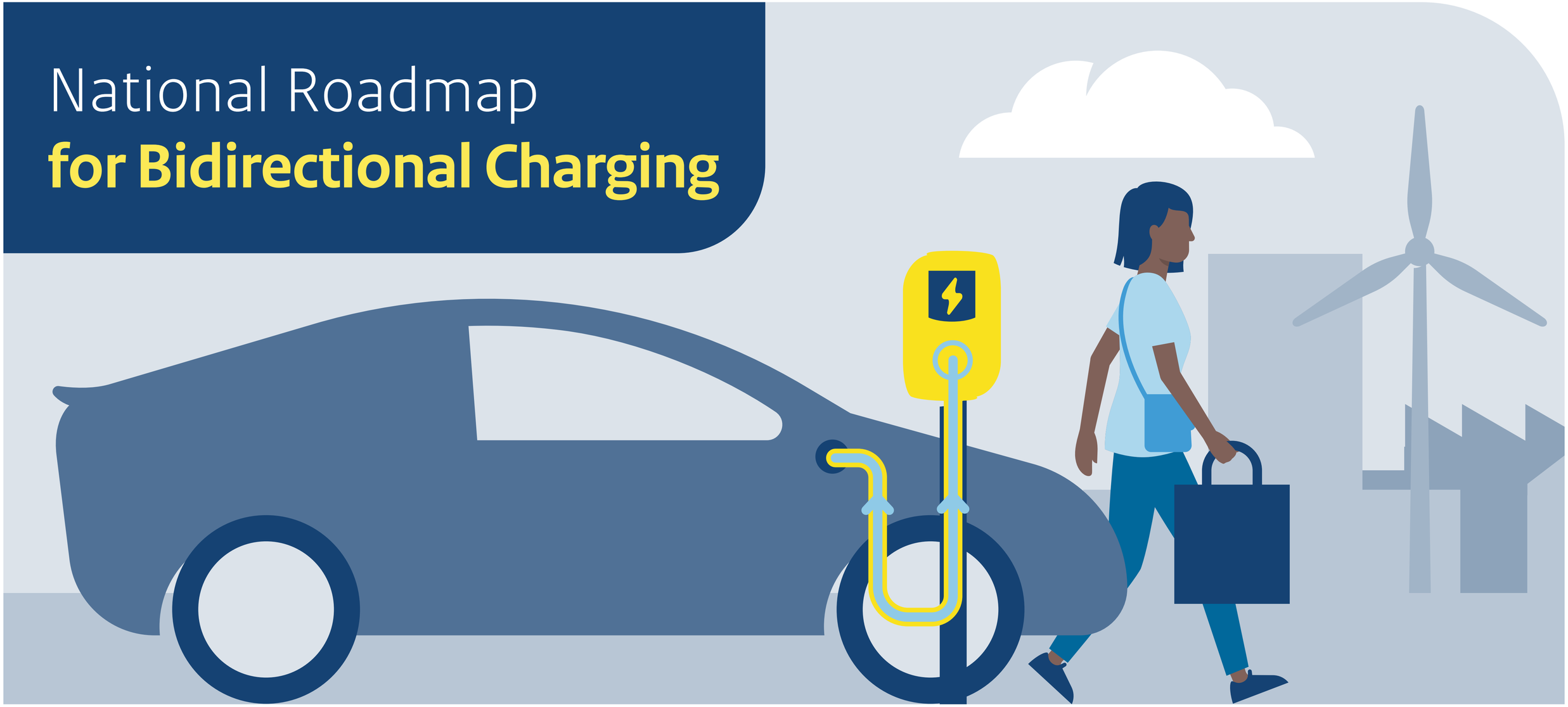
Ministry of Infrastructure
and Water Management

National Roadmap
for Bidirectional Charging



Foreword: a national roadmap for bidirectional charging

The electric car – more than just clean driving

The electric car is the future. It offers a powerful solution for mobility, the climate and for the energy system. Electric driving is cleaner, is becoming increasingly cheaper and is gradually reducing our reliance on scarce, fossil fuels.

With the introduction of bidirectional charging, the electric car is set to take on an additional new role: as a battery on wheels. This not only makes smart charging possible when renewable electricity is readily available but also enables the vehicle to feed power back to the grid when demand peaks. In this way, the electric car helps to reduce pressure on our energy system and improve the stability of the grid.

A national roadmap

With this national roadmap, the Dutch central government aims to provide direction and clarity to consumers, businesses, grid operators, government authorities and other partners. The Netherlands intends to remain a European leader in charging infrastructure by positioning itself as one of the frontrunning countries to successfully introduce commercial bidirectional solutions. The ultimate aim is for **everyone** who buys a new car from 2035 onwards to have the option of bidirectional charging – at home, at work and on the street. To achieve this, this roadmap describes two phases of upscaling and presents a National Action Agenda for bidirectional charging.

The development of bidirectional charging will not happen automatically. It requires the development of open and reliable technology, changes to regulations and the offer of attractive products and services for users. In this, Central government will have the task of creating the right conditions for bidirectional charging in the Netherlands to enable its effective roll-out.

Concerted action

Central government will not be acting alone: the success of bidirectional charging will rely on concerted and continued efforts on the part of businesses, grid operators, government authorities, civil-society organisations and other partners. This is why a range of different parties have been consulted in compiling this roadmap. A list of all these parties can be found in the appendix. As a follow-up to the roadmap, Central government will take the Action Agenda as its basis for ensuring the continuation of the different, cross-sector partnerships that will be required to upscale bidirectional charging. The roadmap will also be reviewed in collaboration with the sector in 2030.

Contents

1. From smart to super smart charging

Currently, some 57% of all charging sessions in the Netherlands are smart (RVO, 2026) and the aim is for all charging to be smart by 2030. With smart charging, the vehicle and charging station agree the charging time and power based on space on the electricity grid, available green electricity and a low price. Charging is moved to times when more electricity is available, prices are cheaper and more green electricity can be used for charging.

The next step is bidirectional charging: the car becomes a battery on wheels, with electricity not just flowing from the charging station to the vehicle, but also enabling the vehicle to feed power back to the grid. This makes it possible for an EV to be charged when electricity is cheap or in excess supply and then to serve as battery storage for a home, building or to support the power grid.

Because an EV battery offers energy storage that can be used rapidly and flexibly, bidirectional charging has the potential for reducing charging costs, limiting peak load and improving the way in which renewable power generation is used. If the right conditions are met, the EV battery can also be used during power outages.

Scope

In the long term, the greatest beneficiaries of bidirectional charging will be homeowners with their own drives. Currently, 61% of EV drivers are in this situation and many of them also have their own solar panels (RVO, 2026). There are also opportunities for charging vehicles at work (around 10% of charging sessions). Approximately 27% of EV drivers park and charge their vehicles on the street. The potential benefits for this growing group are more limited because of greater unpredictability in their charging behaviour and the many agreements still required in the market for bidirectional charging (see Appendix A for more details). Finally, (shared) car fleets and shared charging facilities in housing complexes also offer additional opportunities for application.

For other modalities, such as freight transport, construction vehicles and machinery, buses and shipping, initiatives for bidirectional charging remain limited for now. For this reason, these have been excluded from the scope of this roadmap. Despite this, the Ministry of Infrastructure and Water Management (I&W) recognises the potential of these larger batteries and is eager to see this explored in greater detail in the future, focusing on the differences with passenger vehicles and the role that I&W might play in depot charging, service stations and truck parking facilities.

1. From smart to super smart charging

2. How will it benefit individuals?

Earning opportunities for EV drivers

Bidirectional charging offers additional opportunities for EV drivers to earn money: they can benefit from fluctuating energy prices and anyone who has their own solar panels can also gain more from their own power generation. Over time, other revenue models may emerge, for example in the form of payments for flexibility services when an EV driver contributes to reducing grid congestion.

Initial calculations show that flexible tariffs can earn a Dutch electric driver between 200 and 700 euros per year by feeding energy back to the grid (Vehicle-to-Grid) or to the home (Vehicle-to-Home) combined with smart charging at cheap times (EY Eurelectric report, 2025). How much someone saves in practice will depend on various factors (such as the time, the number of hours that the vehicle is connected and the level of integration with solar panels). A report by Revnext (2026) shows that bidirectional charging can result in savings of up to almost €900 for existing EV drivers (a reduction in TCO of almost 9%) and approximately €1,050 for new EV drivers (reducing TCO by up to 10.8%).

EV drivers currently still find it difficult to capitalise on these advantages, but early examples from the Netherlands show what is possible: shared vehicle fleets in Utrecht are using electric cars as a driving community battery and residents with their own drives can already benefit from smart and bidirectional home charging through the use of appropriate charging stations.

In many other situations, access to the earning potential remains limited for fleets and people with their own drives because this currently often requires customised solutions in practice. For people living in collective buildings and/or using public charging stations, there are also additional organisational obstacles at play, preventing bidirectional charging from taking off at scale. Central government intends to use the roadmap as a means of creating the conditions required to enable all EV drivers to gradually gain access to these benefits.

2. How will it benefit society?

The societal benefits of bidirectional charging have already been explored in a range of reports. Since bidirectional charging is a new technology, this has involved numerous assumptions and mainly focused on the theoretical potential. The theoretical potential revealed in several studies has provided sufficient rationale for Central government to begin active work on bidirectional charging.

Freeing up space on the grid

Bidirectional charging transforms stationary vehicles into flexible capacity that can take the pressure off the power grid at times when it matters most. A study by Haskoning (2026) has shown that 1,000 bidirectional shared vehicles have the potential to feed back 3.7 MW of power to the grid by 2027. Estimates for 2050 reveal that the potential could be as much as 4.5 GW of adjustable capacity for house owners with their own charging stations (ElaadNL, 2025), and up to a total of 9.5 GW of V2G capacity from passenger vehicles by 2050 in a favourable scenario (Netbeheer Nederland, 2025). This means that bidirectional charging could deliver a significant proportion of the flexible capacity required to ensure that the future energy system remains reliable and affordable.

Mitigating grid congestion, creating space for growth

Bidirectional charging can take the pressure off the power grid while also giving a boost to the economy. Currently, grid congestion costs the Netherlands an estimated 10-40 billion euros per year (interdepartmental policy study on electricity grid funding, 2025), waiting lists have reached 15,000 connection requests (Ministry of Climate and Green Growth, 2025) and housebuilding is at risk of grinding to a halt. Targeted charging and discharging of EV batteries could reduce peaks in consumption and feed-in by as much as 40% in the event of optimal control at local level (TNO, 2026).

Studies have shown that these kinds of smart and bidirectional charging strategies could help offset the need for investments in the grid (ElaadNL & PWC, 2025), while also freeing up more space for businesses and housebuilding to invest and to grow.

Smart buffer for solar and wind

As the proportion of our electricity provided by solar and wind gradually increases, flexible buffers will become essential. Bidirectional charging provides this option: cars will store renewable energy at times of oversupply and feed it back into the grid when demand peaks. Less green electricity will be lost as a result, reliance on energy imports will reduce and the Netherlands' strategic autonomy will increase step by step.

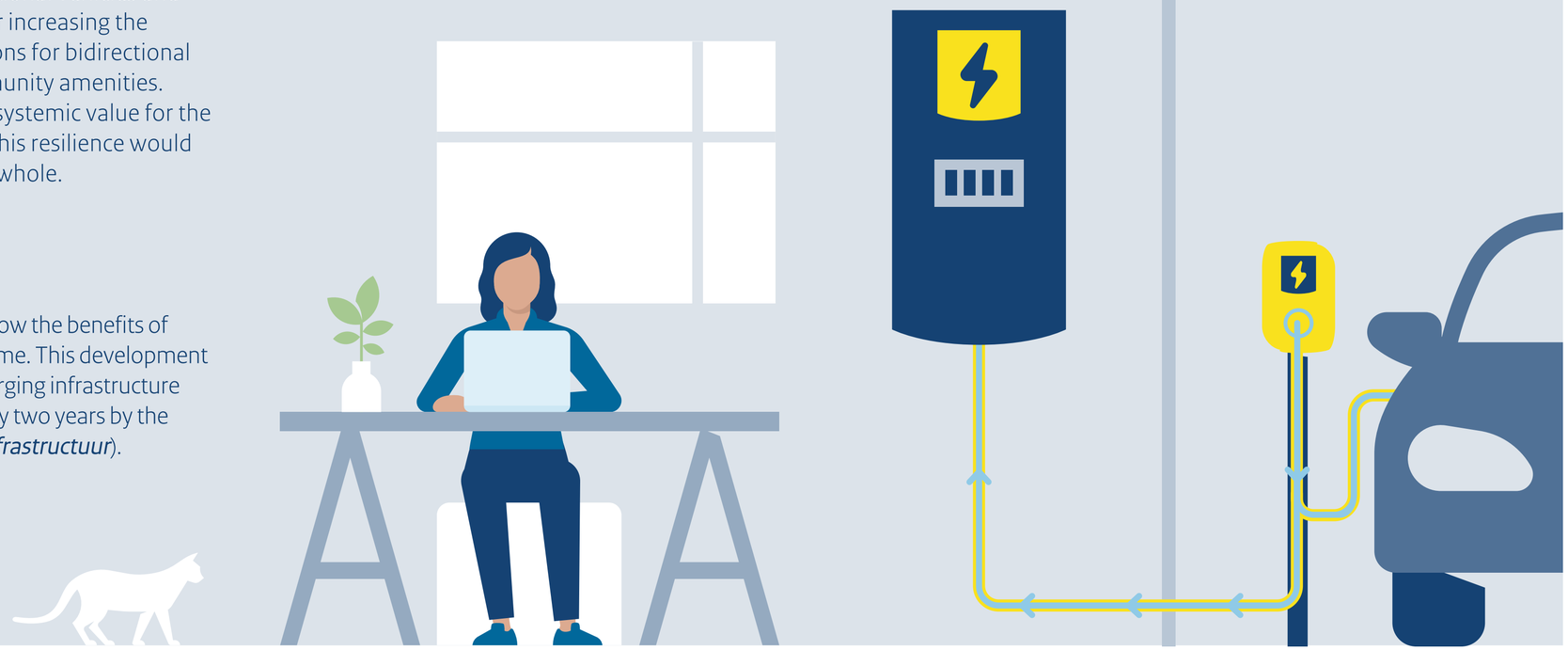
2. How will it benefit society?

Resilience

Bidirectional vehicles are batteries on wheels that have the potential to supply electricity to houses and buildings locally at times of power outages, possibly resulting from hostile action. This will increase an individual's resilience to power outages. At 80 kWh, the battery capacity of a new EV can supply an average household with around ten days of electricity or power several households for a day. Although the technology is not yet this advanced, initiatives to develop bidirectional vehicles and charging systems that could make this possible have potential for increasing the Netherlands' resilience. On the one hand, the resilience applications for bidirectional charging are therefore at local level, in homes, buildings or community amenities. On the other hand, bidirectional charging could potentially have systemic value for the power grid in such areas as balancing and reducing congestion. This resilience would then not only be of benefit to individuals, but also to society as a whole.

Link with other technological developments

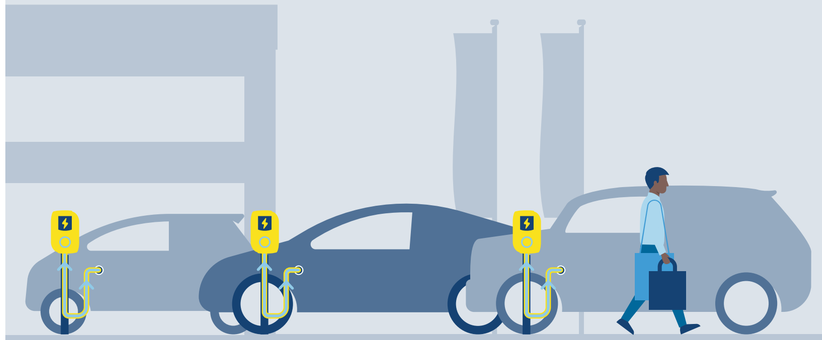
Other battery applications and autonomous driving will also affect how the benefits of bidirectional charging develop and will need to be monitored over time. This development will also have an impact on people's charging behaviour and the charging infrastructure required. This impact will be assessed in the forecasts produced every two years by the National Charging Infrastructure Agenda (*Nationale Agenda Laadinfrastructuur*).



3. What will bidirectional charging look like in the future?

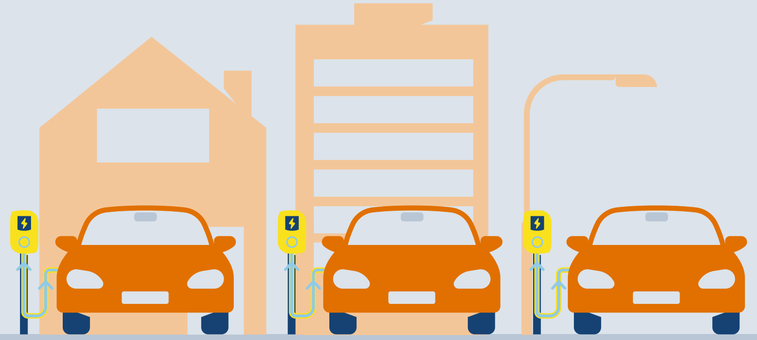
Interoperability

Every vehicle is capable of bidirectional charging with every charging station.



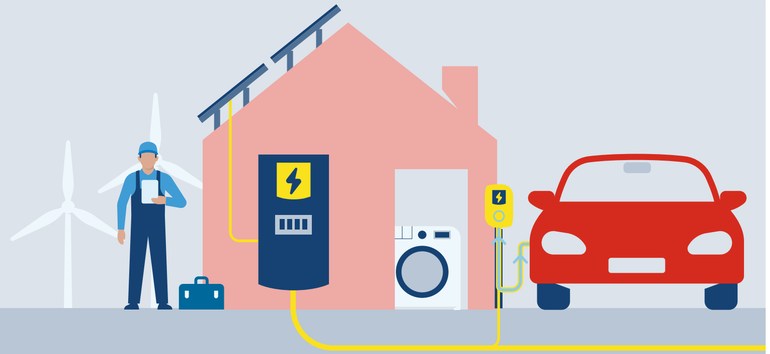
Charging stations

Bidirectional charging is possible at home, but also at on-street chargers and at work.



Application

Bidirectional vehicles work smoothly with the grid, EMSs, solar panels and home batteries.

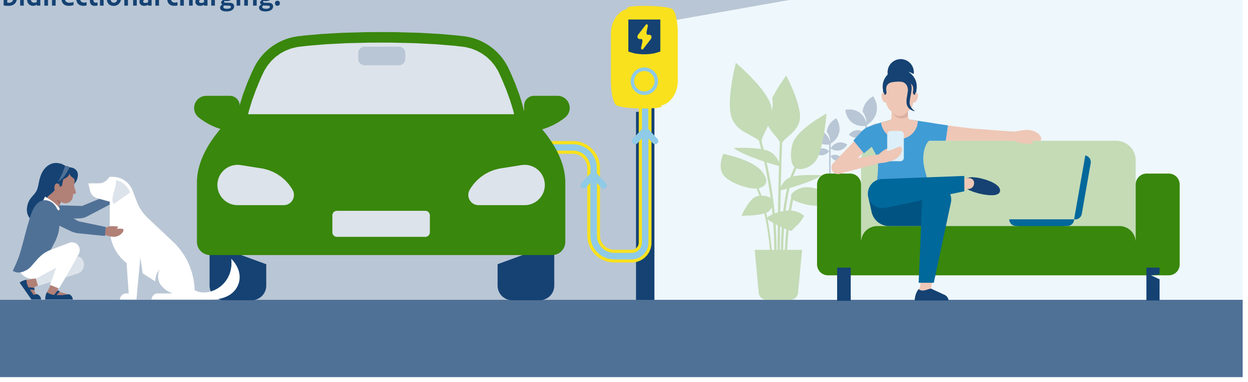


Business case

Bidirectional charging is worthwhile.

Consumer trust

Consumers know where they stand and have trust in bidirectional charging.



4. Upscaling timeline

In the first quarter of 2026, the availability of bidirectional charging in the Netherlands remains limited. At the end of Q1 2026, there are around 150 shared cars on the market capable of bidirectional charging in Utrecht. There are around 50 in Eindhoven. In 2026, a single provider is set to offer a domestic proposition for Dutch people with their own drives. Availability is therefore limited and will be characterised in the years ahead by fixed combinations that offer propositions with closed systems. Bidirectional charging is not yet available at public charging stations.

The upscaling of bidirectional charging will happen gradually in two broadly-defined phases: Phase I (2026-2030) will feature the early applications. In Phase II (2030-2035), increased mass will gradually develop. In both of these phases, Central government will have an active role to play in encouraging, facilitating and potentially also standardising this new technology. After 2035, further developments are expected to take place independently in the market and the Central government's role will be limited to its basic tasks of enforcement or management.

2026-2030
Phase I: Early applications

- Bidirectional charging will still take place in fixed combinations of vehicle and charging station.
- During this phase of early applications, Central government will work on solutions for the challenges (set out in Appendix A). This will enable the Netherlands to remain among the leaders in bidirectional charging.
- The application of bidirectional home charging will begin, enabling the first consumers to benefit from lower charging costs and lower energy costs. This will make electric driving more attractive.
- Bidirectional charging by shared cars, commercial fleets and home chargers with their own drives will be the first to see collective benefits: the impact of bidirectional charging in reducing grid congestion will be understood and the first results known.
- The practical experiences and data required to adapt policy will be available, partly through applications in shared vehicles and at home.
- Government authorities will prepare their tender procedures and concessions for an interoperable roll-out of bidirectional charging.

2030-2035
Phase II: Upscaling

- Every vehicle will be capable of bidirectional charging with every charging station.
- The solutions to the challenges will take effect and the challenges of bidirectional charging will be reduced: interoperability will be a reality and the business case for bidirectional charging will be optimised.
- The first bidirectional charging sessions at public charging stations by people parking on the street will be a reality.
- Bidirectional charging will scale up further and reduce costs for grid expansions.
- Bidirectional charging will be required as a standard technology in public tenders.
- The market organisation for the bidirectional charging supply chain will mature, with clearly defined roles and responsibilities.
- Consumers will be familiar with bidirectional charging and have sufficient experience to apply it as standard.

5. Challenges for upscaling

Successful upscaling will require solutions to a number of challenges.

For the system to work effectively, vehicles and charging stations will both need to support bidirectional charging, communicate via shared protocols and be capable of feeding in safely in accordance with the network codes. Importantly, this will need to be governed by international standards to prevent the need to adapt vehicles and charging stations for the specific national situations.

In 2026, bidirectional charging works only with customised solutions and fixed pairings: combinations of vehicle and charging station registered for each location by the grid operator. Broad interoperability is therefore not yet a reality. Similarly, interoperability with a (Home) Energy Management System ((H)EMS), solar panels and batteries is yet to be achieved.

There are also some missing links on the market and policy side.

In many charging situations, effective markets with clearly defined roles and payment options for EV battery flexibility services have yet to emerge. Moreover, action is required by Central government and the sector to eradicate barriers for the business case. This will give greater certainty to manufacturers and end users wishing to invest in this new technology.

For consumers, factual information about bidirectional charging is in short supply, which is limiting the extent to which public trust in bidirectional charging can develop. Despite this, there is plenty of interest.

Until better coordination is achieved between the technology, market and regulation, many parties will continue to be deterred from investing in and making use of bidirectional functionality.

In summary, there are five key challenges that will require action. These are listed below. The challenges are explained in more detail in Appendix A. The colours below correspond to the colours in the timeline and in the Appendix. The challenges are:

I. Interoperability across the whole bidirectional ecosystem.

II. The roll-out of interoperable bidirectional charging stations.

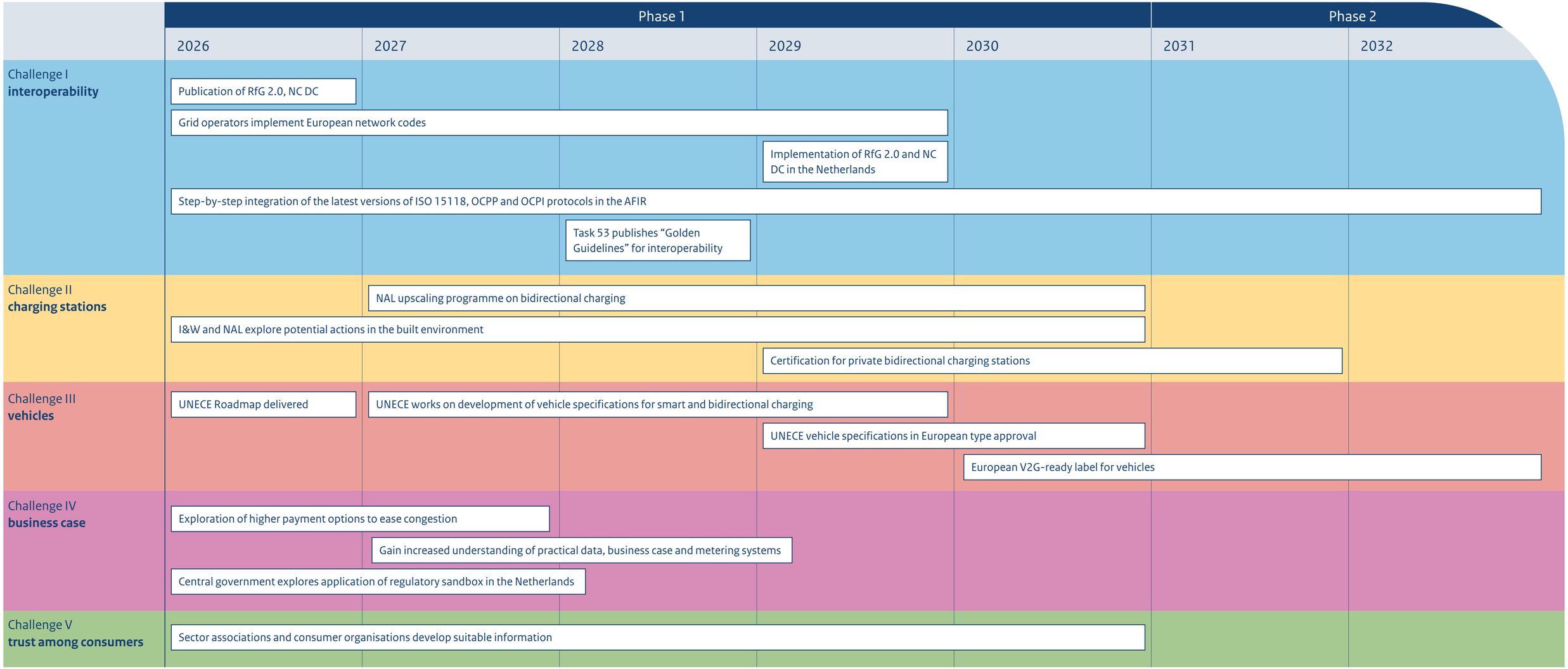
III. The introduction of interoperable bidirectional vehicles.

IV. Improving the business case and the chain.

V. Knowledge and trust among (future) car owners will need to grow.

Challenges and solutions over time

For further details on the milestones and actions required for each challenge, see Section 6 National Action Agenda and Appendix A: Rationale for Action Agenda



6. National Action Agenda for Bidirectional Charging

An overview of the national actions to be taken to accelerate large-scale roll-out.

Process name	Challenge	Key actors	2026	2027	2028	2029	2030	2030-2035
1. Implementation of European network codes in Dutch network code.	I. Interoperability	Grid operators	■	■	■	■	■	
2. Integration of latest versions of ISO 15118, OCPP and OCPI in the AFIR.	I. Interoperability	• I&W represents Dutch interests • European Commission is AFIR initiator	■	■	■	■	■	
3. I&W is contributing actively to the European initiative “Coalition of the Willing on Bidirectional Charging” and to Task 53 via ElaadNL.	I. Interoperability	I&W, ElaadNL	■	■	■			
4. Certification for private bidirectional charging stations.	I. Interoperability	To be determined				■	■	■
5. National set of specifications for V2G-ready charging stations.	II. Introduction of interoperable bidirectional charging stations	ElaadNL			■	■	■	■
6. NAL-upscaling programme, including research into options for retrofitting charging infrastructure.	II. Introduction of interoperable bidirectional charging stations	NAL		■	■	■	■	
7. Research into deployment of charging infrastructure in power outages.	II. Introduction of interoperable bidirectional charging stations	Central government	■	■				
8. National guidelines for municipalities on when integration of V2G-ready charging stations is appropriate.	II. Introduction of interoperable bidirectional charging stations	Central government & municipalities	■	■	■	■		
9. Exploration of requirements for charging infrastructure installation by Central Government Real Estate Agency (RVB).	II. Introduction of interoperable bidirectional charging stations	I&W, RVB	■	■	■			

6. National Action Agenda for Bidirectional Charging

Process name	Challenge	Key actors	2026	2027	2028	2029	2030	2030-2035
10. Improve SVVE subsidy support to achieve collective bidirectional charging.	II. Introduction of interoperable bidirectional charging stations	I&W						
11. Via NAL, support municipalities and project developers in shared procurement and tendering of V2G-ready charging infrastructure.	II. Introduction of interoperable bidirectional charging stations	NAL, VNG and municipalities						
12. Work with municipalities to explore/ develop expansion of charging infrastructure requirements for small-scale residential newbuild with fewer than four parking spaces.	II. Introduction of interoperable bidirectional charging stations	NAL, VNG and municipalities						
13. Assessment of compulsory inclusion of bidirectional charging points in the Bbl from 2029.	II. Introduction of interoperable bidirectional charging stations	NAL, VNG and municipalities						
14. Expanding UNECE vehicle specifications to include aforementioned requirements for smart and bidirectional charging.	III. Introduction of interoperable bidirectional vehicles	• 2026: I&W lead agency for UNECE roadmap on smart and bidirectional charging • 2027 – 2028: UNECE						
15. Inclusion of UNECE vehicle specifications for bidirectional charging in European Type Approval.	III. Introduction of interoperable bidirectional vehicles	• I&W represents Dutch interests • European Commission is lead coordinator for ETG						
16. Research into options for retrofitting existing vehicles.	III. Introduction of interoperable bidirectional vehicles	I&W and RAI Association						
17. Explore inclusion of interoperable bidirectional vehicles in tender procedures for Central government fleet	III. Introduction of interoperable bidirectional vehicles	Central government						

6. National Action Agenda for Bidirectional Charging

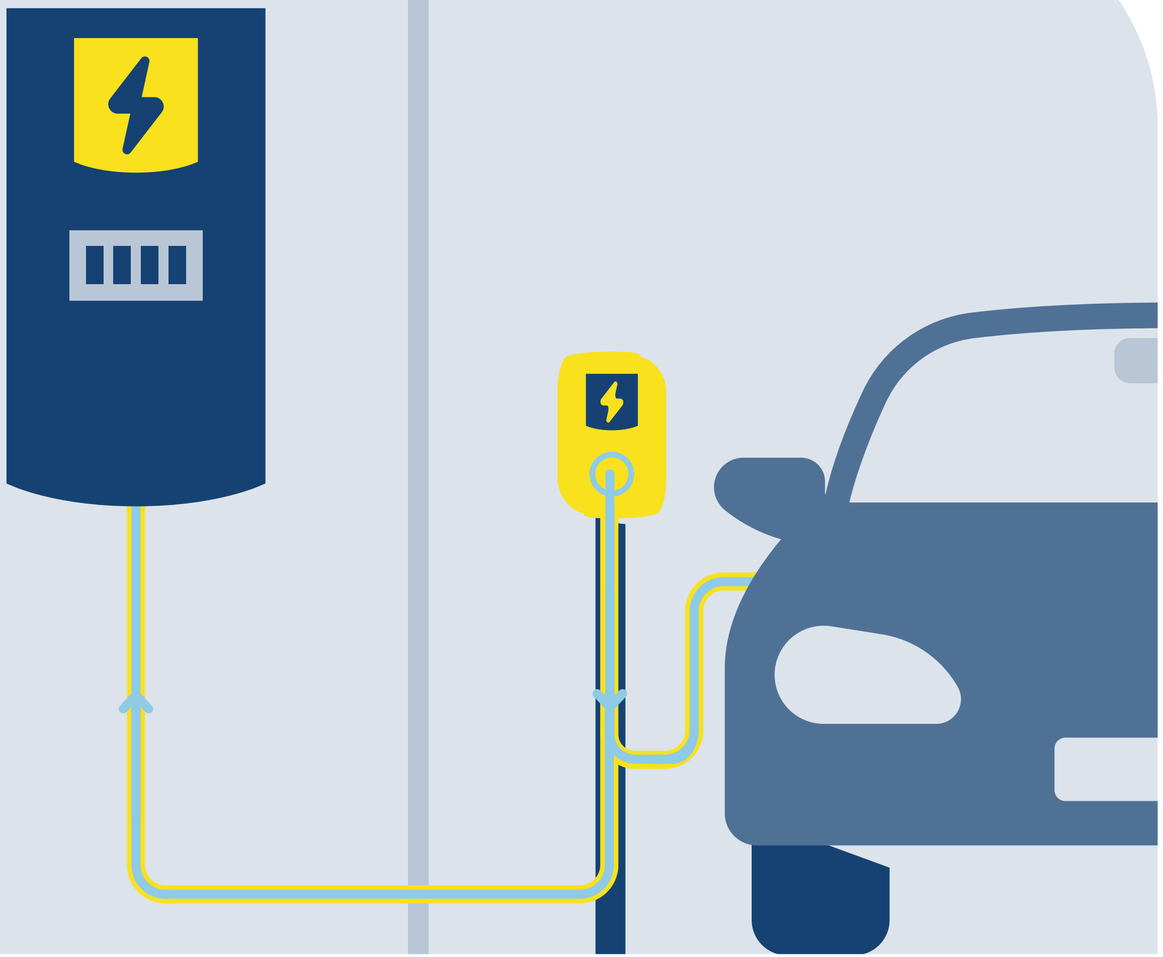
Process name	Challenge	Key actors	2026	2027	2028	2029	2030	2030-2035
18. Explore inclusion of interoperable bidirectional vehicles in local and regional government authority tender procedures	III. Introduction of interoperable bidirectional vehicles	Municipalities and Provinces	■	■	■			
19. Explore increasing payment for feed-in during peaks within LAN	IV. Improving business case	I&W, LAN, ACM and grid operators	■	■				
20. Gain increased understanding of practical data and metering systems for bidirectional charging	IV. Improving business case	Central government and market parties	■	■	■	■		
21. Explore bidirectional charging in tender procedures and planning of car-sharing locations	IV. Improving business case	Central, local and regional government	■	■	■			
22. Explore agreements for metering equipment for bidirectional charging stations	IV. Improving business case	Central government, grid operators, energy sector	■	■	■			
23. Living labs in collective housing, car parks and (semi-)public charging bays	IV. Improving business case	Central government, municipalities, market parties		■	■	■	■	
24. Practical templates with division of roles, model contracts and simple sharing mechanisms for flexibility revenues	IV. Improving business case	Central government, in collaboration with the grid operators and energy sector	■	■				
25. Explore application of regulatory sandbox for bidirectional charging in the Netherlands	overarching	I&W, FIN, EZK	■	■				
26. User organisations, leasing companies and sector organisations develop suitable information on bidirectional charging.	V. Knowledge and trust among EV drivers	I&W, user organisations, leasing companies, sector organisations	■	■	■	■		

7. Follow-up

As a follow-up to the roadmap, Central government will set to work with various parties on the National Action Agenda for bidirectional charging. Some actions will take place under the NAL umbrella, such as the Bidirectional Charging Upscaling Programme. For other actions, the Ministry of Infrastructure and Water Management (I&W), the Ministry of Economic Affairs and Climate (EZK) and the Ministry of Finance (FIN) will work together, including in obtaining more practical data and in exploring the application of the regulatory sandbox announced by Europe. I&W itself will take responsibility for other actions, such as the international actions in Europe and in the UNECE. I&W will also bring together a range of parties to ensure the creation of the right information.

I&W will coordinate the Action Agenda. I&W will provide regular feedback on progress on the Action Agenda as part of the National Grid Congestion Action Programme. The House of Representatives will be informed on progress on the Action Agenda in the annual Letter to Parliament on the Roll-out of Charging Infrastructure.

Appendices



I. Interoperability across the whole bidirectional ecosystem (1)

Challenge

Bidirectional charging currently only works in fixed vehicle/charging station combinations that need to be separately assessed by grid operators in order to feed in to the grid. This is because the requirements and standards for communication and coordination between the different links in the charging and energy supply chain are still in development and/or no binding agreements have yet been made about their application. Without agreements of this kind, bidirectional charging will not be able to develop into a widely scalable solution.

This means that many charging stations and vehicles are not yet interoperable in practice. Further development in the following areas will be required to enable broad interoperability of links in the charging and energy supply chain:

Basically, a vehicle and the charging station need to comply with the same rules as power generation units, such as solar panels: they are not permitted to destabilise the grid, charging needs to automatically adapt to disruptions in the grid and they must automatically disconnect from the grid in order to prevent unintended power 'islanding'. The exact technical requirements are set out in the Netherlands System Code and are based on the European Requirements for Generators (RfG) network code. This network code will be updated in 2026 to a version 2.0. The Network Code for Demand Connection (NC DC) is also being updated. All EU member states will then have three years in which to implement this in national network codes. While this process continues and regulations are yet to be firmed up, manufacturers cannot fully incorporate them in their design and certification.

Additionally, bidirectional charging infrastructure needs to be able to communicate effectively and work safely with other links in the chain. The exchange of information on state of charge, battery capacity and maximum (feed-in) supply capacity between vehicle and charging station occurs in accordance with communication protocol ISO 15118. For charging stations, each version of ISO 15118 is being gradually mandated via delegated acts supplementing the Alternative Fuels Infrastructure Regulation for new (and renovated) charging stations in the EU, in order to ensure that every suitable charging station complies with this protocol. However, the support of protocols alone is not sufficient to create interoperability. This requires additional agreements on the implementation of the protocols.

For the link between the charging station and the operator's back office, a communication protocol such as OCPP is generally used. For payment, roaming and information on (feed-in) supply, a protocol such as OCPI is used. There is not yet any comparable legal mandate for these protocols and implementation still varies according to the market party involved.

As more users and parties become involved – such as charging station operators, charging service providers, aggregator, grid operator and (H)EMS – communication about control, payment and data becomes increasingly complex. Ensuring that charging stations and vehicles respond effectively to grid congestion and price incentives will require a link with grid and market signalling, for example via OpenADR 3.0, while collaboration with (home) energy management systems ((H)EMS) will be needed on location to coordinate charging and feed-in with consumption and local generation; both of these building blocks remain limited and there is no harmonised European standard.

The exchange of data between vehicle and charging station largely occurs securely via ISO 15118, but there are still no clear agreements about data use, privacy and liability between vehicle manufacturers, CPOs and eMSPs.

Finally, RED III requires vehicle manufacturers to make battery and charging data available to end users and to services chosen by the end user, such as charging service providers and aggregators. However, there is not yet any clear definition of the interfaces via which the data must be made available and the conditions under which this can happen safely and without discrimination.

I. Interoperability across the whole bidirectional ecosystem (2)

Solutions

The most obvious solution is the further development of the relevant network codes, protocols and standards and uniform agreements on their implementation. The key elements concerning this are:

Completion of the development of the harmonised European network codes for decentralised power generation (RfG 2.0, NC DC) and their implementation in national network codes. This will make it clear which network and security requirements apply for vehicles and charging stations to enable them to safely connect as 'small-scale energy plants' and feed in electricity.

Additionally, crucial communication standards need to be legally embedded in the chain. Via AFIR and associated delegated decisions, implementation of the latest versions of ISO standards will be mandatory for new and renovated charging stations. This will therefore also apply for versions after ISO 15118-20 (such as Amendment 1). For protocols across the rest of the chain, such as OCPP 2.1 for control by the operator and OCPI for payment and roaming, there will need to be movement towards the introduction of a European mandate so that this is no longer optional but becomes a minimum condition for all new systems. These standards and network codes will also provide the basis for bidirectional charging of heavy transport.

Alongside prescribed standards, a shared implementation and testing framework will also be necessary. As part of the International Energy Agency's Task 53, test cases and "*Golden Guidelines*" are being developed as a basis for test programmes and certification, in which vehicles and charging stations will be tested for interoperability independently of each other. European blueprints for roles, responsibilities and data exchange will also be developed in the years ahead. The Netherlands is contributing actively to the European blueprints via the "Coalition of the Willing on Bidirectional Charging" and to Task 53 HEV TCP via ElaadNL.

Parallel to this, national standards for smart charging infrastructure, such as NTA 8043, are being supplemented with explicit requirements for bidirectional functionality and linkage with (home) energy management systems to enable charging stations to cooperate interoperably with local generation, consumption and other flexible assets.

In 2026, the European Commission is calling for the creation of a "regulatory sandbox for bidirectional charging". This will involve allowing national governments to temporarily relax regulations to create space to experiment with innovations in living labs. Central government intends to investigate whether this loosening of regulation could be an option for the Dutch context. This might include consideration of interoperability requirements for participation in the sandbox.

Overview of actions:

1. Implementation of European network codes in Dutch network codes after publication.
2. I&W is committed to integration of the latest versions of ISO 15118, OCPP and OCPI in the AFIR.
3. I&W is contributing actively to the European initiative "Coalition of the Willing on Bidirectional Charging" and to Task 53 via ElaadNL.
4. Development of private bidirectional charging station certification as a follow-up to the NTA 8043 on smart charging stations.

II. The roll-out of interoperable bidirectional charging stations (1)

Challenges

Since interoperability requirements are still lacking, bidirectional charging stations currently remain limited to niche applications, in combination with specific vehicles at fixed (network) locations. A wider roll-out will not be possible while it remains unclear which additional requirements charging stations will need to meet in the future. However, the Alternative Fuels Infrastructure Regulation (AFIR) will remove some of this uncertainty from 2027 by making ISO 15118-20 mandatory, which will be essential for interoperable communication on bidirectional charging between vehicle and charging station. Another key missing element is harmonised network requirements for the safe feed-in supply of electricity. A European proposal on this is expected in 2026, with the national details to be firmed up in the years after that. Until then (probably until around 2029), it will remain uncertain which requirements bidirectional charging stations will ultimately need to meet, which makes a broad roll-out impossible.

In terms of public charging, the Netherlands is well-positioned to roll out bidirectional functionality at a rapid pace, as soon as there is clarity about interoperability requirements for charging infrastructure. With its National Charging Infrastructure Agenda (NAL), the Netherlands is focusing at national level on the availability of charging stations in the public domain. As a result of this, a network with almost nationwide coverage has now been achieved and is set to be further strengthened in the years ahead. By means of standardised requirements for tender procedures and concessions (developed by ElaadNL in the Purchasing Requirements for smart and bidirectional charging), the National Charging Infrastructure Agenda (NAL) is also focusing strongly on the functionality of charging stations: the current requirements in the NKL standardised sets are already aligned with the future AFIR, including by means of the support of ISO 15118-20.

Because the future network code requirements are still unclear, the NAL is not yet demanding “genuine” bidirectional functionality. However, with support from ElaadNL, the NAL will be able to prepare the groundwork for this before 2029. As soon as the harmonised network code requirements become available in 2026, ElaadNL can work out which additional hardware and software functionalities charging stations will need to incorporate and support from 2029. The NAL can then include these requirements in new concessions from around 2028, enabling concession holders to immediately have charging stations equipped in such a way as to be network code proof and V2G-ready with only limited updates after 2029.

But public charging is just one piece of the puzzle. Currently, EV drivers mainly charge their vehicles at home or at work, where cars are parked for long periods and can often be linked to their own solar energy. This is why, from a bidirectional perspective, the roll-out of charging infrastructure in the built environment is even more important than it is in the public domain.

The roll-out is less tightly organised in the built-up environment than in the case of public charging; the NAL primarily plays a supportive role in this. The European Energy Performance of Buildings Directive (EPBD) and the Environment Buildings Decree (Bbl) make it compulsory for charging infrastructure to be included in any newbuild or radical renovation. Bidirectional charging is mentioned only in terms of being able to apply it where appropriate. However, the Bbl gives no specific guidance to municipalities as to when, where and how they must ensure that bidirectional charging stations happen. Moreover, bidirectional charging can be prepared more effectively in specific situations by ensuring that buildings are “charge-ready”, with cabling and wiring. Currently, the EPBD does not mandate this for smaller newbuild, despite the fact that single-family homes with drives and solar panels offer plenty of opportunities for electric driving and ultimately also bidirectional charging. In existing multi-family buildings, the EPBD and Bbl focus primarily on removing legal impediments for residents who wish to install a charging station themselves. Working to develop a collective basic provision for charging can offer additional benefits in the Netherlands: if charging infrastructure is designed jointly and at the same time, connections and cabling can be realised more efficiently. A collective approach also offers the opportunity to establish a shared system, enabling the focus behind the meter to be on solar panels, communal facilities and ultimately bidirectional charging.

II. The roll-out of interoperable bidirectional charging stations (2)

A completely different challenge affecting bidirectional charging infrastructure is the fact that hardly any thought has yet been given to how bidirectional charging stations can be used in emergencies, for example as a temporary emergency supply in the event of an outage on the public grid. This calls for additional national agreements on operational reliability (how long and under what conditions a charging station is permitted to continue to supply), the sequence in which consumers are disconnected and prioritised, grid safety assurance and the allocation of liability if something should go wrong.

Solutions

In order to progress from separate niches to widely deployable bidirectional charging infrastructure, a package of targeted instruments will be required that can guarantee quality and interoperability, enable safe use in emergencies and incentivise timely investments in bidirectional infrastructure.

As indicated earlier, clear specifications of what constitutes a 'V2G-ready' charging station is the main driver for a wide roll-out of interoperable charging stations. As soon as the harmonised European network code requirements are available, ElaadNL will be able to examine which additional hardware and software functionalities charging stations will have to support and translate this into concrete specifications, test procedures and guidelines for implementation. Parallel to this, national standards for smart charging infrastructure, such as NTA 8043, will be supplemented with explicit requirements for bidirectional functionality and linkage with (home) energy management systems to enable charging stations to cooperate seamlessly with local generation, consumption and other flexible assets.

The NAL will then be able to use these details to formulate uniform requirements for tender procedures and concessions, potentially in anticipation of the national implementation of the network code requirements in 2029. As part of a specific upscaling programme, the technical requirements, quality criteria and use scenarios will be combined and translated into practical guidance for municipalities, concession holders and market parties, including support in shared procurement and tender procedures for 'V2G-ready' infrastructure. This programme will also look at the possibilities for retrofitting existing charging infrastructure to make it bidirectional.

In the built environment, additional efforts will be needed to help bidirectional charging to take off. National guidelines will be able to assist municipalities to determine the situations in which bidirectional application could be appropriate and where it is grid-technically desirable, in line, for example with Commission Notice C/2025/6438 and the examples of application of bidirectional charging described in it.

In addition, an assessment can be made as to whether the National Charging Infrastructure Agenda has the potential to play a more active role. One potential option, similar to the public concession models, would be for regional or municipal joint procurement processes to be established for charging stations in or around buildings, with framework contracts that set out standard requirements for smart- and bi-ready infrastructure and which developers and building owners can opt to apply on a voluntary basis.

In the longer term (after 2029), the option of including a general bidirectional charging infrastructure mandate in the Bbl can also be considered. In consultation with municipalities, Central government can also examine whether the Bbl requirements on making newbuild "charge-ready" can be extended to include small-scale residential projects with fewer than four parking spaces. For existing building stocks, it clearly makes sense to look at how the Sustainability Scheme for Owners' Associations (*SVVE-regeling*) can be strengthened to encourage homeowners' associations to opt for collective rather than fragmented, individual charging solutions with the key conditions and opportunities for bidirectional charging being explicitly included in both the guidance on charging stations and in the basic charging infrastructure.

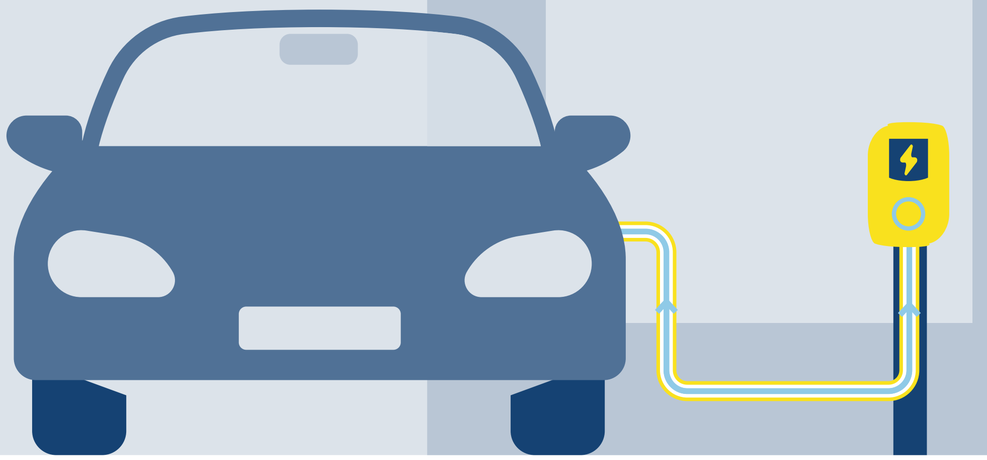
In addition, Central government can collaborate with municipalities to explore how incentives (such as an enhanced SVVE subsidy) can be combined with obligations to gradually make existing multi-family homes charge-ready on a collective basis.

II. The roll-out of interoperable bidirectional charging stations (3)

Finally, there needs to be clarity with regard to how bidirectional charging stations can be used responsibly during power outages and other emergencies. A national study on the technical and organisational conditions required – such as realistic power capacity and supply times, interaction with grid security and power quality and user prioritisation – will form the basis for this. The results can be used to create national guidelines, together with municipalities, setting out the situations in which it is desirable to use bidirectional functionality for emergency facilities and the conditions under which this is legally and operationally viable.

Overview of actions:

5. As soon as harmonised network code requirements are available, ElaadNL will develop a national set of specifications for V2G-ready charging stations (hardware, software, testing, implementation).
6. NAL will ensure the specifications are embedded by means of uniform requirements for tender procedures and concessions and will launch an upscaling programme. The NAL upscaling programme will include a study into the possibilities for the cost-effective retrofitting of existing charging infrastructure.
7. Central government will set up a study into the responsible use of bidirectional charging stations in power outages and emergencies.
8. Central government will establish national guidelines for municipalities setting out when bidirectional application is appropriate in the built environment.
9. An exploration of the merits of including interoperable bidirectional charging infrastructure in RVB tender procedures.
10. An exploration of strengthening and the targeted use of the SVVE scheme for collective solutions for homeowners' associations suitable for bidirectional charging, possibly combined with the phasing in of an obligation to make multi-family homes charge-ready on a collective basis.
11. NAL will support municipalities in joint procurement (framework contracts) of bidirectional infrastructure for newbuild and renovations.
12. An exploration of the merits of including a mandate in the Bbl to make small-scale residential newbuild charge-ready (<4 parking spaces).
13. An exploration of the merits of including a mandate on bidirectional charging points in the Bbl from 2029.



III. The introduction of interoperable bidirectional vehicles (1)

Challenges

In order to give car manufacturers sufficient guidance on the development of vehicle technology, the interoperability requirements mentioned above will need to be translated into a widely supported definition of V2G readiness, in line with international and European vehicle requirements. That is the only way of guaranteeing that it will be possible to market the technology globally, which will significantly reduce producers' uncertainty about investing in interoperable platforms.

This is not just about software but also requirements for hardware: the inverter (for AC charging), high-voltage components, protection systems and battery management systems must be able to safely handle bidirectional power flows and monitor temperature, charging status and degradation. Until there are clear agreements about what is precisely required to achieve this, vehicle manufacturers will be deterred from large-scale investment in these.

What is actually needed is a clear 'V2G-ready' label that guarantees interoperability. The term 'V2G-ready', which is sometimes used now, currently has no fixed definition and says little about the actual interoperability of vehicles. Only when international standards, such as guidelines from the United Nations Economic Commission for Europe (UNECE) and European type approval, set out the minimum requirements that a vehicle or charger must meet in order to qualify as being bidirectional or 'V2G-ready', will a clear and assessable framework for upscaling develop for manufacturers, grid operators and users.

As well as clear agreements about vehicle requirements, there are currently also no clear, intuitive driver/vehicle interfaces that make it possible to set limits on charging and discharging, manage V2G services and gain an insight into earnings and battery impact.

Solutions

To enable systematic upscaling of bidirectional charging, the frameworks described in challenge 1 (network codes, standards, testing programmes) will need to be translated into clear requirements for vehicles. This is expected to happen in around 2030. This will create investment certainty for producers and bidirectional charging will become fully integrated in the market rather than just a niche pursuit. Because vehicle manufacturers operate globally, vehicle specifications will need to be agreed in a UNECE context and then be included in European type approval for Europe. In this, vehicle requirements will need to be developed in conjunction with requirements for charging infrastructure and energy services in order to enable a consistent and interoperable system to develop across the entire chain.

Once this type approval framework has been established for bidirectional charging, an assessment can be made as to whether targeted incentive measures – such as subsidies or tax incentives – will be necessary and effective in order to accelerate the introduction of bidirectional vehicles. This concerns both new vehicles and existing vehicles that can possibly be safely converted. In preparation for that, I&W is working with the RAI Association and BOVAG (Dutch Association of Garage Owners and Motor Vehicle Dealers) to examine the extent to which it is possible to responsibly retrofit vehicles to be bidirectional, including technical feasibility, certification, guarantee and insurance.

III. The introduction of interoperable bidirectional vehicles (2)

Overview of actions:

14. Expanding UNECE vehicle specifications to include aforementioned requirements for smart and bidirectional charging.
15. I&W to work on including UNECE vehicle specifications for bidirectional charging in European Type Approval.
16. Research into the options of retrofitting existing vehicles to enable bidirectional functionality.
17. Explore inclusion of interoperable bidirectional vehicles in tender procedures for Central government fleet.
18. Explore inclusion of interoperable bidirectional vehicles in local and regional government authority tender procedures

IV. Improving the business case and the chain (1)

Currently, market parties and EV drivers have to invest more than bidirectional charging will deliver for them. This is why it is still not financially viable in many cases. On the one hand, this is because of the higher cost of purchasing a bidirectional charging station and a bidirectional vehicle. Central government expects these high purchasing costs to decline over time as a result of market forces. On the other hand, there are also still some barriers in terms of operational costs. The price components for power consumption consist of: a supply tariff, a network tariff, energy tax and VAT. In some bidirectional charging applications, there is a double network tariff and a double energy tax. This is undesirable and inhibits the business case for market parties and ultimately also the earning potential of EV drivers. This section looks at both these challenges and describes the potential solutions envisaged to improve the business case for market parties and EV drivers.

Operational cost challenges

Double network tariff

Currently everyone pays a regular fixed amount to have a grid connection, irrespective of the time and the volume consumed and power. This will change with the introduction of the new tariff system from 2029 under which consumers will pay different Time of Use tariffs. The idea behind this is for the level of the network tariffs to be adjusted in line with the time of day. This enables EV drivers to tailor their behaviour to fit the different tariffs – which largely reflect the available capacity.

In the case of temporary storage, such as with bidirectional charging or home batteries, grid operators sometimes charge market parties and consumers a network tariff twice: once when charging is done for storage and then a second time elsewhere in the chain when the feed-in supply of electricity is consumed elsewhere. This could be by a different user or by the same EV driver using bidirectional charging. In Germany in 2025, the decision was made to change the law to abolish the grid storage fee. This prevents a double network tariff.

Double energy tax

The supply of electricity to a consumer is subject to energy tax. In economic terms, double energy tax for EVs occurs when electricity is consumed from the grid (taxed), stored in an EV battery and then fed back to the grid (untaxed) and is then supplied to a different consumer elsewhere in the chain (taxed).

There is no double energy tax for a consumer who generates their own electricity, stores it in an EV battery and then consumes it themselves; in that case the consumer pays no energy tax whatsoever on this electricity. There is also no double energy tax when a consumer takes electricity from the grid, stores it in an EV battery and then consumes it; the consumer will then pay energy tax once only, when taking power from the grid. There is also no double energy tax paid if the consumer generates their own electricity, stores it in an EV battery and then feeds it back to the grid and that electricity is then supplied to another consumer elsewhere in the chain; this electricity is then taxed once only, when it is ultimately supplied. Finally, double energy tax has not so far occurred because of net metering. Net metering will no longer apply with effect from 1 January 2027.

Steps taken previously

Preventing double energy tax for small-scale connections is a complex process. The solutions will (a) require significant modifications to consumers' metering equipment, (b) create additional burdens for parties and (c) probably result in additional pressure on the tax authorities. Besides, there is no workable solution for the situation where EVs charge behind the main connection while also using solar panels to generate electricity behind that same connection. In that case, it is not possible to determine whether the electricity stored in the EV battery has previously been taxed or not. It is therefore impossible to determine the extent to which double energy tax needs to be deducted (see also the report on this '*Dubbele energiebelasting achter de kleinverbruikaansluiting bij opslag van elektriciteit*').

IV. Improving the business case and the chain (2)

Next steps
Moving forward, it will be important to assess initial practical experiences with bidirectional charging. Obtaining more data from practice and experience of advanced metering equipment will be essential for developing policy.

Based on developments in metering equipment and metering data administration, it will be possible to assess whether a solution can be found in the future for the issues identified in preventing double energy tax; this will also take into account the feasibility and verifiability of energy tax by the tax authorities. Data from practice can also form the basis for a better understanding of the effect of double energy tax on the bidirectional charging business case, the financial aspects for parties involved and the influence of bidirectional charging on grid congestion. In this way, when a technical solution has been found, an assessment can be made as to whether the benefits of removing double energy tax outweigh the burdens for various parties that result from the increased complexity that the solution will entail. Data from practice will also provide the necessary insight with regard to the budgetary consequences of potential changes to energy tax.

The collection of this data from practice will include as a minimum: the number of bidirectional charging stations and vehicles, charging behaviour, price fluctuations, network tariffs and battery depreciation. Contributions to societal challenges, such as reducing grid congestion, will also need to be taken into account. This primarily concerns quantitative analysis that makes as much use as possible of up-to-date data from practice.

Solutions

Increase financial incentive for feeding in power at peak times
Achieving a change in the energy tariff components in favour of bidirectional charging will not be feasible in the short term. This is why I&W is working with EZK, ACM and grid operators to explore ways in which flexibility that demonstrably contributes to reducing congestion can be incentivised by means of a higher payment. This is because electricity feed-in at times of demand-driven grid congestion can reduce peaks and EV drivers and market parties should be rewarded for this. A key condition for this is that feed-in must occur at the right place in the grid in order to reduce or prevent bottlenecks. Systematically reducing peak demand at bottlenecks can prevent or delay the need to expand the grid. This can reduce the need for investment in the grid, slowing down increases in network tariffs.

Account also needs to be taken of the fact that the electricity price is determined on the national market, whereas grid congestion occurs locally. As a result of this, the incentive of a low price can coincide with local grid congestion. Efforts therefore need to be made to ensure that bidirectional charging propositions are driven not only by low price, but also factor in a grid voltage component. Central government is exploring in more detail how frequently this situation occurs in practice and what interventions may be appropriate.

IV. Improving the business case and the chain (3)

Challenges in the financial chain

Improving the operational cost conditions (as described above) will not be sufficient as a means of improving the overall business case. A wider chain of market players will need to participate. Where there are clear benefits and organisation is easy, bidirectional charging can be rolled out at an early stage via customised projects; in more complex or less financially viable situations, barriers may still remain that require additional policy and collaboration efforts, including in the case of better interoperability and payment opportunities for flexibility.

Organising bidirectional charging is at its simplest in cases where the same party invests in vehicle and charging station and the EV owner is the one that receives payment for delivering flexibility services. This kind of situation requires little supply chain coordination and price incentives work effectively. But when earnings need to be shared via links in the chain such as car park operators or charging service providers, this requires additional data connections and agreements, which soon makes organisation more complex. Equally, the potential increases significantly if numerous vehicles can be bundled together under a single operator or contract: this delivers benefits of scale, facilitates customised solutions with grid operators and suppliers and helps to achieve capacity thresholds for congestion services. Even more potential emerges if private power generation and consumption can be optimised 'behind the meter' and if vehicles remain predictably stationary for long periods. Following this logic, three clear policy lines emerge.

The first is: rapid upscaling for commercial and shared car fleets. Commercial fleets and fleets of shared cars offer the greatest promise for early upscaling: investment and operational decisions for vehicle and charging station are under the same control, services can be offered at scale and customised solutions with grid operators and energy suppliers can be organised effectively. Since shared vehicles are available in many places in the city, they can be deployed as 'plannable' relief capacity; practical experiences have shown that just a limited number of vehicles can achieve hundreds of kilowatts in peak reduction, with the potential for around a megawatt with further upscaling. In newbuild areas, where shared cars are already being used to reduce the pressure on parking, bidirectional shared car hubs can not only create opportunities for mobility but also free up additional "space on the grid". For this, policy can focus on including bidirectional shared vehicle hubs as standard in area developments and grid congestion strategies and taking advantage of the data and experiences already available in this context for system planning and further regulation.

The second line of policy concerns private homeowners. The bidirectional supply chain is also relatively easy to organise in this context: the investment decision on vehicle and charging station are under the same control, there is a one-on-one contractual relationship with the energy supplier and vehicles are stationary for long periods, often in combination with private solar panels. But the bottleneck in this case is scale: while interoperability remains limited and only specific vehicle/charging station combinations can function bidirectionally, it is difficult to bundle together sufficient vehicles within a district or congestion zone in order to deliver market-relevant flexibility. In this, fleets of vehicles can serve as a launching pad: starting with a solid supply of shared car and commercial fleets that private users can opt into later – for example by using the same technology or the same aggregator. Parallel to this, there will be a need to work with energy suppliers, aggregators and energy hub initiatives to explore how aggregation of domestic flexibility might be facilitated, with clear market roles, standard products and agreements about data and payment, with a view to making it easy for individual EV drivers to participate in flexibility services and possibly also congestion-related products in the longer term.

IV. Improving the business case and the chain (4)

The third policy line is: focusing on removing barriers in collective and (semi-)public charging situations now to prevent upscaling from stalling after 2030. In the case of collective housing, public parking and at (semi-)public charging bays, investments in charging infrastructure are separate from vehicle ownership and energy supply; moreover, there are several links at play in the chain, including homeowners' associations, municipalities, CPOs and charging service providers. Without a clear division of roles, standard contracts and workable sharing mechanisms for flexibility revenues, making bidirectional services financially viable and manageable is difficult in this context, even when technology and markets are at an advanced level. In terms of policy, this will call for the development of guidance and model contracts for these chains, modifications to requirements for concessions and tender procedures to make it possible for operators to actually earn from bidirectional charging and the setting up of living labs to pilot governance and payment models in practice. This will enable policy to prevent bidirectional charging systematically lagging behind in more complex contexts because the necessary organisational and contractual conditions have not been put in place in time.

As mentioned earlier, in 2026 the European Commission is calling for the creation of a "regulatory sandbox for bidirectional charging". This will involve allowing national governments to temporarily relax regulations to create space to experiment with innovations in living labs. Central government intends to investigate whether this loosening of regulation could be an option for the Dutch context.

Overview of actions to improve business case and financial chain:

19. I&W will work with EZK, ACM and grid operators to explore whether financial payment for feed-in can be increased at peak times.
20. Central government intends to work with market parties to gain an understanding of the latest practical data and experiences of advanced metering equipment.
21. Exploration of whether the options for bidirectional deployment of fleets can be taken into account in all planning and public tenders for shared car spaces and charging infrastructure.
22. I&W, EZK, ACM, grid operators and energy sector to develop agreements on the metering of charging stations.
23. Within living labs, practical trials will be launched involving collective housing, car parks and (semi-)public charging bays to test and further enhance governance and payment models in practice.
24. Central government and the NAL will develop practical templates with division of roles, model contracts and simple sharing mechanisms for flexibility revenues that homeowners' associations, municipalities and property owners can use immediately. Requirements for concessions and tender procedures will be coordinated in line with this to ensure that operators can actually earn money from bidirectional charging.
25. Exploration of the application of regulatory sandbox in the Netherlands.

V. Knowledge and trust among (future) car owners will need to grow

Challenge

Existing electric drivers
Knowledge and trust among car owners will need to increase since many potential users still have doubts about bidirectional charging. Some of the existing EV drivers understand the technology and are open to it in principle, according to the 2025 national charging survey (Nationaal Laadonderzoek 2025) and academic sources (such as Van Heuveln et al., 2021), but have concerns about battery wear, loss of range, the technical suitability of vehicle and charging station and unclear guarantee conditions. Equally, users expect a fair financial compensation for feed-in together with the certainty that they can always drive away with sufficient charge.

Future electric drivers
However, most Dutch people will be making the switch to electric driving over the next few years. Ensuring that this group switches immediately to a bidirectional vehicle and charging will require an understanding of the group's readiness to make that switch. TNO (2026) has conducted a study into the willingness to use bidirectional charging among current residents of the EU. There are various key factors at play in users' motivation to use bidirectional charging. The advantages for the user and the environment and the emotions that this engenders play an important role in the acceptance and use of bidirectional charging.

Solution

In order to create increased trust among (future) EV drivers, it will be important to ensure that the correct information is provided in the right way. With increased knowledge and trust, consumers will have a greater tendency actually to opt for bidirectional charging.

The information that EV drivers will need must at least cover such areas as battery degradation, guarantee, accessibility, guaranteed range, and the technical suitability of the vehicle and charging station to be used. This will help reduce some of users' concerns and perceived bottlenecks.

Many of these aspects will require a carefully pre-designed customer journey, including user preferences. This could include simplifying bidirectional charging accessibility and installation.

It will also be important to ensure that the different advantages of bidirectional charging are clearly communicated and defined in concrete terms. It will be equally important to communicate the cost savings, contribution to reducing grid congestion and the increased use of green energy.

User organisations are closest to the end users and have the best understanding of their needs. It will therefore be up to them to design the most effective customer journey for bidirectional charging and communicate about it with appropriate information concerning what is and what is not possible with the current applications on the market. At the same time, Central government will work to simplify the installation and use of bidirectional charging infrastructure, in close collaboration with the installation sector in order to reduce the complexity of the switch to bidirectional charging for consumers.

Overview of actions:

26. I&W will bring together user organisations, leasing companies, sector organisations, installers and other relevant organisations to ensure suitable communication about bidirectional charging, focusing on quantifiable benefits such as concrete cost savings, more effective use of renewable energy, emergency power supply and stability of the local electricity grid. This will also include explicit focus on battery degradation, guarantee, liability and the short- and long-term impact on the climate, including the alternative costs of continued use of combustion engines. Ready-to-use solutions (as opposed to the modular components currently available) will also be highlighted. Attention will also be paid to independent certification to enhance the credibility of this technology.

V. Knowledge and trust among (future) car owners will need to grow: further work on battery degradation (1)

Because of concerns about battery degradation, further work will be required on general battery development and the potential effects on the battery of bidirectional charging. This will make it possible to determine what steps could be effective to dispel concerns.

Developments in battery technology

During the introduction of EVs over the last fifteen years, the battery cell technology used has primarily been based on nickel-cobalt. While this has high energy density (wide range), it is relatively expensive because of the materials and more prone to ageing. Recent developments are starting to change this. Lithium iron phosphate (LFP) batteries have a longer lifespan (up to 10,000 cycles), are cheaper and do not contain critical materials, such as cobalt. The sodium-ion battery has become increasingly popular and has major potential for stationary energy storage and mobility solutions in the cheaper segment.

Decreasing cost of batteries

As the battery market has grown and with the rise of LFP, the average cost of batteries has fallen over the last 15 years from $1500/kWh to $108/kWh (BloombergNEF, 2025). This fall in price is enabling the current widespread adoption of battery storage for both grid storage and use in heavy transport. Although significant growth is expected in the battery market and new, cheaper technologies are emerging such as sodium-ion, the decline in cost is expected to level off at around $55/kWh by 2035.

Why does the battery age?

The performance of the battery declines over its lifespan, a phenomenon familiar to everyone from their smartphones that run out of power faster the older they get. This is because of unwanted, but unavoidable, processes in the battery that consume storage capacity. This reduces the overall storage capacity, meaning that the phone requires more frequent charging. The same applies to electric vehicles. These unwanted ageing processes continue whether or not the battery is used. However certain conditions accelerate this ageing process, such as deep charging or discharging or batteries being left at high temperature or a high state of charge.

Smarter battery management systems: Every car battery is monitored by means of a Battery Management System (BMS). This is a small computer that monitors the battery to ensure it is safe and healthy. Knowledge of battery ageing has increased significantly in recent years, resulting in much smarter BMSs. This has led to batteries that can charge much faster and a better understanding of unwanted ageing, making it possible to prevent.

For bidirectional charging, it would be useful if a BMS could play a role in regulating and planning charging and discharging in order not only to optimise energy costs, but also reduce or prevent rapid battery ageing.

V. Knowledge and trust among (future) car owners will need to grow: further work on battery degradation (2)

Impact of bidirectional charging on battery ageing

Based on knowledge that a battery will always degrade, but the extent of ageing will depend on the battery conditions and its use, it is clear that bidirectional charging presents both an opportunity and risk when it comes to degradation.

Opportunity: active efforts can be made to identify conditions in which the battery ages less rapidly, such as a set bandwidth for the state of charge. For example, when arriving home at the end of the day, the car can discharge first (favourable for times of typically high energy demand between 17:00-21:00), and then charge again during the night at a cheaper tariff to reach the desired state of charge for departure in the morning. This ensures that the average state of charge remains within the optimum bandwidth for longer, thereby minimising battery ageing. This is similar to the "delayed charging" feature currently available and shows how information from the user has a key role to play in ensuring the success of bidirectional charging.

Studies support this conclusion that, under certain conditions, bidirectional charging is an opportunity for reducing battery ageing and have calculated that up to 62% of the battery energy can be deployed on a daily basis compared to similar battery ageing without bidirectional charging.

Risk: Conversely, "inappropriate" use can also facilitate ageing, for example as a result of excessively deep charging and discharging or leaving the battery fully charged for long periods at higher temperatures.

Guarantee on EV batteries

Currently, the guarantee on EV batteries is generally expressed in terms of the number of kilometres driven or the number of years after purchase, e.g. 200,000 km or eight years. The manufacturer assumes a certain use (driving behaviour) and climatological conditions (temperatures) and makes a risk analysis for the guarantee based on that. In this, efforts are of course made to ensure any worst-case scenario falls within the term of the guarantee. This guarantee is determined within the wider framework of European consumer legislation and vehicle regulations.

The use of bidirectional charging will significantly widen the expected user profile since it will become a mix of driving and stationary storage. The fact that car manufacturers take a worst-case scenario for battery ageing as their basis means they are reluctant to invest in bidirectional charging.

However, since the cost of batteries is expected to fall further and knowledge of battery ageing is increasing all the time and can be mitigated by means of better batteries and battery management, this reluctance to apply bidirectional charging is expected to decline or even disappear. This trend has already been initiated by several manufacturers.

Appendix B: List of abbreviations

AC	Alternating Current
ACM	*Autoriteit Consument en Markt* (Netherlands Authority for Consumers and Markets)
AFIR	Alternative Fuels Infrastructure Regulation
BMS	Battery management system
Bidirectional charging	charging technology in which the vehicle is both charged and discharged
CCS Combined Charging System	Charging cable technology used for both AC and DC
CHAdeMO	Japanese standard for bidirectional data exchange between vehicle and charging station
CPO	Charge Point Operator (responsible for charge session management)
DC	Direct Current
DSO	Distribution Network Operator (grid operator)
EB	Energy tax
EPBD IV	Energy Performance of Buildings Directive IV
ETG	European Type Approval
EU	European Union
EZK	Ministry of Economic Affairs and Climate
(H)EMS	(Home) Energy Management System
FIN	Ministry of Finance
HEV TCP IEA	Hybrid and Electric Vehicle Technology Collaboration Programme of the IEA
IEA	International Energy Agency
IEC	International Electrotechnical Committee
I&W	Ministry of Infrastructure and Water Management
ISO	International Standards Organisation
ISO 15118	the international standard that actually makes bidirectional communication possible from version ISO 15118-20 and beyond
LAN	*Landelijk Actieprogramma Netcongestie* (National Grid Congestion Action Programme)

Appendix B: List of abbreviations

MSP	Mobility Service Provider
NAL	*Nationale Agenda Laadinfrastructuur* (National Charging Infrastructure Agenda)
NEN	*Nederlands Normalisatie-instituut* (Royal Netherlands Standardization Institute); NEN-EN - European standard adopted in the Netherlands
NKL	*Nationaal Kennisplatform Laadinfrastructuur* (National Charging Infrastructure Knowledge Platform)
NTA	*Nederlands Technische Afspraak* (Dutch Technical Agreement)
OCPI	Open Charge Point Interface/Open protocol that enables data exchange between charging station operator and charging service provider
OCPP	Open Charge Point Protocol/Open protocol that enables data exchange between charging stations and charging station operator
OpenADR 3.0	Open Automated Demand Response (version 3.0)
PKI	Public Key Infrastructure/digital system that makes data exchange and identification more secure
REDIII	Renewable Energy Directive III
RVO	*Rijksdienst voor Ondernemend Nederland* (Netherlands Enterprise Agency)
SoC	State of Charge/battery status, often expressed as %
ToU	Time-of-use (network tariffs)/time blocks in which different network tariffs apply
TSO	Transmission System Operator - grid operator
UNECE	United Nations Economic Commission for Europe
V2G	Vehicle-to-Grid/Delivery of power from vehicle to grid
V2H/B	Vehicle-to-Home/Vehicle-to-Building - delivery of power from vehicle to house or building
V2L	Vehicle-to-Load - delivery of power from vehicle to separate appliance (such as a refrigerator)
V2X	Vehicle-to-Everything - overarching term that covers all types of feed-in power delivery
VNG	*Vereniging Nederlandse Gemeenten* (Association of Netherlands Municipalities)

Appendix C: Parties consulted

Alliander

Royal Dutch Touring Club (ANWB)

Blue Max Studio

Dutch Organisation Electric Transport (DOET)

Enexis

ElaadNL

Ministry of Finance

Ministry of Economic Affairs and Climate

Dutch Sustainable Energy Association (NVDE)

Netbeheer Nederland (Association of Energy Network Operators in the Netherlands.)

Province of Utrecht

RAI Association

National Charging Infrastructure Agenda regions

Revnext

Netherlands Enterprise Agency (RVO)

Stedin

The Sharing Group

Netherlands Organisation for Applied Scientific Research (TNO)

Netherlands Association of Electric Drivers (VER)

Netherlands Association of Car Leasing Companies (VNA)

Association of Netherlands Municipalities (VNG)

Watture

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