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Implementation programme for recharging and hydrogen refuelling infrastructure

Final report

This is a joint publication with the Swedish Transport Administration

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Preface

Because the modern, fossil-free welfare society is largely electrified, digitalised and even partly automated, electrification is a key prerequisite for eliminating fossil fuels from many sectors and industries. Electrification is also essential for the climate change adaptation of the transport system, and access to vehicles as well as the expansion of recharging and hydrogen refuelling infrastructure will be central to this process.

Electrification will provide society with extensive opportunities, but challenges must be addressed including access to electricity networks, land, skills supply and updated regulations for an electrified transport sector. This transition will require behaviours to change in various ways. New business opportunities and increased competitiveness for Swedish companies are also positive consequences of an increasingly electrified sector. However, the green transition towards a more sustainable society must also ensure security of supply and preparedness.

This is the final report of the Government's joint mission for the Swedish Energy Agency and the Swedish Transport Administration to develop a implementation programme for recharging and hydrogen refuelling infrastructure. A vision for future recharging and hydrogen refuelling infrastructure has been developed, and an implementation programme has been formulated based on this vision together with analyses regarding, among other things, effective deployment. The implementation programme includes 55 proposed measures in a number of areas deemed urgent to promote the expansion of recharging and hydrogen refuelling infrastructure.

During the course of the mission, numerous stakeholders from the business community, academia, trade organisations, public authorities, regions and municipalities participated in interviews and dialogue meetings as well as providing written submissions pursuant to the mission. In the final stage, a webinar and Q&A session was organised to present preliminary conclusions and measures. We would like to thank everyone involved for their important contributions to this work.

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Summary

In order to promote the electrification of road transport, the Swedish Energy Agency and the Swedish Transport Administration were commissioned by the Government to develop a national implementation programme for the rapid, coordinated and socio-economically efficient deployment of suitable publicly and non-publicly accessible recharging and hydrogen refuelling infrastructure for light- and heavy-duty vehicles[1]. This is the final report in this mission.

The mission also includes a review of existing missions, regulations, State aid, tax breaks and requirements for recharging and hydrogen refuelling infrastructure, and an interim report on this topic was submitted on 1 February 2023.[2]

The measures proposed in the implementation programme are based on the Swedish Energy Agency's and the Swedish Transport Administration's own analyses, as well as the knowledge base obtained via external consultancy studies, written and oral submissions and dialogue meetings with stakeholders.

The measures in the implementation programme will contribute to achieving the objectives for recharging and hydrogen refuelling infrastructure. The vision developed through this work defines seven objectives including requirements for infrastructure and its deployment. In brief, such infrastructure shall be:

- Reliable and accessible
- Coordinated and fit for purpose
- Safe and robust
- User-friendly
- Include effective processes for establishment
- Flexible for the future
- Hydrogen as part of the solution

In recent years, the number of plug-in vehicles in society has increased significantly, and as of September 2023 they represented 11 percent of all light-duty vehicles. The expansion of publicly accessible recharging infrastructure has also gathered momentum, and at present there are more than 30,000 publicly accessible recharging points in Sweden. Development of hydrogen and its refuelling infrastructure has not been as extensive. At present, this technology involves few vehicles and refuelling stations.

To encourage use of battery electric vehicles, it must be possible to charge them easily, reliably and safely. The objective is to ensure availability of sufficient power where and when it is needed. Recharging and refuelling infrastructure must have good geographical coverage to enable use of battery electric vehicles throughout the country. Charging at home or during long-term parking is important and should be made possible for all types of housing.

[1] The Ministry of Rural Affairs and Infrastructure (2022) *Uppdrag att ta fram ett handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* I2022/01562.

[2] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ER 2023:06.

The expansion of infrastructure must be market driven, with the State's efforts focused on providing coordination, monitoring and support in instances where market conditions are initially lacking. Establishment involves a variety of stakeholders drawn from different sectors. Individual recharging points and refuelling stations are less significant than the establishment of an ecosystem with synergies and dependencies among numerous stakeholders.

The need for greater coordination at different levels and in different areas has been repeatedly mentioned. In interviews and dialogues, stakeholders from various sectors have emphasised the need for a public authority with overall coordination responsibility in the long-term for the expansion of recharging infrastructure. These stakeholders consider that unified responsibility for information, knowledge, statistics, follow-up and investment support would increase clarity, improve and simplify processes and likely make expansion faster and more efficient.

The Swedish Transport Administration and the Swedish Energy Agency deem that the Swedish Energy Agency is the public authority most fit for purpose for coordinating Sweden's recharging infrastructure. While the public authority with principal responsibility must be allocated resources for implementation, other relevant public authorities must also be given the appropriate missions and resources to assist in this work.

Increased coordination is also considered important for the deployment of hydrogen refuelling infrastructure. However, responsibility for coordinating deployment of hydrogen refuelling infrastructure should await the results of the ongoing Government mission on the coordination mission for hydrogen, to be reported in December 2024[3].

This implementation programme for recharging and hydrogen refuelling infrastructure focuses on the deployment of stationary, wired recharging infrastructure. Other technologies, in addition to behavioural changes, may impact the need for recharging and hydrogen refuelling infrastructure, e.g., battery swapping, vehicle battery size, car pooling, bi-directional recharging, electric roads and plug-in hybrids. However, the overall assessment is that these trends will have a marginal impact on the need for publicly accessible recharging and hydrogen refuelling infrastructure, at least in the next decade. The range of battery electric vehicles and battery swapping stations could have an impact, but the development of this technology and market remains uncertain.

Hydrogen-powered vehicles may fulfil the requirements of expanded driving range and higher payload better than battery-powered vehicles. Currently, fossil-free hydrogen is significantly more expensive than hydrogen from fossil fuel, and the cost of vehicles is prohibitive for many. Establishing and maintaining hydrogen infrastructure entails high costs, and aid is deemed necessary for investment and even possibly operations over a number of years.

Fit-for-purpose recharging infrastructure is, in essence, the opportunity for users to recharge while the vehicle is stationary for a longer period of time, often referred to as home or depot recharging. As well as saving time by recharging while the car is parked, such recharging is generally cost-effective for users and socio-economically beneficial, as lower power levels are often used and recharging can take place at times of reduced demand for transmission capacity in the electricity grid.

Fit-for-purpose deployment must also include the deployment of publicly accessible recharging and hydrogen refuelling infrastructure along roads. The recently adopted regulation on alternative fuels infrastructure (AFIR) includes requirements for the deployment of recharging pools and hydrogen refuelling stations along a strategic European road network (TEN-T).

[3] Ministry of Climate and Enterprise (2023), *Uppdrag att samordna arbetet med vätgas i Sverige*, ref KN2023/02715.

There are two separate requirements for the expansion of recharging infrastructure for light-duty vehicles: a geographical requirement, for deployment along the TEN-T road network, and a capacity requirement, for the deployment of publicly accessible recharging in proportion to the number of plug-in vehicles in the country.

Even if the requirements of AFIR are met, deployment along major roads in addition to TEN-T will need to include publicly accessible high-power recharging to provide geographical coverage throughout the country. Finally, to ensure the robustness, redundancy and reliability of infrastructure, additional capacity must be added and deployment must occur in strategic locations.

To create fit-for-purpose infrastructure, continued aid for both home and depot recharging, as well as publicly accessible recharging and hydrogen refuelling infrastructure, is likely necessary. Following an in-depth analysis of certain subsidies, it has been concluded that aid for semi-publicly accessible recharging is needed, that operating aid for hydrogen may be justified in some places and that the tax break for recharging points in single-family homes should be retained and hopefully benefit more social groups with the increasing pace of electrification.

Among stakeholders identified as important for the successful and rapid deployment of recharging and hydrogen refuelling infrastructure, municipalities and their important role were repeatedly highlighted. For many municipalities, deployment is an urgent issue for the transition of the transport system, but varying conditions and priorities among municipalities have resulted in varying degrees of progress in this work. To support municipalities in their continued work, more aid is needed at both regional and national level. Other stakeholders which are crucial and enable establishment of recharging infrastructure are property owners and electricity grid companies.

A critical factor for rapid deployment is access to electricity grids. The main challengesare long lead times for connection and a lack of capacity in the electricity grid. Faster permitting processes for the development of local and regional as well as national electricity grids is essential for the future. Predictability, increased planning opportunities and better communication between parties are other elements considered important in facilitating and accelerating deployment.

Recharging and refuelling vehicles must be easy and predictable for end users. AFIR includes requirements to help improve user-friendliness, including increased accessibility for people with disabilities, payment technologies and price transparency. To ensure that infrastructure is user-friendly, the implementation of regulations must be monitored to determine whether additional measures are needed.

Digitalisation is necessary to streamline the planning, development and operations of the electrified transport system infrastructure. This means, among other things, that data must be shared between energy system stakeholders, the recharging system and transport system, while the importance of data security must also be taken into account. Rather than being of a technical nature, the most significant barriers to data sharing involve organisations which are either unwilling or forbidden to share data, or a combination of both.

Data and statistics are needed to monitor progress. There are currently no official statistics on recharging and hydrogen refuelling infrastructure. The Swedish Energy Agency is working to develop such statistics but must be appointed as the public authority responsible for energy infrastructure statistics to ensure a clear mandate for further work.

As transport is a critical societal function which needs to operate at all times, even during crises, its resilience must be ensured. Sweden's energy supply is subject to numerous threats. These threats range from natural disasters and technological failures to antagonistic, i.e., deliberate, attacks. In transitioning to an electrified transport system, risk and vulnerability assessments need to be continuously carried out and potential threats need to be considered when situating and designing recharging and hydrogen refuelling infrastructure.

Based on the vision for future infrastructure and our analysis, an implementation programme for recharging and hydrogen refuelling infrastructure has been developed. It includes a list of 55 measures which the Swedish Energy Agency and the Swedish Transport Administration deem necessary to promote and accelerate electrification of the transport sector.

These measures are assigned a number but are not listed according to priority. The measures are not listed in order of priority as a holistic and systemic approach is needed for the measures to enable and accelerate electrification. Some of the measures can be implemented individually, while others are more interdependent and build on each other.

IMPLEMENTATION PROGRAMME FOR RECHARGING AND HYDROGEN REFUELLING INFRASTRUCTURE	
National responsibility for coordination of recharging infrastructure	
Measure 1	Appoint the Swedish Energy Agency as national coordinator of recharging infrastructure
Measure 2	Develop knowledge support and information
Measure 3	Work with market intelligence
Measure 4	Create platforms for dialogue and collaboration
Measure 5	Increase support to municipalities
Measure 6	Assign county administrative boards responsibility for regional coordination
Measure 7	Collect and coordinate grants
Measure 8	Ensure participation in work at EU level
Deployment of fit-for-purpose recharging infrastructure	
Measure 9	Assess the need for improved legislation on residents' access to recharging
Measure 10	Evaluate the need for publicly accessible recharging for those without access to private parking
Measure 11	Introduce dedicated aid for non-publicly accessible recharging for heavy-duty vehicles
Measure 12	Extend aid to large property owners who wish to install numerous recharging points
Measure 13	Prepare investment aid for semi-publicly accessible recharging
Measure 14	Maintain aid for deployment as required by AFIR
Measure 15	Assign the Swedish Energy Agency to develop policy frameworks according to AFIR
Measure 16	Target aid for publicly accessible high-power recharging for light-duty vehicles in coverage gaps along major roads
Measure 17	Further develop aid for publicly accessible high-power recharging for heavy-duty vehicles
Measure 18	Launch study to identify critical sites
Measure 19	Assess land needs
Measure 20	Use public right of way to make land available for charging

IMPLEMENTATION PROGRAMME FOR RECHARGING AND HYDROGEN REFUELLING INFRASTRUCTURE	
Grid capacity and shorter connection lead times	
Measure 21	Assign suitable public authority to investigate whether and how to create capacity maps
Measure 22	Monitor EU regulations on demand response and assess conditional agreements
Measure 23	Assess the need for additional measures after network companies have reported their grid-development plans
Measure 24	Assign the Swedish Energy Agency to assess how battery electric vehicles can contribute to the flexibility of the energy system
Measure 25	Monitor the development of bi-directional charging
Measure 26	Assign the Swedish Energy Markets Inspectorate to assess how bi-directional recharging can reduce costs
Digitalisation	
Measure 27	Appoint appropriate public authority supervisory responsibility for provision of static and dynamic data via the national access point
Measure 28	Examine legislation to promote data sharing
National coordination for hydrogen refuelling infrastructure	
Measure 29	Develop national coordination for deployment of hydrogen refuelling infrastructure
Measure 30	Develop investment aid for hydrogen refuelling stations
Measure 31	Monitor the need for operational aid to hydrogen refuelling stations
Enabling safe handling of hydrogen	
Measure 32	Supplement the relevant regulatory framework for handling of hydrogen
Measure 33	Streamline permitting processes for the establishment of hydrogen refuelling stations
Measure 34	Disseminate knowledge in relation to hydrogen refuelling station safety
Measure 35	Develop knowledge base for planning and building permits
Measure 36	Recommend stakeholder participation in standardisation work on hydrogen refuelling stations
Strategic localisation of hydrogen refuelling stations	
Measure 37	Monitor deployment of planned hydrogen refuelling stations and compliance with EU regulations
Measure 38	Monitor aid granted
Measure 39	Investigate robust deployment of hydrogen refuelling infrastructure
User-friendly	
Measure 40	Assign appropriate public authority to monitor AFIR ‘recharge/refuel on an ad hoc basis’ requirements
Measure 41	Assign appropriate public authority to ensure compliance with price transparency
Measure 42	Assign appropriate public authority to monitor accessibility of recharging infrastructure
Skills development	
Measure 43	Monitor continued work within the Government mission to analyse skills supply in the electrification of society

IMPLEMENTATION PROGRAMME FOR RECHARGING AND HYDROGEN REFUELLING INFRASTRUCTURE	
Statistics and monitoring	
Measure 44	Appoint the Swedish Energy Agency as the authority responsible for energy infrastructure statistics
Measure 45	Produce official statistics on recharging and hydrogen refuelling infrastructure at national level
Measure 46	Develop a database to, e.g., produce statistics at regional and local level
Measure 47	Assign the Swedish Energy Agency to produce progress reports for AFIR
Measure 48	Assign the Swedish Energy Agency to produce annual reports on the development of plug-in vehicles, recharging infrastructure and recharging power output
Measure 49	Assign the Swedish Energy Agency to be the Identification Registration Organisation (“IDRO”) in Sweden
Robustness, reliability and redundancy	
Measure 50	Conduct risk and vulnerability assessments continuously and at multiple levels
Measure 51	Investigate increased resilience of recharging and hydrogen refuelling infrastructure
Measure 52	Investigate the consequences of diminished emergency stocks
Measure 53	Investigate the need for and design of future emergency energy stockpiles
Measure 54	Swedish Energy Agency to develop directives for Styrel to prioritise recharging infrastructure and hydrogen refuelling stations
Measure 55	Provide funding for improved knowledge regarding future preparedness

1 Introduction

The Swedish Energy Agency and the Swedish Transport Administration were given a joint Government mission[4] to develop a national implementation programme for the rapid, coordinated and socio-economically efficient deployment of fit-for-purpose publicly accessible and non-publicly accessible recharging and hydrogen refuelling infrastructure for light-[5] and heavy-duty vehicles[6]. This is the final report in this mission.

The background to this mission is the National Electrification Strategy[7], which was delivered in February 2022.

This mission includes a description of the background as well as a prospective analysis and assessment of the deployment of recharging and hydrogen refuelling infrastructure to enable the socio-economically efficient electrification of road transport throughout the country. This mission also includes analysing the responsibilities and roles of various stakeholders during this deployment as well as any necessary proposals regarding whether and how responsibilities and roles can be clarified. This implementation programme must serve to ensure that Sweden meets its obligations under EU legislation. The mission will also consider the consequences of electrification for total defence, emergency preparedness and the robustness and vulnerability of the infrastructure as well as the transport system at large.

The mission also includes a review of existing missions, regulations, State aid, tax breaks and requirements for recharging and hydrogen refuelling infrastructure. An interim report on this topic was submitted on 1 February 2023.[8]

1.1 Interim reporting of review of current missions, regulations, State aid, tax breaks and requirements

On 1 February 2023, an interim report was submitted regarding the review of current missions, regulations, State aid, tax breaks and requirements. This interim report focused on barriers to the continued deployment of recharging and hydrogen refuelling infrastructure and provided preliminary proposals for various measures. Most of these proposals were further analysed in the ongoing work.

Numerous stakeholders from business, academia, industry organisations, public authorities, regions and municipalities provided written submissions and participated in interviews and dialogues. This input provided a solid basis for the work, including the identification of challenges and barriers, views on the suitability of current instruments and regulations and opinions regarding the conditions for continued deployment of recharging and hydrogen refuelling infrastructure.

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[4] The Ministry of Rural Affairs and Infrastructure (2022) *Uppdrag att ta fram ett handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* I2022/01562.

[5] Light-duty vehicles include passenger cars and light trucks with a maximum weight of 3.5 tonnes.

[6] Heavy-duty vehicles refer to trucks and buses with a total weight of more than 3.5 tonnes.

[7] The Ministry of Rural Affairs and Infrastructure (2022), *Nationell strategi för elektrifiering – en trygg, konkurrenskraftig och hållbar elförsörjning för en historisk klimatomställning* , ref I2022/00299 .

[8] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ER 2023:06

These dialogues also demonstrated most stakeholders' positive opinions regarding the basic principle that deployment of infrastructure can and should be market driven and carried out by private stakeholders. However, financial aid will be required, in particular for hydrogen refuelling infrastructure, at least initially and in some cases.

To facilitate and speed up deployment of recharging and hydrogen refuelling infrastructure, responsibility for knowledge dissemination and coordination among companies, industry organisations and public authorities concerned should be assigned. The lack of centralised and updated information regarding recharging pools and hydrogen refuelling stations is considered problematic by several stakeholders, who also desire coordination and designated responsibility. Many stakeholders emphasise the importance of considering the transition from a holistic perspective as well as the importance of clarity and long-term planning and regulations. Other important conditions include short lead times for access to grid capacity as well as ensuring access to land for recharging and hydrogen refuelling infrastructure.

One proposal, presented in the interim report, is to appoint a public authority as the principal coordinator of recharging and hydrogen refuelling infrastructure. The public authority with principal responsibility will require resources for implementation, while other relevant public authorities must receive the resources and missions to assist. The coordination mission should include, for example, grants, information and knowledge dissemination, statistics, active monitoring of technical and economic developments and, if necessary, proposing regulatory changes at national and EU level.

Numerous stakeholders have expressed a desire to review the processes for disbursing aid and the design of some forms of aid, both to simplify application and to help users take advantage of such aid. The interim report provided a number of proposals regarding how this could be done. One recurring request is to review the possibility of providing aid for so-called semi-publicly accessible recharging points. Other areas identified for further investigation including operating aid and energy storage. Several of the proposals are, however, dependent on regulatory changes at EU level, or on Sweden seeking and obtaining exemptions in specific cases.

Home recharging accounts for the majority of private motorists' charging, and the ability to charge at home is central to enabling more people to own and drive electric cars. Regarding private individuals' access to recharging facilities, there are two groups: those with the right to install recharging points and those without. In the latter group, a range of barriers associated with recharging one's car have been confirmed, and processes, regulations and opportunities for increased aid should be reviewed.

1.2 Methodology

1.2.1 Interim report 1 February

As described in section 1.1, numerous stakeholders from the business community, academia, trade organisations, public authorities, regions and municipalities participated in interviews and dialogue meetings as well as providing written submissions pursuant to the mission.

WSP conducted a study focusing on the review of aid, regulations and tax breaks[9]. A workshop was held with various stakeholders, using the WSP study as a basis. The focus of the workshop was to discuss various obstacles and proposed solutions.

[9] WSP (2023), *Underlag till handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ref 2022-11266, Jan. 2023.

1.2.2 Continuation of the implementation programme mission

Next, work packages were formed as shown in Figure 1. In the formation of work packages, the requirements of the terms of reference were used in addition to the needs for in-depth analysis identified based on the results of the interim report.

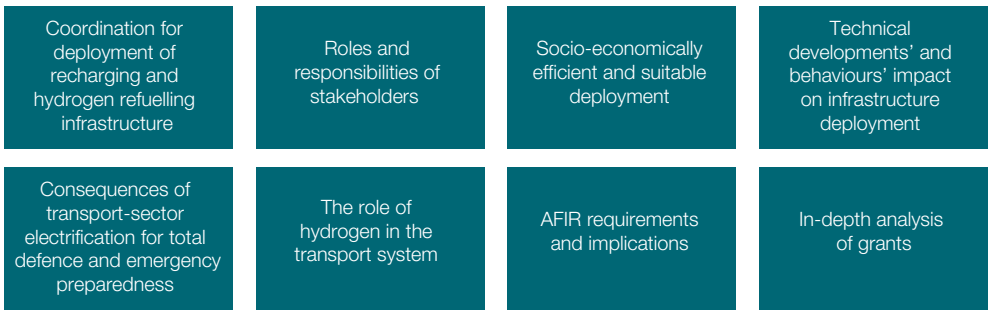

Figure 1. The different work packages of the study.

In addition to the authorities' own analyses, four consultancy studies were carried out:

- WSP: The role of hydrogen in the transport system[10]
- Trivector: In-depth analysis of grants[11]
- RISE: Impact of technological and behavioural developments on recharging and hydrogen refuelling infrastructure deployment[12]
- Ramboll: Consequences of the implementation programme for recharging and hydrogen refuelling infrastructure for total defence[13]

In May 2023, dialogue meetings were held with different themes linked to these work packages. These meetings were attended by approximately 80–100 people. In September of the same year, a webinar and Q&A session was held, with around 260 participants, to present preliminary conclusions and measures.

A reference group was formed, which met during the course of the mission. Table 1 lists the participating organisations. The conclusions and results of the report are the responsibility of the Swedish Energy Agency and the Swedish Transport Administration.

[10] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[11] Trivector (2023), *Behov av stöd till laddning och vätgastankinfrastruktur. Utredning av tre olika förändringar av stöd och avdrag behov – möjligheter – konsekvenser,* TRV2022/90068.

[12] RISE (2023), *Teknisk utveckling och beteende och påverkan på behov av infrastruktur,* on behalf of the Swedish Energy Agency, ref 2022-11266.

[13] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* on behalf of the Swedish Energy Agency, ref 2023-008891.

Table 1. Participating organisations in the reference group.

Swedish National Board of Housing, Building and Planning	National Electrical Safety Board	Swedish Energy Markets Inspectorate
Swedish Armed Forces	Swedish Mapping, Cadastral and Land Registration Authority	County administrative boards
Agency for Digital Government	Swedish Civil Contingencies Agency	Swedish Environmental Protection Agency
Swedish Transport Analysis Agency	Swedish Transport Agency	Vinnova
Swedish Association of Local Authorities and Regions	Swedish National Road and Transport Research Institute	

1.3 Limitations

The mission is limited to include only recharging and hydrogen refuelling infrastructure for road transport; i.e., light- and heavy-duty vehicles. The mission does not include recharging and refuelling infrastructure for shipping or aviation or dedicated infrastructure for non-road mobile machinery. However, machinery is included as a potential co-user, together with road traffic, of hydrogen refuelling infrastructure.

Furthermore, the mission is limited to wired stationary recharging in terms of the measures presented. Measures dealing with other stationary recharging technologies or electric road technologies are not included.

However, there is a discussion of the impact of different technologies on the need for recharging and hydrogen refuelling infrastructure.

Measures for the promotion of battery- or hydrogen-powered vehicles will also not be presented in the framework of this mission.

The mission does not include submission of proposals for amendments related to taxation.

1.4 Related missions

1.4.1 Inter-agency monitoring of the electrification of society

The Government has commissioned the Swedish Energy Agency, the Swedish Energy Markets Inspectorate, Swedish National Grid and the Swedish Transport Administration to carry out joint monitoring, between 2022 and 2024, of the electrification of society and the development of the electricity system, including electricity production[14]. This mission consists of several parts, of which sub-mission 2 includes monitoring the deployment of recharging and hydrogen refuelling infrastructure. Sub-mission 2 consists of the following:

- Monitor the nationwide deployment of recharging and hydrogen refuelling infrastructure and assess any gaps in the deployment of recharging infrastructure that impede the electrification of the transport sector. If new EU requirements on the deployment of recharging and refuelling infrastructure are introduced, these should be taken into account in the assessment.
- Statistics on recharging infrastructure for road transport, including method development to quantify the number of non-publicly accessible recharging points in Sweden.

[14] The Ministry of Rural Affairs and Infrastructure (2022), U*ppdrag att genomföra en myndighetsgemensam uppföljning av samhällets elektrifiering*, ref I2022/01060.

Investments made with State aid should be accounted for separately. Any new EU requirements must also be taken into account when producing statistics. The Swedish Transport Administration, the Swedish Environmental Protection Agency and the Swedish Tax Agency shall, if necessary, assist the Swedish Energy Agency with supporting materials for the compilation.

The mission runs until 2024 and is to be reported annually: 15 December 2022, 15 December 2023 and 13 December 2024.

Sub-mission 2 is to be carried out in close connection with the mission to produce an implementation programme for recharging and hydrogen refuelling infrastructure.

1.4.2 Special inquiry: Removing barriers to the electrification of the transport sector

The Government has appointed an inquiry chair to analyse and propose specific measures to accelerate the electrification of the transport sector and to help strengthen the conditions for living, working and operating across Sweden[15]. This inquiry chair is to adopt a forward-looking perspective and assume that, in the near future, road transport will be electrified.

The inquiry chair shall, among other tasks:

- analyse expanded possibilities for municipalities to make exceptions for electrified transport
- analyse and, as necessary, make proposals to facilitate the construction of recharging points for battery electric vehicles by community properties
- develop a knowledge base regarding grid connection for recharging infrastructure. This includes:
  - clarifying the nature and extent of the problem, examining any geographical differences in wait times, and assessing how the problem may evolve in electrification of the transport sector,
  - examining the challenges and opportunities that exist, particularly in terms of skills supply, stakeholder dialogue and process development to meet the need for future grid connection of recharging infrastructure, and
  - proposing measures to reduce lead times, including permitting recharging infrastructure planning to consider grid conditions to a greater extent.
- propose, if necessary, further measures to remove barriers to the electrification of the transport sector
- make necessary legislative proposals.

This mission shall be reported no later than 31 December 2024.

[15] Committee terms of reference (2023), *Undanröja hinder för elektrifieringen av transportsektorn*, terms of reference 2023:80.

1.4.3 Mission to develop statistics on electrification

The Government has commissioned the Swedish Transport Analysis Agency[16] to develop statistics in the transport area, i.e., the Agency's current subject areas for statistics[17], regarding electrification.

Within the framework of this mission, the Swedish Transport Analysis Agency will do the following:

1. Analyse how official statistics and other transport statistics can and should be developed to describe the electrification of the transport sector wherever relevant.
2. Conduct an international comparison of the development of transport statistics and statistical models regarding electrification.
3. Produce a plan for the development and production of advanced statistics on electrification, indicating which statistical areas should be prioritised.

By 15 January 2024, the Swedish Transport Analysis Agency shall report the parts of the mission relating to items 1, 2 and 3. The Swedish Transport Analysis Agency shall thereafter report annually on the progress of implementation of development work. The Swedish Transport Analysis Agency will present a final report in the annual report for 2026.

1.4.4 Mission to review and simplify regulations concerning public land

The Government commissioned the Swedish Transport Agency[18] to review the regulations relevant to the recharging of parked vehicles on public land. This review aims to simplify the regulatory framework to accelerate the electrification of road transport. The barriers to organising parking on public land which were identified in the Swedish Energy Agency's report *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*[19] will be a starting point for this review.

This mission shall be reported to the Government Offices no later than 5 April 2024.

1.4.5 Coordination mission for hydrogen

The Government has commissioned the Swedish Energy Agency[20] to coordinate work on hydrogen in Sweden. This coordination mission will help to achieve an efficient energy and climate transition while allowing companies to grow and increase employment, contributing to a robust and secure energy supply. The purpose of the coordination mission is to identify and help remove barriers, enabling integration of the use, production, distribution and storage of hydrogen into the energy system in a socio-economically efficient manner which contributes to achieving the energy and climate policy goals.

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[16] The Ministry of Rural Affairs and Infrastructure (2023), *Uppdrag att utveckla statistik avseende elektrifiering*, ref I2023/02047.

[17] Swedish Transport Analysis Agency (2023), *More about our statistics*, trafa.se

[18] The Ministry of Rural Affairs and Infrastructure (2023), *Uppdrag att se över och förenkla vissa regler avseende allmän platsmark*, ref LI2023/02739, LI2023/01087, LI2023/01092.

[19] Swedish Energy Agency (2021), *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*, ER2021:24.

[20] Ministry of Climate and Enterprise (2023), *Uppdrag att samordna arbetet med vätgas i Sverige*, ref KN2023/02715.

The mission has three main parts. The first part involves the Swedish Energy Agency coordinating Sweden's hydrogen work, through collaboration, dialogue and knowledge dissemination among government agencies and companies, industry organisations and other public stakeholders, including regions and academia. This collaboration must include broad issues related to hydrogen development and ongoing processes, as well as permitting processes, standardisation, certification, security of supply and safe handling.

The second part consists of investigating how hydrogen and Swedish hydrogen infrastructure can be developed from a systems perspective.

The third part consists of monitoring the development of hydrogen in Sweden and internationally.

The interim report is due on 28 February 2024, and the final report on 1 December 2024.

1.4.6 Mission to develop regional and local energy planning for electrification

The Government has commissioned the County Administrative Board of Västra Götaland and the Swedish Energy Agency to develop regional and local energy planning. This mission will contribute to enabling large-scale electrification of industry and transport, among other things[21].

By 15 November 2023, the County Administrative Board of Västra Götaland shall present a structure for the regional action for electrification as well as the working methods and methodology for its development. The complete regional electrification action plan must be presented by 31 December 2024.

The Swedish Energy Agency will identify the need for methodological support in calculating future electricity and power needs to support local and regional stakeholders. This methodological support must facilitate the preparation of the knowledge base in the regional action plan and enable aggregated assessments at national level.

The Swedish Energy Agency will also develop local energy planning in municipalities by producing guidance and methodological support for the Act on Municipal Energy Planning (1977:439) based on the large-scale electrification that is expected as well as the needs of total defence.

Both parts of the Swedish Energy Agency's mission are to be reported by 30 June 2024.

1.4.7 Mission to coordinate skills supply for electrification

The Swedish Energy Agency has been assigned the mission of coordinating a national effort to ensure skills supply for electrification. While this mission is carried out in direct dialogue with Swedish National Grid, the Swedish Electrical Safety Board, the Swedish Energy Markets Inspectorate and the Swedish Transport Administration, the aim is to coordinate a broader collaboration among all relevant public authorities and industry stakeholders.

The mission will last for two years with the hope of creating conditions and synergies with positive long-term effects. The key words for the project are cooperation, collaboration and coordination.

[21] Ministry of Climate and Enterprise (2023), *Uppdrag att utveckla regional och lokal energiplanering för elektrifiering,* ref KN2023/03646, KN2023/01462 (partial).

The work is divided into two sub-missions:

1. Mapping of skills needs and ongoing initiatives
2. Identification of barriers, challenges and proposals for measures

In the second part, the Swedish Energy Agency will identify barriers and challenges to the supply of skills in the energy sector and related sectors as well as proposing measures to meet short- and long-term skills needs.

The first sub-mission was completed and reported in October 2023[22]. The second sub-mission and final report must be submitted to the Government Offices by 1 December 2024.

1.5 Note to reader

This report consists of several interconnected parts. Initially, in Chapter 2, a vision for Sweden's recharging and hydrogen refuelling infrastructure is presented. The implementation programme itself is found in Chapter 6 and comprises 55 measures aimed at realising the vision.

Chapter 3 describes the current situation, i.e., the status of the development process. Chapter 4 describes the EU regulations which establish the framework and conditions for what can and must be implemented.

The analysis in Chapter 5 examines the distance between the current situation and the vision. This chapter analyses and describes existing barriers and opportunities as well as considering what is necessary to create the conditions to achieve the objectives.

The implementation programme in Chapter 6 presents the measures generated through analysis and which, together, can contribute to the effective and socio-economically efficient deployment of recharging and hydrogen refuelling infrastructure. These measures are numbered but are not placed in order of priority.

Annex 2 provides a list of terms used in this report. In the area of recharging infrastructure, the concepts adopted in the Regulation on the deployment of alternative fuels infrastructure (AFIR)[23] are used throughout.

[22] Swedish Energy Agency (2023), *Kompetensförsörjning för elektrifiering*, ER2023:21.

[23] Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on *the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU.*

2 Vision for Sweden's recharging and hydrogen refuelling infrastructure

Large-scale electrification of the transport sector is crucial for Sweden to reach its climate goals. Development is happening quickly, but to achieve the goals, it must speed up.

One important prerequisite for the successful transition to fossil-free transport is fit-for-purpose infrastructure to provide energy to electric and hydrogen-powered vehicles. Fit-for-purpose recharging and refuelling infrastructure help ensure availability of the correct power or fuel where it is most useful and where residents and businesses expect.

This chapter describes the vision for Sweden's recharging and hydrogen refuelling infrastructure. The vision illustrated in Figure 2 has been developed during the mission and aims to set a direction for the measures that will be described later. The vision is projected for 2030.

Figure 2. Vision for recharging and hydrogen refuelling infrastructure.

2.1 Reliable and accessible

To achieve widespread electrification of the transport sector, it must be possible to easily, reliably and safely recharge vehicles.

Recharging and refuelling infrastructure must have a geographical coverage that extends across Sweden, so that drivers can confidently use electric and hydrogen-powered vehicles for all types of journeys. Recharging pools and refuelling stations must be non-discriminatory and accessible, so that everyone has the opportunity to use electrified vehicles.

Enabling recharging at home or during long-term parking is key to increasing the uptake of plug-in vehicles. Access and proximity to recharging infrastructure must be independent of housing or business location.

Hydrogen refuelling stations must be sited to meet the need for refuelling while remaining at a safe distance according to the specific safety requirements.

2.2 Coordinated and fit-for-purpose

An important prerequisite for transition of the vehicle fleet is the availability of recharging and hydrogen refuelling infrastructure. Infrastructure must be well-suited for its purpose. In simple terms, this means ensuring availability of sufficient power where and when it is needed.

Deployment will be mainly market driven and by private and commercial operators. Where a market has not yet developed to accommodate fit-for-purpose deployment, the State will apply adapted investment aid. Otherwise, efforts by the State will be focused on supporting deployment through coordination, knowledge, analysis and follow-up.

2.3 User-friendly

Recharging your car must be easy and predictable, whatever vehicle you drive and wherever you are.

Recharging pools must be available in sufficient numbers wherever drivers stop to perform other tasks, e.g., at home, at work or when stopping to rest, shop, load or unload.

Using digital tools, users can easily find available recharging points and hydrogen refuelling stations, enabling them to efficiently plan and optimise their journeys and routes.

Paying for your energy must be simple, and costs must be transparent and comparable.

Smart technologies will also contribute to the optimised and efficient use of available power.

2.4 Robust and safe

The transport system is an essential and critical societal function, both from day-to-day and in times of crisis. The transport energy supply must therefore be robust and capable of withstanding all kinds of disruptions. With increased electrification and digitalised technology, the consequences and vulnerabilities in total defence and preparedness must be continuously analysed and considered.

Sweden’s recharging and hydrogen refuelling infrastructure must have an effective preparedness plan that includes adapted emergency stocks, priorities and repair plans.

Hydrogen must be handled with a high level of safety, particularly in the planning, establishment and operation of hydrogen refuelling stations.

2.5 Effective processes

Recharging operators, hydrogen-refuelling station operators, landowners and grid owners are key stakeholders in the rapid deployment of recharging and hydrogen refuelling infrastructure. To facilitate the work and speed up deployment, processes need to be effective.

The expansion of electrical grid capacity and lead times for connection must follow reasonable schedules and be easy to follow and understand. To improve planning efforts, available grid capacity should be made visible. Interaction among the different stakeholders early in this process creates consensus and predictability.

To ensure an effective process in terms of connectivity, the resources and skills needed for planning and establishment must be secured.

2.6 Flexible for the future

To achieve a fossil-free vehicle fleet, several technologies and solutions must work together. Different technologies are fit for different circumstances, depending on geography, transport needs, access to infrastructure, and resources, among other things. Deployment of recharging and hydrogen refuelling infrastructure is needed immediately, but the system must be able to adapt to future technological developments and new conditions.

New energy transmission technologies and methods can play a role in the future transport system and must be integrated. New technologies for efficiency and balancing in the electricity system also need to be continuously implemented to improve and optimise use of the infrastructure.

2.7 Hydrogen – part of the solution

Hydrogen is likely to be part of the solution for the transport system of the future. Hydrogen will be used wherever it is socio-economically efficient and provides the greatest systemic benefit.

Hydrogen refuelling infrastructure should be deployed at a pace that does not impede development of the market for hydrogen-powered vehicles. At the same time, the rate of deployment must take into account expected demand for hydrogen from the automotive sector and is not to be exaggerated. Balanced deployment is needed to achieve acceptable hydrogen prices and sufficient availability.

Hydrogen can also contribute to security of supply, through its ability to store surpluses for use as needed. It can also be used to produce electrofuels (diesel- and petrol-like fuels), which can be used by vehicles in times of crisis.

3 Background information

3.1 Electrification and fleet development

Rechargeable road vehicles have increased rapidly in recent years. There were 299,220 new passenger cars registered in 2022. This year is notable for the fact that, for the first time, electricity was the most common powertrain in new car sales, and rechargeable cars accounted for 54 percent of first-time registrations.[24]

Thanks to the sharp increase in rechargeable car sales, the share of rechargeable cars has now reached 11 percent of all passenger cars on the road, with a 50/50 split between plug-in hybrids and purely electric cars. Figure 3 shows the status of the electrification of the road transport sector.

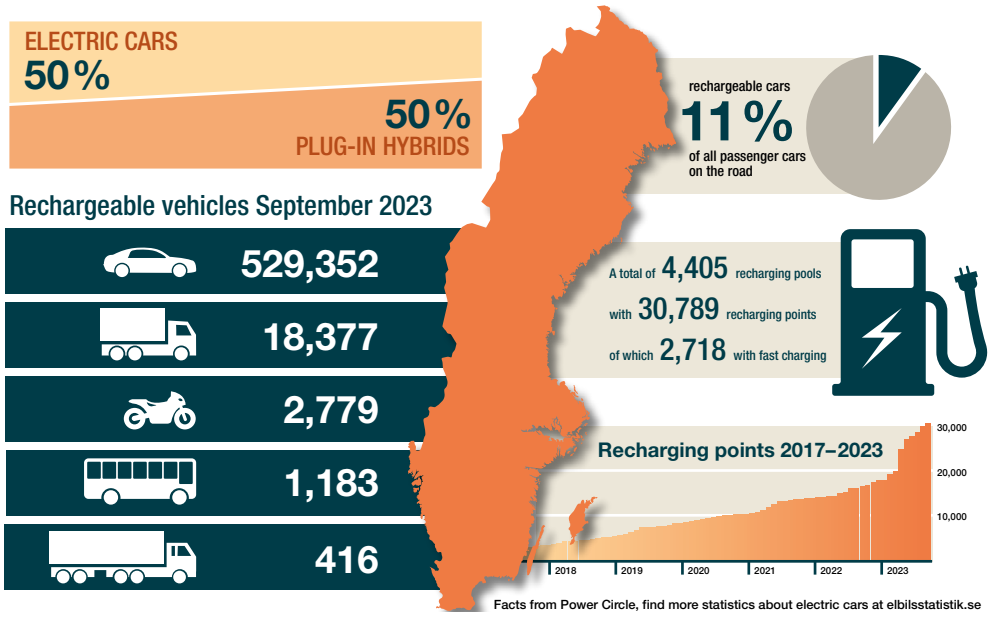

Figure 3. Electrification of the road transport sector, September 2023. Based on statistics from Power Circle[25].

As with passenger cars, electrification is increasing for trucks, both light- and heavy-duty, although diesel remains the dominant fuel. Two percent of light-duty trucks on the road are powered solely by electricity. The number of battery electric vehicles among all heavy-duty trucks on the road has increased from 72 trucks in 2021, to 231 in 2022. The number of electric buses increased from 662 in 2021, to 915 in 2022.[26]

The Swedish Transport Analysis Agency's short-term forecast for passenger cars, light-duty trucks, heavy-duty trucks and buses is affected by the recession and reduced purchasing power of Swedish households, which will primarily affect the number of newly registered passenger cars in coming years. Given the poor economy in addition to the expiration of

[24] Swedish Transport Analysis Agency official statistics (2023), *Fordon 2022-Trafikanalys Statistik* 2023:3.

[25] Power Circle, *Kunskap – PowerCircle,* September 2023, https://powercircle.org/kunskap/

[26] Swedish Transport Analysis Agency official statistics (2023), *Fordon 2022-Trafikanalys Statistik* 2023:3.

the bonus for rechargeable light-duty vehicles, the growth rate of newly registered rechargeable passenger cars is expected to decrease slightly in the coming years.

Nevertheless, it is projected that around one million, or 21 percent, of all passenger cars on the road will be rechargeable by 2026. More than half of these are projected to be electric cars.[27]

The vehicle development forecast is shown in Figure 4.

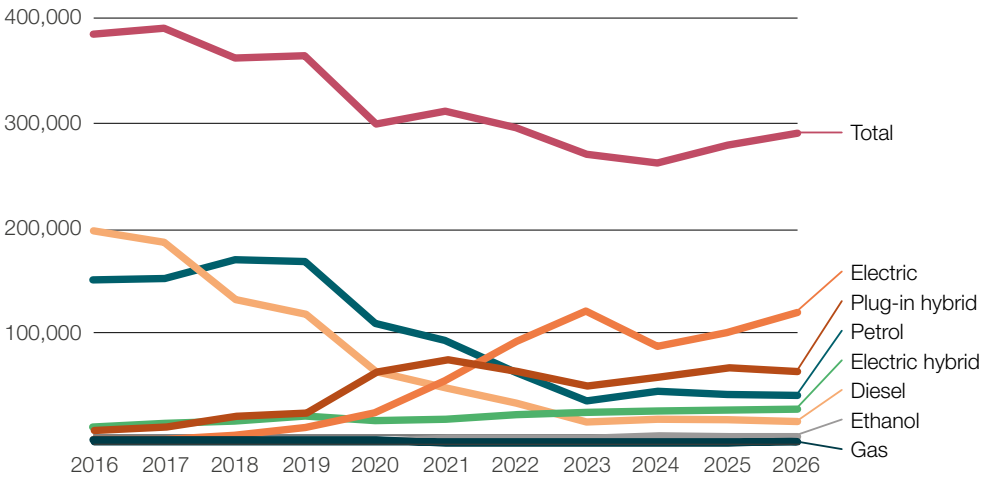

Figure 4. Swedish Transport Analysis Agency's short-term forecast for road vehicle fleet 2023–2026, data from: *Antalet nyregistrerade fordon fortsätter att minska de kommande åren* (trafa.se).

The number of newly registered light-duty trucks is expected to remain at a relatively low level for the next four years. However, the number of such trucks which can be powered by electricity is expected to increase. By 2026, it is estimated that nine percent of all light-duty trucks on the road will be rechargeable, accounting for 35 percent of newly registered light trucks.[28]

Rapid electrification of the bus fleet is expected to continue. As the majority of all buses are subject to procurement, the number of newly registered buses varies significantly from year to year. It is predicted that 36 percent of newly registered buses will be rechargeable by 2026, representing 17 percent of buses on the road. The number of newly registered electric heavy-duty trucks is expected to increase gradually, albeit from low levels. By 2026, it is estimated that almost 13 percent of newly registered rechargeable heavy-duty trucks will be electric, representing just under three percent of heavy-duty trucks on the road.[29]

In March 2023, the Swedish Energy Agency published long-term energy scenarios describing possible developments for transport sector energy use through 2050. Two of these scenarios reflect different rates of electrification: one with higher electrification and one with lower electrification. It is presumed that no barriers arise, e.g., materials shortages for battery manufacturing, and that the necessary recharging infrastructure is in place.[30]

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[27] Swedish Transport Analysis Agency (2023), *Korttidsprognoser för vägfordonsflottan* 2023–2026.

[28] Ibid.

[29] Ibid.

[30] Swedish Energy Agency (2023) *Scenarier över Sveriges energisystem – med fokus på elektrifiering 2050*, ER2023:07.

The passenger car fleet is assumed to be almost fully electrified by 2050. The share of pure battery electric vehicles is assumed to vary between 83 and 97 percent in 2050. This development is entirely dependent on the adequate deployment of recharging infrastructure and the availability of battery electric vehicles. Around 90 percent of heavy-duty trucks are assumed to be electrified by 2050 in the higher-electrification scenario, while around 45 percent are electrified in the lower-electrification scenario. These developments are shown in Figure 5.[31]

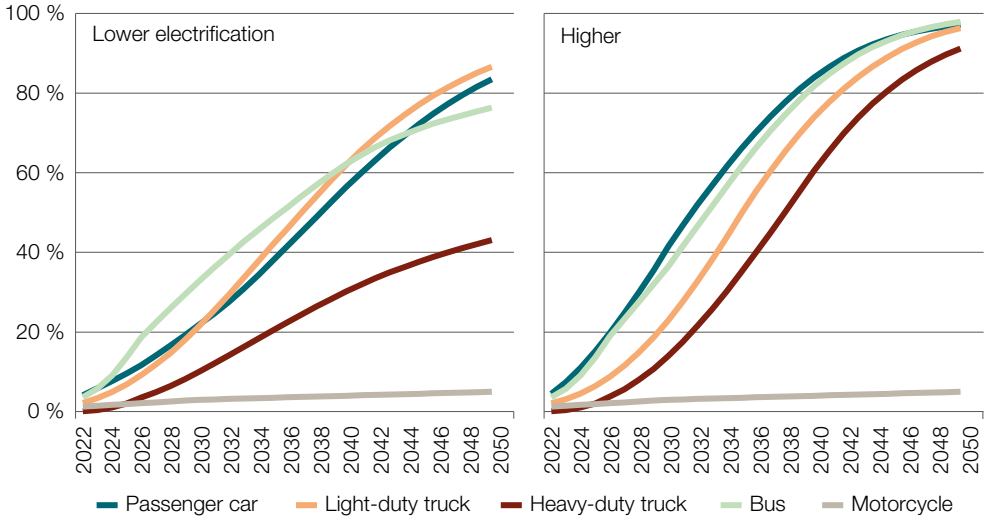

Figure 5. Share of the vehicle fleet which is rechargeable (electric cars and plug-in hybrids) in Higher Electrification vs. Lower Electrification scenarios.

There are currently about ten passenger cars with fuel cells on the road in Sweden, and a few delivery trucks and non-road mobile machinery serving as test prototypes. Manufacturers are currently able to deliver fuel cell trucks of up to 42 tonnes to Sweden.

The number of hydrogen vehicles globally has increased from around 8,000 vehicles, in 2017, to around 59,000 in 2022, according to the IEA[32]. Most of these vehicles are passenger cars located in South Korea, Japan and China. At present, there is no large-scale production of either light- or heavy-duty hydrogen vehicles. In Europe, both fuel cell trucks and buses up to 42 tonnes are in commercial use in limited numbers. Most heavy-duty vehicles (mostly buses but also trucks) are currently in China. The market for heavy-duty hydrogen vehicles is expected to expand globally in the coming years. Several manufacturers, mostly in Asia, have already put heavy-duty hydrogen vehicles on the market, but European manufacturers are also undertaking development of fuel cell vehicles. Also in development are internal combustion engines fuelled by hydrogen. Ongoing EU-funded projects for the development of hydrogen-powered vehicles include H2-HAUL[33] and H2-REVIVE[34].

[31] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266

[32] International Energy Agency (2022) *Global Hydrogen Review 2022*

[33] Clean Hydrogen Partnership (former FCH JU), *H2Haul (Hydrogen Fuel Cell Trucks for Heavy Duty Zero Emissions Logistics – Grant Agreement No. 826236),* project direction 2019–2023.

[34] Clean Hydrogen Partnership (former FCH JU), H2 REVIVE *(Refuse Vehicle Innovation and Validation in Europe – Grant Agreement No 779589),* project duration 2018–2024.

3.2 Development and status of recharging infrastructure

A prerequisite for the attractiveness of battery electric vehicles is the deployment of recharging infrastructure at a sufficiently fast pace. Extensive recharging infrastructure provides security and predictability for electric-car drivers. The Norwegian Battery electric vehicle Association is commissioned annually by the Nordic Council of Ministers to conduct an opinion survey in all Nordic countries regarding barriers to buying battery electric vehicles.[35] In 2022, the high price of electric cars was the biggest barrier in Sweden, but issues related to recharging infrastructure came second and third. The lack of home recharging opportunities and lack of confidence in public roadside recharging are thus crucial factors in decisions by Swedes to buy electric cars.

Publicly accessible recharging infrastructure

The deployment of publicly accessible recharging infrastructure has accelerated significantly in recent years. In September 2023, Sweden had over 4,400 recharging pools and over 30,000 recharging points.[36]

Existing aid for deployment contributes greatly to the constant increase in the supply of recharging pools across Sweden. Extensive efforts are also currently underway regarding recharging infrastructure for heavy-duty vehicles via regional electrification pilots[37] and the Climate Leap initiative[38].

There are currently no official statistics on the number of recharging pools, stations and points in Sweden. Figures used by, among others, Power Circle to produce statistics are provided by NOBIL[39], a Nordic database of recharging pools. The process of producing statistics for recharging infrastructure is described in greater detail in Chapter 5.11.

In April 2023, the NOBIL database was updated with automatic input of recharging points by several major recharging operators, resulting in a relatively significant increase in registered recharging points. Automatic input is welcome, as it more accurately depicts the situation than the previous database points, which required manual input.

Non-publicly accessible recharging

One advantage of plug-in vehicles is the ability to charge the car while it is parked. The possibility of ‘home charging’ is crucial to encourage more people to invest in and adopt battery electric vehicles. This may involve recharging close to home, at work or, for commercial vehicles, in garages or car parks where the vehicle is parked when not in use.

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[35] Norsk elbilforening og Nordisk Energiforskning (2022), NORDISK ELBIL-BAROMETER 2022.

[36] Power Circle (2023), *Statistik,* retrieved 4 Oct. 2023, https://powercircle.org/kunskap/

[37] The Ministry of Rural Affairs and Infrastructure (2022) *Uppdrag att hantera statligt stöd till regionala elektrifieringspiloter för tunga transporter*, ref I2022/00352.

[38] SFS 2015:517, *Förordning (2025:517) om stöd till lokala Klimatinvesteringar.*

[39] Swedish Energy Agency, ”Transporter”, *Registrera din laddstation,* retrieved 30 Sept. 2023, https://www.energimyndigheten.se/klimat--miljo/transporter/laddinfrastruktur/registrera-din-laddstation/

The Swedish Energy Agency estimates that 80–95 percent of total battery electric vehicle recharging currently takes place through so-called non-publicly accessible recharging. Some car owners lack access to private parking or non-publicly accessible recharging and rely entirely on publicly accessible recharging infrastructure.

The number of non-publicly accessible recharging points is estimated to be in the order of ten times the number of publicly accessible recharging points. There is no official data on the number of non-publicly accessible recharging points, but aid for non-publicly accessible recharging points via the Climate Leap initiative, the "Ladda bilen" subsidy, the former "Ladda hemma" subsidy, and the current tax break for recharging points in single-family homes, have together subsidised over 320,000 recharging points[40].

3.3 Hydrogen refuelling infrastructure

In June 2023, there were five hydrogen refuelling stations in operation in Sweden. These were located in Gothenburg, Mariestad, Stockholm (Arlanda), Sandviken and Umeå[41]. The stations were installed between 2015 and 2022 with financial aid from the EU (HIT-2-Corridors) as well as municipalities engaged in the project and local companies. The left-hand side of Figure 6 shows the location of these refuelling stations. The grey circle represents a catchment area with a radius of 100 km, based on the location of the refuelling station. Another hydrogen refuelling station was opened on 31 August 2023 in Älghult, Småland. Analysis and figures in this report are based on the number of hydrogen refuelling stations available in June 2023.

Deployment of a number of new stations is planned in the coming years with support from the Climate Leap initiative (39 stations), regional electrification pilots (13 stations) as well as EU aid through the programmes Greater4H (4 stations) and Nordic Hydrogen Corridor (8 stations). In addition to these, the company Everfuel has announced the establishment of two more stations. All are reported to be publicly accessible. The requirements of the various aid programmes have differed in terms of hydrogen capacity and technical performance. Most of the planned stations will be built for a low hydrogen capacity, but some of the small stations may increase their capacity as demand catches up with supply.

The right-hand side of Figure 6 shows the location of existing and planned stations, with an estimated coverage of 100 km (maximum 200 km between two stations). As can be seen from the Figure, coverage is relatively good. Low coverage areas, i.e., where a hydrogen refuelling station is more than 100 km from another hydrogen refuelling station, emerge in Jämtland, northern Västernorrland and Norrbotten. Such areas are also found in Dalarna, Gävleborg and Västerbotten.

[40] Calculations made by the Swedish Energy Agency based on *Lägesbeskrivning för Klimatklivet,* NV-00692-23, April 2023 and Swedish Tax Agency, "Statistikportalen", *Skattereduktion för grön teknik – Översikt*, retrieved 1 September 2023, https://www6.skatteverket.se/sense/app/b25adfd3-2836-4414-8510-2cdce893477d/sheet/e4f9aa7e-de62-483a-801f-912761d52dbd/state/analysis

[41] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

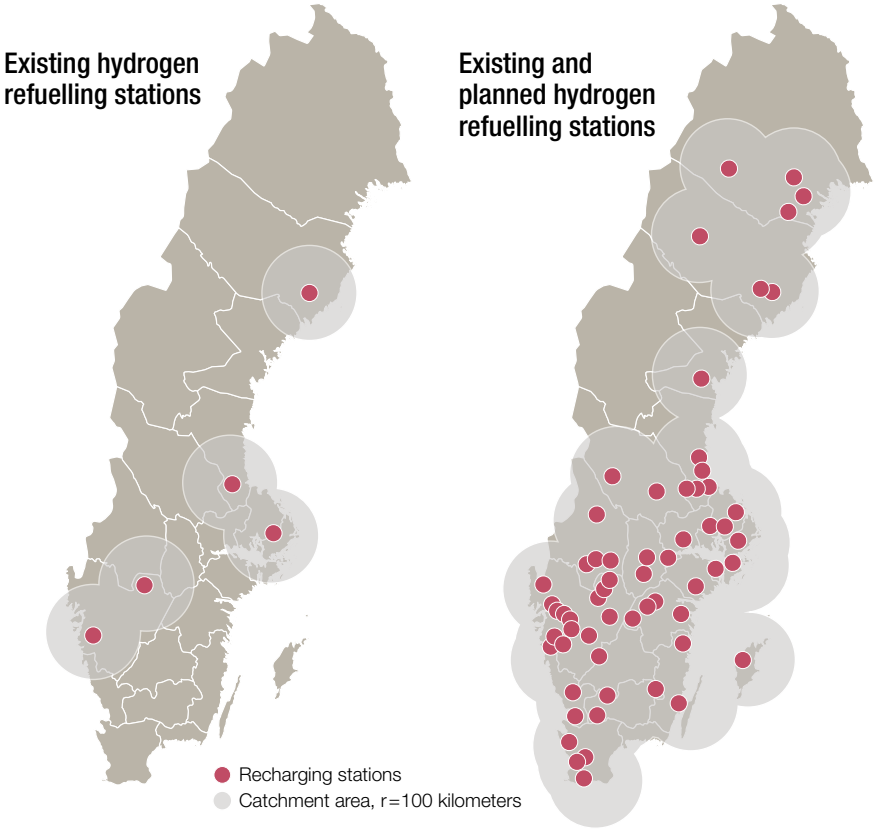

Figure 6. Existing (left) and planned (right) hydrogen refuelling stations in Sweden (June 2023) with a 100 km radius catchment area marked in grey around each station (black dot)[42].

3.4 International outlook

In recent years, several countries have developed policies and aid programmes to stimulate and accelerate deployment of recharging and hydrogen refuelling infrastructure. Several countries considered to lead in deployment are highlighted below.

3.4.1 Recharging infrastructure in Germany, the Netherlands and Norway

Germany

Germany has around 85,000 recharging points and, in recent years, has led the EU in the number of publicly accessible recharging points installed per week. Germany has set a goal of one million publicly accessible recharging points by 2023. This goal has been debated during the year, as various analyses indicate that the need for publicly accessible recharging is not so great.

The coordination of the deployment of recharging infrastructure is done at ministerial level, with a national centre for recharging infrastructure providing expertise and coordination. Germany has a national strategy and action plan for recharging infrastructure[43], which was last updated in 2022. The plan defines 68 concrete measures in ten areas: to improve coordination,

[42] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[43] Federal Ministry for Digital and Transport (BMDV), (2022) *Charging Infrastructure Masterplan II.*

evaluate development, streamline processes, strengthen the role of municipalities, make more land available for recharging infrastructure, increase digitalisation and data collection, integrate recharging and electricity infrastructure, adapt the legal system and develop infrastructure for heavy-duty vehicles.

The National Centre for Charging Infrastructure (NLL) is responsible for coordinating the deployment of recharging infrastructure.[44] This organisation, which has around 50 employees, is part of the federally-owned company NOW GmbH and works on behalf of the Federal Ministry for Digital and Transport. As part of its mission, it coordinates and manages activities in five different areas: information and network, analysis, planning, support and funding, and technology. Among other things, they provide support for the implementation and financing of recharging infrastructure. As part of this mission, they actively collect relevant data and information to better understand the need for recharging pools and provide digital tools to improve planning and monitoring.

Germany's deployment of recharging infrastructure is based on three key principles. Firstly, the recharging infrastructure must be built nationwide, and in advance, where users expect it to be. Secondly, recharging infrastructure must be demand-driven, meaning that the number of recharging points and their capacity must meet the needs of today and the near future. Last but not least, recharging infrastructure must be user-friendly and accessible, with transparent pricing models.

While many of the current aid programmes expire in 2025/2026, there is already a shift from broad aid programmes to more targeted aid. However, the need for aid is expected to diminish after 2025/2026.

The Netherlands

The Netherlands has one of the densest networks of recharging pools in the world and the most publicly accessible recharging points in Europe.[45] In the Dutch tradition, there is a governance system that focuses heavily on collaboration between public and private stakeholders. The National Agenda for Recharging Infrastructure (NAL) brings together a number of stakeholders, including network operators and the National Knowledge Platform for Recharging Infrastructure (NKL). These stakeholders have agreed on a number of measures for the coming years: how regions and municipalities will work together to place recharging points on public land, standards for data collection and price transparency, conditions for smart recharging management and a roadmap for recharging infrastructure for heavy transport[46].

As part of the interim reporting of this assignment, WSP interviewed a representative of Rijkswaterstaat.[47] It emerged that one key to success is that the Netherlands started early, with an initial network of 1,000 recharging pools more than ten years ago. Since that time, deployment has been dynamic thanks to various aid schemes for recharging infrastructure as well as battery electric vehicles, and the active role played by municipalities.

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[44] National Centre for Charging Infrastructure, retrieved 30 Sept. 2023, Nationale Leitstelle Ladeinfrastruktur | für E-Mobilität in Deutschland (nationale-leitstelle.de).

[45] EU Commission, "European Alternative Fuels Observatory", *Country Comparison,* retrieved 30 September 2023, Country comparison | European Alternative Fuels Observatory (europa.eu).

[46] Dutch National Charging Infrastructure Agenda (2023), *Dutch National Charging Infrastructure Agenda Brochure.*

[47] WSP (2023), *Underlag till handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ref 2022-11266.

Today, the level of aid for the purchase of battery electric vehicles is relatively low, but the pace of the transition remains high thanks to effective recharging facilities and the growth of the electric car market. One recommendation that was highlighted is to ensure interoperability, so that publicly accessible recharging points can be easily used by all users. This has been a major focus in the Netherlands, which has supported technical standards and applied interoperability requirements in its aid programmes. Roaming protocols were adopted over a decade ago, allowing drivers to charge wherever they want with one card or app, rather than multiple cards, as required in many other countries.

The interview showed that the three main bottlenecks in the Netherlands have been limited land availability, lack of electricity grid capacity and lack of technical and administrative staff to build infrastructure. Regarding the timeline, aid for recharging infrastructure is needed at least until 2030 and especially for heavy-duty battery electric vehicles. A very rapid uptake of electric trucks is expected as soon as they are economically viable, which is predicted to occur between 2025 and 2030 for all types of heavy-duty vehicles.

Perhaps most interesting is the country's strong focus on publicly accessible, on-street recharging and the aid programme for recharging points in multi-owner, multi-dwelling blocks. Publicly accessible on-street recharging is procured by municipalities based on demand, and such infrastructure no longer requires financial aid, only provision of public land. The aid programme for multi-dwelling blocks provides aid for costs related to consultancy fees for advice.

Norway

In Norway, Enova, Statens vegvesen and Nye Veier AS are designated to collaborate in the deployment of recharging infrastructure.

Enova's role is to support the green transition, and it has long been the government's most important instrument for supporting the establishment of publicly accessible recharging infrastructure for light-duty vehicles. Enova monitors developments in the area of recharging infrastructure and adapts its funding programme calls to aid construction of the necessary recharging infrastructure.

Statens vegvesen has overall responsibility for the road sector, including responsibility for national and European roads, road-users and vehicles. Statens vegvesen develops regulations and standards for efficient transport and modern road construction. The agency's work on recharging infrastructure is mainly linked to lay-bys and parking spaces along the national road network[48].

Nye Veier is wholly owned by the Norwegian government and has produced data on technical requirements as well as locating recharging infrastructure along roads.

Norway launched its national recharging infrastructure strategy in late 2022. This strategy will contribute to the continued development of more user-friendly recharging infrastructure for the passenger car fleet, promote electrification of heavy-duty traffic, ensure fit-for-purpose frameworks for land use and facilitate access to grid capacity. The strategy includes 18 proposals in the areas of: the electricity system, access to land, cooperation among Enova, Statens vegvesen and Nye Veier, and user-friendliness.[49]

[48] Statens vegvesen (2020), *Strategidokument: Ny rasteplasstrategi på riksvei.*

[49] Samferdselsdepartementet, *Nasjonal ladestrategi (2022)*, N-0582 B.

In addition to Enova's national aid system, numerous municipal and regional systems provide aid for recharging infrastructure. In 2023, Enova has no funds allocated to subsidise publicly accessible recharging infrastructure for passenger cars, but funding is available for publicly accessible recharging infrastructure for heavy-duty vehicles, depot recharging and chargers for goods transport.

3.4.2 Hydrogen refuelling infrastructure in the US and Germany

The hydrogen strategies or national energy and climate plans of some EU countries include specific targets for hydrogen refuelling stations and vehicles. Examples of such targets:

- Bulgaria: Target of 32 GWh for hydrogen-powered vehicles and hydrogen refuelling stations with a total installed capacity of 20 MW by 2030.
- France: Target of 100 hydrogen refuelling stations in operation by 2023 and 400 to 1,000 hydrogen refuelling stations by 2028.
- The Netherlands: Target of 50 refuelling stations, 15,000 fuel cell vehicles and 3,000 heavy-duty vehicles in operation by 2025 and 300,000 fuel cell vehicles in operation by 2030.
- Poland: at least 32 hydrogen refuelling stations in operation by 2025.
- Portugal: Target of 50 to 100 hydrogen refuelling stations, minimum 150 to 200 hydrogen buses and 5,000 to 7,500 light- and heavy-duty vehicles by 2023.
- Other EU countries, such as Austria, the Czech Republic and Luxembourg, mention hydrogen use in the transport sector without setting any specific targets for refuelling stations and hydrogen vehicles.

On behalf of the Swedish Energy Agency, WSP[50] has studied Germany and the US in greater detail, as these can be seen as good examples.

USA

The US has a national strategy and roadmap for hydrogen[51], and hydrogen is part of the U.S. National Clean Hydrogen Strategy and Roadmap[52]. Three main objectives are set out in the national strategy:

- Use hydrogen in the areas where it is most beneficial and other options are limited.
- Reduce the cost of renewable hydrogen.
- Focus on regional networks and clusters with production close to the end user.

By September 2023, there were 66 public hydrogen refuelling stations in the US[53]. Fifty additional stations are in various stages of planning or construction. Most of the existing and planned stations are in California, with one in Hawaii and five planned in the Northeast.

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[50] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[51] United States Department of Agriculture (USDA) (2023) *U.S National Clean Hydrogen Strategy and Roadmap.*

[52] Berube, Wishnia, Simon and Pelosi (2023) *U.S. National Clean Hydrogen Strategy and Roadmap,* DOE/EE-2674.

[53] U.S Department of Energy, "Energy Efficiency and Renewable Energy", *Alternative Fuels Data Center,* retrieved 30 Sept. 2023, https://afdc.energy.gov/stations/states?count=public&include_temporarily_unavailable=true

Access to hydrogen refuelling stations providing reasonably priced hydrogen where vehicles are used remains a challenge for deployment of the technology.

One of California's success factors has been reducing the time between issuing calls for grants and completion of hydrogen refuelling stations from 1,500 days (in 2009) to 500 days in 2019, partly as a result of expedited permitting processes. In addition, each city and county office will soon have a checklist to follow when processing permits for hydrogen refuelling stations.[54]

In the US, investment aid for alternative fuelling stations is available under the Inflation Reduction Act (IRA) with a 30 percent tax credit up to $100,000 if the stations are in use by 2033. There is also aid for the purchase of hydrogen vehicles under 6.35 tonnes, with $7,500 in tax credits and $40,000 in tax credits for heavier vehicles. The construction of factories producing fuel cell vehicles, hydrogen infrastructure, electrolysers, etc., can be subsidised by 30 percent tax credits. The IRA also includes investment aid for energy storage, including hydrogen storage.[55]

Germany

Germany launched a national hydrogen strategy in June 2020.[56]

The strategy includes the following points:

- Establish hydrogen produced from renewable energy sources.
- Create a domestic market for hydrogen by scaling up hydrogen production capacity and developing related technologies.
- Establish a regulatory framework for the development and expansion of hydrogen transport and distribution infrastructure.
- Strengthen the competitiveness of German companies by promoting use, R&D and export of hydrogen technologies.
- Promote international cooperation to ensure future access to renewable hydrogen.

Germany has just over 100 hydrogen refuelling stations as of September 2023[57]. Most hydrogen refuelling stations are located on the corridor connecting Stuttgart, Frankfurt am Main and Dortmund[58].

In Germany, relevant public authorities have managed to speed up permitting processes by using standards for specific technologies and applying them to other similar technologies. Furthermore, German authorities have developed specific regulations for the hydrogen network to facilitate the deployment of the hydrogen infrastructure.[59]

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[54] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[55] Ibid.

[56] The Federal Government, *The National Hydrogen Strategy,* retrieved 30 Sept., https://www.bmwk.de/Redaktion/EN/Hydrogen/Dossiers/national-hydrogen-strategy.html

[57] H2Stations" Statistics: Hydrogen Infrastructure", *Development of H2 refuelling infrastructure in selected European countries,* retrieved 30 Sept. 2023, https://www.h2stations.org/statistics/

[58] H2Station, *Filling up with H2 – Hydrogen mobility starts now*, retrieved 30 Sept 2023, Refuelling hydrogen in Germany & Europe – H2.LIVE.

[59] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

In 2022, Germany published guidelines which all market participants must follow, simplifying the permitting process. According to H2 Mobility (Germany's largest project developer of hydrogen stations), problems persist despite the guidelines, with varying regulations and preferences among regions.[60]

In Germany, aid for up to 80 percent of investment costs is granted to hydrogen refuelling stations that: provide hydrogen produced with 100 percent renewable energy, have a minimum capacity of 2,000 kg/day, dispense 700 bar of pressure, are located along the Trans-European Transport Network and are fit-for-purpose for both light- and heavy-duty vehicles. This aid is part of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP). In Germany, companies can also obtain investment aid for the purchase of both light- and heavy-duty hydrogen vehicles. Such aid represents 80 percent of the additional costs compared to conventional diesel vehicles. Hydrogen-powered vehicles may also benefit from reduced customs duties. Germany has not provided aid for the production of hydrogen in general or of green hydrogen specifically.[61]

[60] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[61] Ibid.

4 EU regulatory frameworks and national instruments impacting electrification of road transport

On 14 July 2021, the European Commission presented several legislative proposals aimed at achieving climate neutrality in the EU by 2050, including the intermediate target of a net reduction of at least 55 percent in greenhouse gas emissions by 2030, the so-called Fit for 55 package. The Fit for 55 package proposes a review of several aspects of EU climate legislation, including the EU Emissions Trading Scheme, the effort sharing regulation, and transport and land use legislation, setting out in real terms how the Commission intends to achieve the EU's climate goals under the European Green Deal. In addition, a number of other important regulations in this area have been amended. For example, the Commission recently proposed amendments to the regulatory framework on maximum authorised weights for trucks, which would allow battery-powered trucks to weigh more without any reduction in payload capacity[62].

This chapter describes the EU regulations with the greatest impact on recharging and hydrogen refuelling infrastructure and the development of the vehicle fleet. It does not aim to comprehensively describe all EU regulations affecting the road transport sector.

4.1 Regulatory framework for deployment of alternative fuel infrastructure

The Regulation on deployment of alternative fuels infrastructure (AFIR)[63] requires deployment of recharging pools and refuelling stations for hydrogen. There are also requirements regarding price information and payment models to facilitate end users. Member States must produce national policy frameworks and progress reports at regular intervals. The Commission has also been tasked with developing standards and the market readiness report related to heavy-duty vehicles as well as establishing a European access point[64] for information on recharging pools and refuelling stations for alternative fuels.

AFIR lays down mandatory minimum targets for deployment. Member States must ensure that deployment is at least equivalent to the requirements. Therefore, all requirements described in the report are 'at minimum'.

[62] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Council Directive 96/53/EC on the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic for certain road vehicles circulating within the Community COM/2023/445 final

[63] Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU

[64] This entails a single point of access to facilitate the work of information service providers. The access point may contain metadata or be a database where the information is stored. Often, the access point is accessed via a website

AFIR, replacing the current Directive (AFID), takes the form of a regulation and is directly binding on all EU Member States. There is a lead time for bringing national legislation into conformity with AFIR. Most of the requirements of AFIR are imposed on the Government. However, it is not intended that the State will build, own and operate such infrastructure; markets are to be created.

The AFIR requirements are very much based on the TEN-T framework[65] and its nomenclature, e.g., core network, comprehensive network, urban nodes[66] and safe and secure parking areas. Figure 7 shows the TEN-T core network, with bold red lines, and the comprehensive network in thinner red lines. Urban nodes are marked with red (existing urban nodes) or blue (future urban nodes) dots. The total length of the TEN-T core network in Sweden is approximately 6,400 km, of which 3,000 km constitutes the core network and the rest is the comprehensive network. There are currently three urban nodes, but under the proposal currently being negotiated for the new TEN-T Regulation, these will grow to 18.

Figure 7. TEN-T road network and urban nodes. Bold red lines indicate the TEN-T core network and thinner red lines indicate the TEN-T comprehensive network. Red dots indicate existing urban nodes and blue dots indicate future urban nodes.

[65] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Union guidelines for the development of the trans-European transport network, amending Regulation (EU) 2021/1153 and Regulation (EU) No 913/2010 and repealing Regulation (EU) 1315/2013, COM/2021/812 final

[66] Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU

4.1.1 Recharging pools for light-duty vehicles

The deployment of recharging pools for light-duty vehicles is subject to two separate requirements under AFIR: deployment along the TEN-T road network and general deployment of publicly accessible recharging in proportion to the number of plug-in vehicles nationwide.

Recharging pools along the TEN-T road network

Along the TEN-T road network, which is defined as within three km of the road, recharging pools must be constructed at intervals of no more than 60 km and with specific capacity requirements. The initial phases must be complete by the end of 2025, and the entire TEN-T road network must be covered by 2030. Table 2 shows the different stages for the core and comprehensive networks.

Table 2. Requirements for light-duty vehicle recharging pools along the TEN-T road network.

Road network	Year	Maximum distance between recharging pools (km)	Total capacity per recharging pool and direction of travel (kW)	Recharging point requirements per direction of travel (kW)
Core network	2025	60	400	1×150
	2027	60	600	2×150
Comprehensive network	2027	60 for 50 % of road network	300	1×150
	2030	60	300	1×150
	2035	60	600	2×150

For a recharging pool to be counted, it must meet all the requirements. The relationship between recharging points, recharging stations and recharging pools is illustrated in Figure 8.

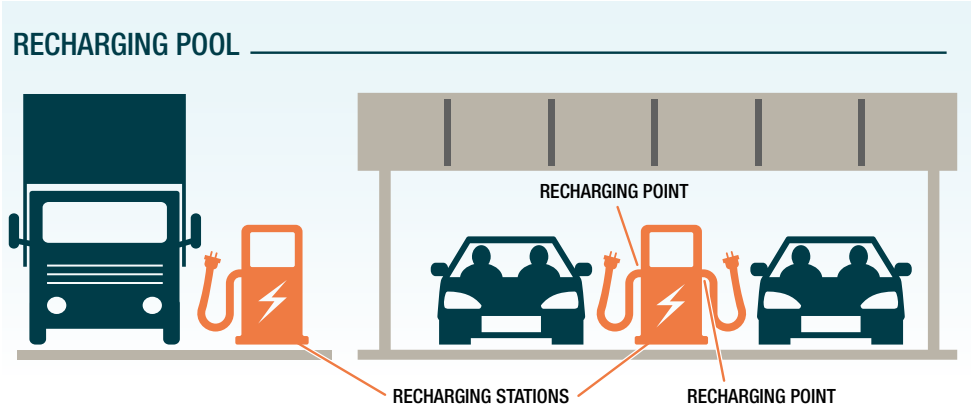

Figure 8. Illustration of recharging point, recharging station and recharging pool.

According to AFIR, the recharging point is the interface where one vehicle at a time can be charged while a recharging station refers to a physical installation consisting of one or more recharging points. A recharging pool consists of one or more recharging stations at a specific location. These definitions differ slightly from those commonly used in Sweden. The main difference is that AFIR has defined three different levels, while Sweden usually uses two. AFIR's definition of a recharging station is basically the pole where the recharging

point is mounted. If the recharging pool does not fulfil all requirements on proximity to the next recharging pool, total recharging capacity or the number of individual recharging points with a specific capacity, no part of the recharging pool counts towards the fulfilment of the requirements.

Exceptions to the requirements

There are two exceptions to the requirements for recharging pools along the TEN-T. In the event of low traffic volumes, Member States may reduce the size of the recharging pool compared to the requirements in Table 2. In such cases, the total power of recharging pools can be reduced by up to 50 percent.

Low traffic volumes are defined as less than 8,500 AADT[67] for light-duty vehicles. In Sweden, this corresponds to about half the length of the TEN-T road network but only about 15 percent of vehicle mileage on the TEN-T.

The second exception concerns the distance between two recharging pools. In the event of very low traffic volumes, Member States may increase the maximum distance between two recharging pools from 60 to 100 km. Very low traffic volumes are defined as less than 3,000 AADT for light-duty vehicles. This represents about 30 percent of the TEN-T road network and three percent of vehicle mileage.

Publicly accessible recharging in relation to the number of rechargeable cars

To ensure sufficient access to publicly accessible recharging for light-duty vehicles, AFIR imposes a general capacity requirement. This requirement is stated as 1.3 kW per electric car and 0.8 kW per plug-in hybrid. The requirement is also combined with a possibility for Member States to renegotiate or even ignore the requirement if the share of electric cars constitutes at least 15 percent of the total light-duty vehicle fleet. For Sweden, this requirement entails the greatest impact on the extent of deployment of recharging infrastructure, calculated in kW. For countries with relatively few battery electric vehicles, the requirements along the TEN-T will have a greater initial impact, as these requirements are independent of the number of plug-in vehicles in the country.

4.1.2 Recharging pools for heavy-duty vehicles

The requirements for heavy-duty vehicles include more individual elements than the requirements for light-duty vehicles, although no requirements are imposed on the fleet of electric heavy-duty vehicles. There are requirements for recharging pools along TEN-T, in safe and secure parking areas and in urban nodes.

Recharging pools along the TEN-T road network

The requirements for recharging pools will be phased in starting 2025 and achieve full deployment in 2030. At full deployment, there should be one 3.6 MW recharging pool in each direction of travel with a maximum distance of 60 km between them along the TEN-T core network, and one 1.5 MW recharging pool in each direction of travel every 100 km along the TEN-T comprehensive network. The increasing requirements from 2025 to 2030 are shown in Table 3.

[67] AADT = Annual average daily traffic.

Table 3. Requirements for recharging pools for heavy-duty vehicles along the TEN-T road network.

Road network	Year	Maximum distance between recharging pools (km)	Total capacity per recharging pool and direction of travel (kW)	Recharging point requirements per direction of travel (kW)
Core network	2025	120 for 15 % of TEN-T	1,400	1×350
	2027	120 for 50 % of TEN-T	2,800	2×350
	2030	60	3,600	2×350
Comprehensive network	2025	120 for 15 % of TEN-T	1,400	1×350
	2027	120 for 50 % of TEN-T	1,400	1×350
	2030	100	1,500	2×350

For the years 2025 and 2027, the requirements are the same for both the TEN-T core network and the TEN-T comprehensive network. This should be interpreted to grant Member States the right to decide how to allocate the requirement between the two road networks. It is possible to place all recharging pools on the core network, as long as the length of the road network equipped with recharging pools is at least 15 percent of the length of the entire TEN-T core network.

In practice, the requirements mean that a slightly sparser network of publicly accessible recharging pools can initially be built on parts of the TEN-T road network. Over time, an increasing amount of the road network is covered, so that by 2030 the distance between two recharging points is never more than 60 km on the TEN-T core network or 100 km on the TEN-T comprehensive network, throughout the EU.

Exceptions to the requirements

For road sections that have low traffic flows, defined as less than 2,000 AADT heavy traffic, the requirements for total capacity per recharging pool may be halved. In Sweden, this corresponds to about 70 percent of the length of the TEN-T road network and one third of the traffic on this road network. The requirements for the number of recharging points with at least 350 kW are not affected. In the event of very low traffic flows, defined as less than 800 AADT heavy traffic, the distance between recharging pools can be increased from 60 to 100 km on the core network. In Sweden, few routes are impacted by this, but one example is E10 in Norrbotten.

Recharging stations in safe and secure parking areas

In addition to the requirements along the TEN-T, recharging stations must also be built in safe and secure parking areas.

A safe and secure parking area is an area accessible to drivers engaged in the carriage of goods or passengers which has been certified in accordance with Commission Delegated Regulation (EU) 2022/1012. By 2027, there must be at least 200 kW of power per safe and secure parking place, and this must increase to at least 400 kW by 2030.

Recharging points in urban nodes

For heavy-duty vehicles, recharging will also be deployed in urban nodes. By 2025, there must be recharging points with a total output of at least 900 kW per urban node, and this must increase to 1,800 kW by 2030. If the recharging points in the urban nodes are within three km of the TEN-T road network, they can be included in the requirement along the TEN-T road network.

Recharging pools along the TEN-T which are located within an urban node count towards the requirements for the urban node.

4.1.3 Hydrogen refuelling stations

This requirement applies to both light- and heavy-duty vehicles. There must be hydrogen refuelling stations designed for a capacity of at least one tonne/day every 200 km along the TEN-T core network by 2030. These must be able to dispense pressurised hydrogen up to 700 bar. Member States must develop a plan to ensure a linear increase in the number of hydrogen refuelling stations from 2027. In addition to hydrogen refuelling stations to be located along the TEN-T, defined as within ten km of the TEN-T road network, there must also be a refuelling station at each urban node. In some cases, the requirement for refuelling stations along the TEN-T and in urban nodes may overlap or complement each other.

4.1.4 Other requirements for recharging pools and hydrogen refuelling stations

AFIR states that recharging must be easy. For example, at recharging points with outputs of 50 kW and above, it must be possible to pay by regular payment card. This also applies to existing publicly accessible recharging points located along the TEN-T road network and in safe and secure parking areas. One card reader can serve several recharging points within a recharging pool. All publicly accessible recharging points must be digitally connected, and recharging points installed after 13 April 2024 or renovated after 14 October 2024 must provide smart recharging (power regulation). The requirement for digitally-connected recharging points applies regardless of the power of the recharging point or when it was built.

At publicly accessible recharging points with a power output equal to or more than 50 kW, the ad hoc price must be based on the price per kWh. In addition, the operators of those recharging points can charge an occupancy fee as a price per minute to discourage long occupancy of the recharging point. The latter can be used to price parking after recharging has ended. For recharging points below 50 kW, the recharging operator can use different price models, such as price per kWh, price per minute, price per session or any other model, provided this information is clearly and easily available.

For hydrogen refuelling stations, the price shall be charged per kg of hydrogen. Payment by card reader must also be possible for hydrogen. These requirements apply to both existing and newly built refuelling stations.

National policy framework and reporting

Member States shall draw up national policy frameworks including specific information, such as:

- An assessment of the current situation and future development of the market for alternative fuels in the transport sector,
- National objectives and targets for recharging pools and hydrogen refuelling stations,
- Measures necessary to ensure that the objectives and targets of the national policy framework are achieved,
- Measures, planned or adopted,
  - for alternative fuel infrastructure for specific fleets, e.g., public transport or car sharing,
  - to facilitate recharging of road vehicles in non-public places,
  - to promote alternative fuels infrastructure in urban nodes,
  - to promote a sufficient number of high-power publicly accessible recharging points,
  - to ensure a sufficient geographical spread of recharging points capable of bi-directional charging,
  - to ensure that recharging points and refuelling stations for alternative fuels are accessible to elderly people, persons with reduced mobility and persons with disabilities,
  - to remove barriers with regard to planning, permitting, procuring and operating of alternative fuels infrastructure.

The policy framework may also include national objectives and targets for the promotion of alternative fuels infrastructure along the non-TEN-T road network, geographical distribution and adaptation to population density.

Every two years, Member States must submit a report to the Commission describing the progress of the implementation of the national policy framework. Member States must also report certain data on an annual basis, such as total recharging power, number of publicly accessible recharging points and number of electric cars and plug-in hybrids in the country.

The Commission will develop guidelines and templates for the policy framework and reporting.

Preparation and publication of data

The Government must establish an Identification Registration Organisation ('IDRO') for managing unique identification ID codes for recharging points. The IDRO must issue and manage unique identification ('ID') codes to identify, as a minimum, operators of recharging points and mobility service providers.

Furthermore, operators of recharging points and refuelling stations for alternative fuels shall provide certain static and dynamic data via the national access point[68]. Such data may include physical characteristics, opening hours, operational status, whether the point is used or not, prices and whether it uses renewable electricity.

Most of the data requested in AFIR are likely missing from both databases and/or communication standards at present. This will be clarified at EU level, including through delegated acts.

[68] A digital interface set up by a Member State that constitutes a single point of access to data.

Technical specifications

A key element of AFIR is the ability to refuel or recharge vehicles anywhere along the Union's TEN-T road network. Common technical standards will be required to make this possible. In some areas, not least stationary charging, several established technical specifications are in place and must be used to fulfil the requirements of AFIR. These mandatory standards are described in Table 4.

Table 4. Prescribed standards for publicly accessible recharging points according to AFIR.

Type of recharging	Mandatory standard
Light- and heavy-duty vehicles	
Normal AC	Type 2, EN 62196-2:2017
Normal DC	Combo 2, EN 62196-3:2014
Fast AC	Type 2, EN62196-2:2017
Fast DC	Combo 2, EN 62196-3:2014
Motorcycle (category L)	
Up to 3.7 kW	Type 3A, EN 62196-2:2017 or (Mode 3) IEC 60884-1:2002-A1:2006+A2:2013 (Mode 1 or 2)
Buses	
Normal AC	Type 2, EN 62196-2:2017
Normal DC	Combo 2, EN 62196-3:2014
Fast AC	Type 2, EN 62196-2:2017
Fast DC	Combo 2, EN 62196-3:2014

According to AFIR, these standards must be used for each recharging point, but adding other connectors as a supplement to the same recharging point is permitted.

The Commission will request European standardisation organisations to draft European standards setting technical specifications. These include wireless recharging, automated recharging for heavy-duty vehicles, dynamic recharging, battery swapping, hydrogen refuelling, data exchange and accessibility requirements.

4.1.5 Revision of the Regulation

Before the end of 2024, the Commission will produce a report on technical and market readiness for heavy-duty vehicles. This report must specifically address whether there is any indication of market preference. The report will take into account the development of standards for high-power charging[69], electric roads and liquid hydrogen. By 31 December 2026, the Commission will evaluate AFIR and send a report including any suggested revisions to the regulatory framework.

4.1.6 Entry into force

Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure shall apply from 13 April 2024.

[69] Megawatt Charging System (MCS).

4.2 Energy Performance of Buildings Directive

The aim of the current Energy Performance of Buildings Directive (EPBD)[70] is to promote energy performance in buildings while taking into account indoor climate requirements and cost-effectiveness. In Sweden, this directive has been implemented through changes to the Swedish building code.

Since 15 May 2020, recharging of battery electric vehicles is a new characteristic requirement in the Planning and Building Act (PBL). The Planning and Building Ordinance (PBF) will specify which buildings are to be equipped with wiring infrastructure and recharging points.[71]

When constructing new buildings or renovating existing building, residential blocks with a car park of more than ten spaces in the building or on the plot must be equipped with wiring infrastructure (empty pipes, etc., as a preparatory measure) for recharging battery electric vehicles in all spaces. For car parks with more than ten spaces located in or on the plot of non-residential buildings, wiring infrastructure for 20 percent of parking spaces and at least one recharging point are required. These rules also apply to the renovation of buildings.[72]

In existing buildings, car parks with more than twenty spaces located in or on the plot of non-residential buildings must, as of 1 January 2025, be equipped with at least one recharging point for battery electric vehicles. For residential blocks, there are no changes in 2025.[73]

A revision of the EPBD is currently being negotiated. The requirement to prepare and install recharging infrastructure in car parks in and near buildings is expected to increase, complementing the updated regulation on alternative fuels infrastructure.[74,75,76]

The Commission's proposal for a revised Directive makes pre-installed wiring the norm for most new buildings and some buildings undergoing major renovations, as well as reinforcing the deployment of recharging points in new and renovated office buildings specifically. Recharging points are proposed to enable smart charging, and Member States are to remove obstacles to the installation of recharging points in residential buildings and ensure a 'right to plug', entailing a strengthened right for those currently without the right (e.g., residents of housing cooperatives or rented accommodation) to install home recharging points.[77]

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[70] DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast Dec. 2018)

[71] Swedish National Board of Housing, Building and Planning , "PBL Kunskapsbanken – en handbok om plan- och bygglagen", *Regler för laddning av elfordon,* reviewed 10 May 2023, retrieved 30 Sept. 2023, https://www.boverket.se/sv/PBL-kunskapsbanken/regler-om-byggande/laddning-av-elfordon/

[72] Ibid.

[73] Ibid.

[74] Commission proposal for a European Parliament and Council Directive on the energy performance of buildings (recast) COM/2021/802 final

[75] Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM (2021) 802 final

[76] Ibid.

[77] Commission proposal for a European Parliament and Council Directive on the energy performance of buildings (recast) COM/2021/802 final

4.3 Directive on the promotion of clean and energy-efficient road transport vehicles

Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles as amended by (EU) 2019/1161 sets public procurement requirements for road vehicles. This applies to both private vehicles and services using vehicles.

The Directive requires Member States to ensure that contracts awarded following the procurement of vehicles and certain services, including public transport, meet a minimum proportion of clean and energy-efficient road transport vehicles, known as minimum targets.

4.4 Regulatory framework on emission standards for new vehicles

On 19 April 2023, the EU updated Regulation 2019/631 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles (EU 2023/851)[78]. This update includes a stepwise reduction of CO_2 emissions to eliminate 100 percent of CO_2 emissions by 2035. Carbon-neutral fuels can be used after 2035.

Corresponding requirements for heavy-duty vehicles are included in Regulation (EU) 2019/1242, but a proposed update is currently under negotiation[79]. Compared to 2019 emission levels, a gradual reduction of up to 90 percent of CO_2 emissions is proposed through 2040 for heavy-duty vehicles.

4.5 Directive on common rules for the internal markets in renewable gases and hydrogen and Regulation on the internal markets for renewable and natural gases and for hydrogen

This is a proposed legislative package, including a Directive and a Regulation, which is currently under negotiation in the EU: COM 2021 (803) Directive and COM 2021 (804) Regulation[80]. The overall aim of the proposals is to rapidly increase the use of renewable and low-carbon gases in the energy system while reducing the use of natural gas. There are specific targets for hydrogen which include facilitating new hydrogen infrastructure and a new hydrogen market. The Commission proposes a new regulatory framework for transport, supply and storage in the hydrogen network. The Directive also reviews security of supply.

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[78] Regulation (EU) 2023/851 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition

[79] Regulation of the European Parliament and of the Council amending Regulation (EU) 2019/1242 as regards strengthening the CO_2 emission performance standards for new heavy-duty vehicles and integrating reporting obligations, and repealing Regulation (EU) 2018/956

[80] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal markets in renewable and natural gases and in hydrogen COM/2021/803 final

4.6 Renewable Energy Directive (RED III)

The Renewable Energy Directive (RED III) was adopted on 9 October 2023.[81] The next step is publication in the EU Official Journal, 20 days after which the Directive enters into force. Member States then have 18 months to implement the directive in national law.

The new version of the Renewable Energy Directive[82], RED III, introduces requirements on Member States related to plug-in vehicles and recharging infrastructure.

Article 20a(1) deals with information regarding the share of renewable electricity and the greenhouse gas content of electricity supplied in bidding zones or local networks to enable, for example, operators of recharging points to pass on this information.

Article 20a(3) describes that Member States shall take measures requiring vehicle manufacturers to enable real-time access to basic battery management system (BMS) information, and, where appropriate, the location of cars. This is to make the information available free of charge to electricity market participants and, e.g., electromobility service providers in a secure way.

According to Article 20a(4), Member States shall ensure that new and replaced non-publicly accessible normal recharging points can support smart recharging functionalities and, where appropriate, interface with smart metering systems and bi-directional recharging functionalities

Article 20a(5) requires Member States to have systems in place to enable small electricity system operators to participate in the electricity market. Article 22a sets out an objective for a strategy to increase industrial use of renewable energy and support the production of renewable hydrogen in the EU.

The Commission Delegated Regulation 2023/1184[83] includes the definition of renewable electricity for the production of green hydrogen and further production of renewable fuels of non-biological origin (RFNBO).

4.7 State aid rules and the Block Exemption Regulation

The possibility of granting aid is largely governed by the EU State aid rules, Council Regulation (EU) 2015/1588, and, according to Article 1, the European Commission may adopt so-called block exemption regulations for State aid under certain conditions.

The General Block Exemption Regulation (GBER) is a regulation adopted by the Commission under the authorisation of the Council. GBER makes specific categories of State aid compatible with the Treaty on the Functioning of the European Union (TFEU) if they fulfil certain conditions, thereby exempting such aid from the standstill rule in article 108(3) TFEU. According to Article 59 of GBER, the Regulation is binding in its entirety and directly applicable in all Member States.

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[81] European Council (2023), *Renewable energy: Council adopts new rules* , retrieved 28 Oct. 2023, https://www.consilium.europa.eu/en/press/press-releases/2023/10/09/renewable-energy-council-adopts-new-rules/

[82] European Parliament and the Council (2023), *Directive of the European Parliament and of the council amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652.* 2021/0218 (COD)/ PE-CONS 36/23

[83] Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin

Evolution of GBER

The current Regulation (651/2014) was previously amended by Regulations (2017/1084) and (2021/1237). Of particular interest in this context is Article 36a, on investment aid for publicly accessible infrastructure for recharging or refuelling zero- and low-emission road vehicles, introduced in 2021.

In June 2023, the European Commission amended the General Block Exemption Regulation (GBER), extending it and expanding aid possibilities (2023/1315).[84] Aid for certain purposes can be granted under the conditions of the GBER without prior authorisation by the Commission. The new rules include new provisions on aid for broadband and recharging infrastructure for battery electric vehicles.

One change is the recasting of Article 36a, which was renamed Investment aid for recharging or refuelling infrastructure. At the same time, Article 36b was introduced: Investment aid for the acquisition of clean or zero-emission vehicles and for the retrofitting of vehicles.

Article 36a Investment aid for recharging or refuelling infrastructure

The main features of the Article are:

- New possibility to subsidise investment costs for on-site production of renewable electricity or renewable hydrogen or the investment costs of storage units for renewable electricity or hydrogen. The nominal production capacity of the on-site renewable electricity or renewable hydrogen production facility shall not exceed the maximum rated output or refuelling capacity of the recharging or refuelling infrastructure to which it is connected.
- New possibility to subsidise the upgrade of existing recharging pools and hydrogen refuelling stations.
- Some new conditions for funding and calls for proposals, including publication of aid criteria at least six weeks before the deadline for applications. At least 70 percent of the selection criteria must be based on costs.
- Possibility of forgoing a competitive bidding process with maximum aid intensities of 20 percent, 40 percent and 50 percent for large, medium and small enterprises respectively.
- The previous condition for public accessibility of recharging infrastructure has been removed, permitting the possibility of subsidising non-publicly available recharging. There are conditions regarding universal accessibility of recharging points, e.g., equal treatment of payment options, fees, etc.

4.8 National instruments

Several national instruments and measures are aimed at contributing to electrification of the vehicle fleet. The measures target vehicles, fuels and infrastructure. This section summarises the measures that impact the electrification of road transport. It includes a table describing the national instruments. More detailed descriptions can be found in the interim report of February 2023[85]. Adjustments made since that time including limiting the electric bus

[84] COMMISSION REGULATION (EU) 2023/1315 of 23 June 2023 amending Regulation (EU) No 651/2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty and Regulation (EU) 2022/2473 declaring certain categories of aid to undertakings active in the production, processing and marketing of fishery and aquaculture products compatible with the internal market in application of Articles 107 and 108 of the Treaty

[85] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas* , ER 2023:06

premium to class II and III buses, limiting the low-emission zone to low-emission zone 3, addition of *Förordning (2020:486) om miljö- och trafiksäkerhetskrav för myndigheters bilar* for public procurement and addition of the reduction mandate.

Instruments for plug-in vehicles and hydrogen vehicles

Table 5 summarises national instruments impacting plug-in vehicles.

Table 5. Instruments impacting plug-in vehicles

Name	Focus of the instrument	Responsible authority
Electric bus premiums	Aid for the purchase of electric buses (Class II and III)	Swedish Energy Agency
Climate premiums	State aid for the purchase of clean and energy-efficient trucks and electric/clean and energy-efficient machinery	Swedish Energy Agency
CO_2-based vehicle tax	Vehicle tax differentiated according to CO_2 emissions per km.	Swedish Tax Agency
Malus	High-emission vehicles are subject to a higher vehicle tax (malus) for the first three years after the vehicle first becomes taxable	Swedish Tax Agency
Reduced benefit value	Green electric or non-fossil fuel vehicles receive reduced valuation for benefit taxation.	Swedish Tax Agency
Lower vehicle tax for heavy-duty vehicles	Hybrid buses as well as buses and trucks-running on, e.g., electricity, ethanol or gas, instead of diesel pay only the minimum tax level of SEK 984 per year	Swedish Tax Agency
Public procurement	Requirements for public procurement of passenger transport, freight transport, fuel, tyres, public transport and vehicles[86] as well as environmental and road safety requirements for public authority vehicles[87]	National Agency for Public Procurement
Fuel tax	Fuel used for transport is generally taxed with a combined energy and carbon tax.	Swedish Tax Agency
Reduction mandate	Instrument to reduce life-cycle emissions from petrol and diesel by blending biofuels, which can increase fuel prices and promote the transition to electrification. The Government has adopted a bill[88] to reduce the reduction mandate to six percent for petrol and diesel in 2024–2026. The proposal removes the reduction levels for 2027–2030. The mandate to be imposed on fuel suppliers to reduce emissions in 2027–2030 should be further analysed. The amendments will enter into force on 1 January 2024.	Government Offices

[86] SFS 2011:846, *Lag (2011:846) om miljökrav vid upphandling av bilar och vissa tjänster inom vägtransportområdet.*

[87] SFS 2020:486, *Förordning (2020:486) om miljö- och trafiksäkerhetskrav för myndigheters bilar.*

[88] Govt. bill 2023/24:28. *Sänkning av reduktionsplikten för bensin och diesel.*

Policy instruments for recharging and hydrogen refuelling infrastructure

Aid and tax breaks aimed at promoting recharging and hydrogen refuelling infrastructure are summarised in Table 6.

Table 6. Summary of existing aid and tax breaks for recharging and hydrogen refuelling infrastructure

Name	Targeting of aid	Type of recharging	Responsible authority
Climate Leap initiative	Recharging infrastructure for heavy- and light-duty vehicles and hydrogen refuelling infrastructure	Publicly and non-publicly accessible recharging	Swedish Environmental Protection Agency
Regional electrification pilots	Recharging and hydrogen refuelling infrastructure for heavy-duty vehicles	Publicly accessible high-power recharging	Swedish Energy Agency
High-power recharging infrastructure along major roads	Recharging infrastructure for heavy- and light-duty vehicles	Publicly accessible high-power recharging	Swedish Transport Administration
Ladda bilen	Light-duty vehicle recharging infrastructure at co-operative housing associations, organisations and businesses. Mainly intended for residents and employees.	Non-publicly accessible recharging	Swedish Environmental Protection Agency
Tax break for green tech	Installation of recharging points for light-duty vehicles	Non-publicly accessible recharging	Swedish Tax Agency
Connecting Europe Facility[89] (CEF)	Recharging infrastructure for heavy- and light-duty vehicles	Publicly accessible recharging	Swedish Transport Administration[90]

[89] Swedish Transport Administration, ”Fonden för ett sammanlänkat Europa (CEF)”, *Ansök om bidrag från Fonden för ett sammanlänkat Europa (CEF)*, retrieved 30 September 2023, https://bransch.trafikverket.se/tjanster/ansok-om/ansok-om-bidrag/finansiering/

[90] The Swedish Transport Administration manages CEF applications in transport for Sweden. However, not all approved applications have passed through the Swedish Transport Administration; some have been approved by other countries.

5 Analysis

This chapter presents conclusions and assessments from, among other things, the work packages used in this project (see Figure 1). The conclusions and assessments are also based on the interim report from February, consultancy studies carried out pursuant to the mission, previous reports, input from stakeholders and internal calculations.

The purpose of this chapter is to describe the analysis which lead to the measures proposed in the implementation programme. This chapter includes analyses of recharging infrastructure as well as hydrogen refuelling infrastructure, in distinction to the implementation programme, where proposed measures are divided among recharging infrastructure, hydrogen refuelling infrastructure and common measures. Many of the measures in the implementation programme follow the sections of this chapter, although there are some exceptions. The analysis chapter includes, e.g., sections on technological developments and the impact of behaviour as well as in-depth analysis of aid, all of which are not included as separate headings in the implementation programme. Similarly, measures from the analysis of stakeholder roles and responsibilities have been included under other headings of the implementation programme.

To summarise, the Swedish Energy Agency and the Swedish Transport Administration note that technological development is rapid, and much is being done to increase the high pace. However, measures can be taken to further accelerate the deployment of coordinated and fit-for-purpose recharging and hydrogen refuelling infrastructure.

5.1 Coordination of recharging infrastructure

Successful deployment of recharging infrastructure requires a holistic approach. Rather than individual recharging points, this involves an entire ecosystem with synergies and dependencies between several stakeholders at different levels.

Furthermore, clarity, predictability and a long-term approach to conditions and regulations are seen as contributing to, speeding up, and ensuring the success of the transition.

Increased collaboration and improved understanding and coordination among stakeholders has repeatedly been mentioned, by both private and public stakeholders, as an important prerequisite for effective and efficient deployment.

In interviews and dialogues, stakeholders from various sectors have emphasised the need for a public authority with overall coordination responsibility in the long-term for the expansion of recharging infrastructure. These stakeholders consider that unified responsibility for information, knowledge, monitoring and support would increase clarity, improve and simplify processes and likely make expansion faster and more efficient.

In the interim report of 1 February, the Swedish Energy Agency and the Swedish Transport Administration present a number of areas specifically identified as needing greater coordination.[91]

[91] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ER 2023:06.

Information and dissemination

To overcome barriers, information and knowledge about recharging and hydrogen refuelling infrastructure must reach the right target groups[92]. The coming years will bring new electrification needs in society, and many stakeholders will have completely new roles and responsibilities.

Coordinated efforts to inform and support stakeholders would facilitate and streamline the transition. Similar processes will enable quicker and simpler action by market stakeholders.

Coordinating aid

At present, State aid for investments in recharging and hydrogen refuelling infrastructure is provided by three authorities: the Swedish Environmental Protection Agency, the Swedish Transport Administration and the Swedish Energy Agency. In addition, private individuals can apply for the green tax break via the Swedish Tax Agency for the installation of a recharging point at single-family homes. In interviews, several stakeholders stated that aid remains significant in accelerating and facilitating deployment where the market alone is unable to do so. This particularly applies to the development of recharging and hydrogen refuelling infrastructure intended for heavy-duty vehicles, where deployment and market conditions are less mature.

However, grants by numerous public authorities is considered by stakeholders to be a barrier to rapid and efficient deployment. Several stakeholders suggest gathering guidelines and aid for recharging and hydrogen refuelling infrastructure under one responsible authority. This would provide clarity for those seeking aid, increase opportunities for a more uniform assessment of needs and streamline grants processes.

To make aid relevant and target it to areas where it is most useful, grants must be continuously assessed with regard to needs, infrastructure types primarily requiring aid, appropriate aid levels, geographical distribution, infrastructure requirements with regard to, e.g., data sharing, etc. Such assessment must precede each call for proposals and be continuously monitored.

In order to improve coordination and achieve more efficient grants, it is concluded that aid currently overseen by the Swedish Transport Administration, the Swedish Energy Agency and the Swedish Environmental Protection Agency should be unified within the framework of the proposed coordination responsibility. Tax break for green technologies (recharging points in single-family homes) is further processed by the Swedish Tax Agency. Coordination responsibilities should also include coordination with EU-level aid.

A transfer of aid processing must be carefully planned among the relevant public authorities, and the consequences for the deployment of recharging infrastructure must be investigated. Such a transfer must be carried out with care and over time, to ensure the pace of deployment. A gradual transfer, whereby support more urgently requiring coordination is initially transferred, may be appropriate. For example, prioritising the transfer of aid intended for heavy-duty vehicle infrastructure may be required.

[92] Swedish Energy Agency (2021), *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*, ER2021:24.

Need for reliable data and statistics

There are currently no official statistics for recharging infrastructure. The mission to carry out joint monitoring of the electrification of society includes the production of statistics and indicators related to recharging and hydrogen refuelling infrastructure for road transport.[93] The statistical work is described in greater detail in section 5.11.

Continued responsibility for producing and managing statistics and indicators on recharging infrastructure should be assigned within the framework of coordination responsibility.

Regular monitoring and reporting under, for example, the new regulation on alternative fuels infrastructure, AFIR, will also be extensive and require dedicated resources.

Take responsibility for ongoing monitoring of developments and identifying necessary changes to regulations, aid and missions

The coordination mission should also include continuous work in monitoring developments and actively highlighting, for the Government and other stakeholders, the need for amended regulations, updated aid and new missions.

Early and proactive regulatory work at EU level is also needed. This includes ensuring that national developments align with, e.g., EU directives and regulations revised under the EU's Fit for 55 package as well as being engaged at an early stage at EU level in development of new regulations.

5.1.1 Current coordination missions of the Swedish Energy Agency

Any prospective coordination mission should not be confused with the Swedish Energy Agency's current coordination mission for recharging infrastructure, which is primarily to support the Climate Leap initiative on a regional level. The latter is much smaller in scope, lacks many of the responsibilities and mandates described, and does not include grants.

In the Swedish Energy Agency's budget request for 2024, the Agency proposes that its current role as coordinator of recharging infrastructure become a new task in the Agency's terms of reference, as this role should be long-term and more extensive.

To enable national coordination of the deployment of recharging infrastructure, the Swedish Energy Agency's direct government funding would be increased by SEK 8 million as of 2024 in the 2024 Budget Bill.[94]

5.1.2 Coordination responsibility

In order to coordinate resources, increase clarity and ensure a holistic approach, the Swedish Transport Administration and the Swedish Energy Agency consider that one public authority should be appointed the main body responsible for coordinating and promoting the deployment of recharging infrastructure.

[93] The Ministry of Rural Affairs and Infrastructure (2022), U*ppdrag att genomföra en myndighetsgemensam uppföljning av samhällets elektrifiering*, ref I2022/01060.

[94] Government (2023) *Budget Bill for 2024. Govt. bill 2023/24:1.*

This coordinating authority must meet the needs of various stakeholders for information and knowledge as well as actively working to facilitate and remove barriers, so that deployment is socio-economically acceptable, fit-for-purpose and timely.

The Swedish Energy Agency is deemed the public authority most suitable for coordinating Sweden's recharging infrastructure.

For the Swedish Energy Agency to be responsible for national coordination, a defined principal, a recipient of the results of this work, and the appropriation of resources are required. To ensure continuity, it is also proposed that this mission be included in the Swedish Energy Agency's terms of reference in the long term.

While the public authority with principal responsibility must be allocated resources for implementation, other relevant public authorities must also be given the appropriate missions and resources to assist in this work.

Regarding coordination of hydrogen refuelling infrastructure, we propose awaiting the results of the Swedish Energy Agency's current coordination mission for hydrogen, to be reported on 1 December 2024. At present, coordination of hydrogen is not included in the framework of the coordination responsibility described above, although this may change if combining the two is deemed appropriate. Hydrogen coordination is described in greater detail in Chapter 5.6.

5.1.3 Proposal for a coordination function

To ensure the holistic coordination of recharging infrastructure and promote it efficiently and effectively, a coordination function as per the organisation described in Figure 9 is deemed necessary.

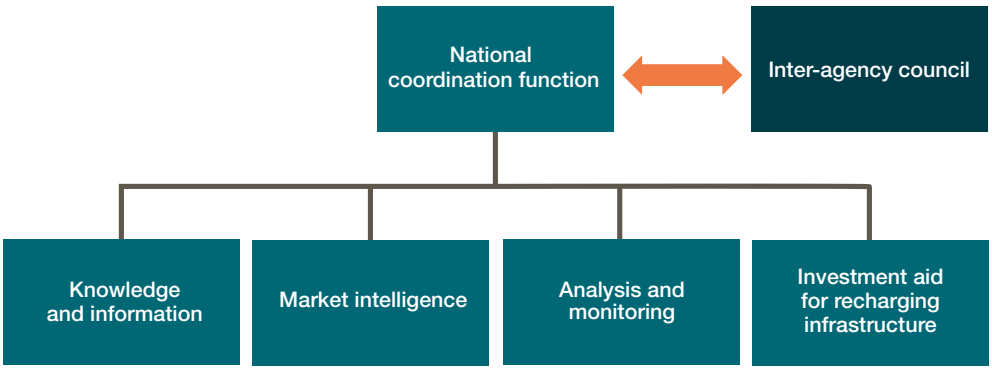

Figure 9. Proposal for organisation of the coordination function.

Four different areas of responsibility have been identified. It is important to emphasise that these four areas should not be seen as isolated silos; continuous interaction among these areas is crucial for success. Responsibilities are described below, along with suggestions for tasks that may be included in the responsibilities.

Knowledge and information

The focus of this area is to increase the general level of knowledge regarding the development of the electrified road transport sector and its associated recharging infrastructure. A platform for knowledge exchange should be developed and established. The aim is to promote and facilitate dialogue among different stakeholders in the electrified road transport system. Furthermore, this work should aim to actively support and assist, in the first case, municipalities, but also regions, county administrative boards and other organisations in their work on the deployment of recharging infrastructure.

Market intelligence

The focus of this area is on building recharging infrastructure expertise and actively tracking developments, nationally and internationally. This function should assist other parts of the coordination function as well as internal and external stakeholders with data and knowledge in the area.

Analysis and monitoring

The main responsibility of this area is to actively monitor the deployment of recharging infrastructure, conduct prospective analyses and scenario projections and report to various bodies, including AFIR. High-quality monitoring requires the development and maintenance of statistics and indicators, for which the function is also responsible.

Investment aid for recharging infrastructure

Responsibility for overall State aid for the deployment of recharging infrastructure. This work also includes continuously analysing and monitoring the scope and design of aid, to ensure the effectiveness and high yield of interventions.

Inter-agency council

The coordination function should include an inter-agency council with representatives from public authorities assisting in work related to recharging and hydrogen refuelling infrastructure. This inter-agency council will act as a reference group as well as regularly providing and receiving information about ongoing work and assisting in inter-agency coordination.

5.2 Socio-economically efficient and effective recharging and hydrogen refuelling infrastructure

For users of the road transport system to feel confident that electrified transport can be used across Sweden, fit-for-purpose recharging infrastructure must be in place. The same applies to hydrogen, although it is less developed at present and is considered to have a more limited target group. All aspects of the deployment of fit-for-purpose recharging and hydrogen refuelling infrastructure are not guaranteed to be socio-economically efficient, even if deployment as a whole is deemed so.

This section describes the principles of fit-for-purpose deployment and explains why deployment should be based on these principles. It also includes some overall cost estimates for the deployment of fit-for-purpose recharging and hydrogen refuelling infrastructure.

For the infrastructure to be fit-for-purpose, information about where recharging pools and refuelling stations are located and what they offer must be easily accessible. However, this section does not describe the mapping and planning tools which aim to do this, e.g., Drivmedla, launched in autumn of 2023[95]. While the Swedish Energy Agency and the Swedish Transport Administration deem such tools as very important, it is mainly up to the market to develop and offer them. However, the availability of basic data on recharging pools and hydrogen refuelling stations is significant, and the work commenced by the Swedish Energy Agency to produce official statistics should continue, as should development of the Nobil database (see section 5.11).

5.2.1 Fit-for-purpose infrastructure

Fit-for-purpose recharging infrastructure is based on home and depot recharging, together with publicly accessible and semi-publicly accessible recharging for those without private parking, and, to a certain extent, depot hydrogen refuelling. Deployment of publicly accessible recharging and hydrogen refuelling stations will follow, according to the EU AFIR regulation. AFIR mainly imposes deployment requirements along the most heavily trafficked roads, but deployment along other major roads is also needed to achieve fit-for-purpose infrastructure. Finally, to ensure the robustness and redundancy of infrastructure, deployment must be added at strategic locations (see Figure 10).

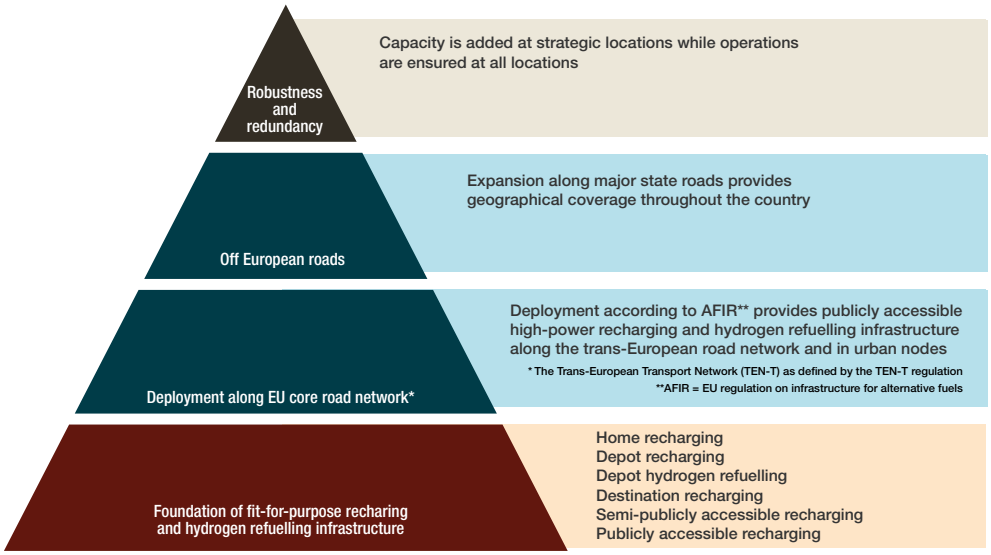

Figure 10. Illustration of fit-for-purpose recharging and hydrogen refuelling infrastructure.

[95] Drivmedla, *Tillsammans banar vi vägen för framtidens fordonsflotta*, retrieved 30 Sept. 2023, https://www.drivmedla.se/

Foundation of fit-for-purpose recharging and hydrogen refuelling infrastructure

Home and depot recharging accounts for the majority of electric car and truck recharging, and the ability to charge at home and at a depot is central to enabling more people to buy and drive plug-in vehicles. Providing those without access to private parking the opportunity to charge an battery electric vehicle in the future is also important. In the course of a prior mission, concerning improved access to recharging infrastructure at all types of homes[96], the Swedish Energy Agency carried out an analysis and presented measures, some of which are still deemed relevant. This foundation also includes destination recharging and semi-publicly accessible recharging, which will be an important complement to home and depot recharging. The possibility of depot hydrogen refuelling will be part of a future refuelling infrastructure system.

Home and destination recharging for individuals

Individuals' access to recharging facilities is divided into two groups: those with authority over their own parking and those without. This authority refers to the right to decide (e.g., over land, parking space, necessary infrastructure) to install a recharging point without the authorisation or approval of others.

For residents in single-family homes with access to their own parking, there are no identified barriers to establishing a recharging point.

However, for those without authority over their own parking, several barriers exist to accessing recharging infrastructure. This applies primarily to residents in residential blocks, who require property owner approval for the installation of recharging infrastructure, residents without access to parking and who depend on publicly accessible recharging infrastructure, and residents whose parking is community property, which entails costs and the risk of long lead times related to amending facility decisions to include recharging. See the descriptions of these obstacles in this mission's February 2023 interim report from the Swedish Energy Agency and Swedish Transport Administration[97].

Employing destination recharging when vehicles are stationary for long periods is an important part of fit-for-purpose recharging infrastructure.

Property owners play a significant role, as most recharging occurs when vehicles are parked for long periods. Property owners must make long-term plans to meet the recharging needs of both residential and commercial tenants.

The revised Energy Performance Buildings Directive (EPBD), currently under negotiation, proposes to increase requirements for the preparation and installation of recharging infrastructure in car parks in and around heated buildings. In addition, it is proposed that Member States be required, where possible, to remove barriers to the installation of recharging points

[96] Swedish Energy Agency (2021), *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*, ER2021:24.

[97] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas*, ER 2023:06.

in residential blocks and ensure a 'right to plug' [98,99,100] (see section 4.2). As this is still under negotiation, the outcome is uncertain.

The Government has initiated a commission to facilitate recharging on public land (see section 1.4.4), and a public inquiry to remove barriers to electrification where home recharging in community property is indicated (see section 1.4.2).

Depot recharging and semi-publicly accessible recharging

Business vehicles (both light- and heavy-duty) are generally used much more than private vehicles, especially heavy-duty vehicles. For such vehicles, recharging during extensive parking periods, such as at a depot, is important, as is recharging during natural stops such as loading and unloading, breaks for driving and rest time, and high-power recharging for short stops along the road[101].

The majority of recharging for heavy-duty battery electric vehicles will take place via depot recharging, but so-called semi-publicly accessible recharging is also called for. This is especially true in the first stage of the electrification process, when the electrification of heavy-duty vehicles will primarily occur across local and regional transport. The barriers to and challenges of installing depot recharging are somewhat similar to those of installing home recharging for individuals occupying rental properties. These challenges include the availability of parking and access to power.

Semi-publicly accessible recharging is deemed to require approximately the same amount of power as publicly accessible high-power recharging for heavy-duty vehicles, and the cost can thus also be compared with that of publicly accessible high-power recharging.

Depot hydrogen refuelling

Depot hydrogen refuelling may benefit vehicles operating as part of a fleet, including buses or commercial vehicles, which return to the depot for refuelling after completing routes/shifts. Until hydrogen refuelling infrastructure is fully developed, stakeholders, such as haulage contractors or bus companies, may see benefits from centralised depot refuelling. This could enable hydrogen production at the depot, improved control of safety protocols and maintenance of the hydrogen refuelling station. Actors can also track refuelling patterns and more easily service vehicles as needed.

Deployment gaps

It has not been possible to perform a gap analysis or estimate the costs of achieving fit-for-purpose infrastructure for home and depot recharging and hydrogen depot refuelling. Aid for such recharging is deemed socio-economically effective and thus justified going forward.

However, the forms of aid may need to be reviewed. Aid for depot recharging of trucks, for example, may be needed. Applications for aid can currently be made within the Climate Leap initiative, but several stakeholders have emphasised that the application periods are inconvenient, and that applications should be accepted on an ongoing basis. Aid for

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[98] Commission proposal for a European Parliament and Council Directive on the energy performance of buildings (recast) COM/2021/802 final.

[99] Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast), COM (2021) 802 final.

[100] Ibid.

[101] Power Circle (2022) *Effektbehovet från elektrifierade transporter.*

non-publicly accessible recharging could possibly be removed from the Climate Leap initiative, and, like Ladda bilen for passenger cars, form a separate aid. In this way, aid can be simplified for both the applicant and the disbursing authority. Achieving this will require a review of the regulatory framework for grants.

Aid under Ladda bilen must also be reviewed. This aid is basically intended to enable recharging for homeowners. However, property owners' eligibility for aid is contingent on the size of the property.

Large property owners quickly reach the limit of maximum aid. Ultimately, those living in an apartment belonging to a large property company risk having less opportunity to access recharging than those living in properties owned by smaller companies. Provision of aid to large property owners must be reviewed.

Grants for non-publicly accessible recharging up to the present are compiled below. At present, aid is not provided for hydrogen refuelling, and it has not been possible to assess the need for this.

Climate Leap initiative and Ladda bilen

In 2019, aid for non-publicly accessible recharging for organisations, companies and cooperative housing associations seeking to provide recharging pools, mainly for employees or residents, was separated from the Climate Leap initiative. This aid was called Ladda bilen and, through 20 March 2023, SEK 1,109 million in aid has been granted, contributing to the construction of 104,300 new non-publicly accessible recharging points for passenger cars.[102] Before 2019, just over SEK 231 million within the Climate Leap initiative also went to non-publicly accessible recharging, which contributed to 1,383 measures. A measure can include numerous recharging points[103].

Tax break for green technology for recharging points in single-family homes

Table 7 shows the total number of non-publicly accessible recharging points that have benefitted from the green tax break: 188,962 items and total cost of SEK 1,987 million since the deduction was introduced on 1 January 2021.

Table 7. Number of recharging points benefiting from the green deduction, average cost and total cost of the deduction [104].

Year	Number of recharging points	Average deduction, SEK	Total cost of the deduction, SEK millions
2021	53,953	10,708	578
2022	94,367	10,699	1,010
2023 data retrieved 01/09/23	40,072	9,961	399
Total	**188,392**		**1,987**

[102] Swedish Environmental Protection Agency(2023) *Lägesbeskrivning för Klimatklivet*, NV – 00692-23.

[103] Informed by e-mail by Swedish Environmental Protection Agency administrator 03/10/2023.

[104] Swedish Tax Agency, "Statistikportalen", *Skattereduktion för grön teknik – Översikt*, retrieved 1 Sept. 2023, https://www6.skatteverket.se/sense/app/b25adfd3-2836-4414-8510-2cdce893477d/sheet/e4f9aa7e-de62-483a-801f-912761d52dbd/state/analysis

Deployment along the EU core road network

Deployment according to AFIR provides publicly accessible high-power recharging and hydrogen refuelling infrastructure along the trans-European road network (TEN-T) and in urban nodes (see section 4.1). Some parts of the TEN-T road network already have good coverage, but to get an overall picture, Sweden must analyse the status of recharging and hydrogen refuelling infrastructure in relation to the requirements. This means not only meeting capacity and distance requirements along the road network, but also the requirements of the recharging pools and refuelling stations themselves.

Power requirements per electric car and plug-in hybrid

At the end of 2022, there were more than 210,000 electric light-duty vehicles and almost 240,000 plug-in hybrids, according to the Swedish Transport Analysis Agency. If the requirements for publicly accessible recharging capacity per electric car and plug-in hybrid are to be met, this corresponds to approximately 470,000 kW[105]. According to the Nobil[106] database, there were approximately 725,000 kW of publicly accessible recharging in Sweden in September 2023. This means that Sweden currently fulfils AFIR's requirements for publicly accessible recharging in relation to the number of plug-in vehicles. However, plug-in vehicles are growing rapidly in Sweden. According to the scenario for growth of the vehicle fleet presented by the Swedish Environmental Protection Agency in April 2023[107], the number of plug-in vehicles is expected to grow relatively quickly in the coming years, and AFIR's requirements for publicly accessible recharging capacity will also increase (see Figure 11).

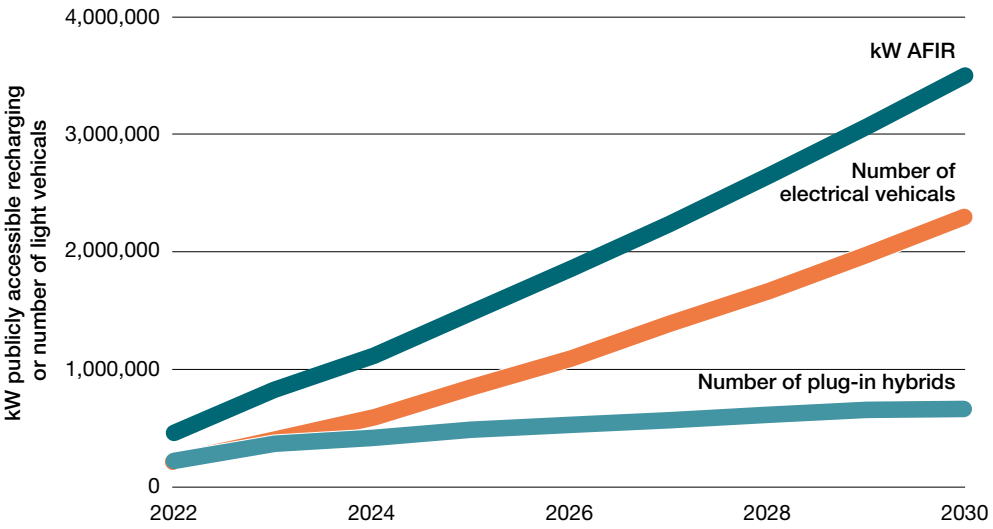

Figure 11. Forecast regarding rechargeable light-duty vehicles and need for publicly accessible recharging capacity according to AFIR.

The existing publicly accessible recharging capacity must, according to Nobil, be expanded to match the expected growth of rechargeable light-duty vehicles in Sweden in the coming years. The Swedish Environmental Protection Agency, the Swedish Energy Agency and the Swedish Transport Administration have granted extensive aid for recharging pools. These

[105] Swedish Transport Analysis Agency official statistics (2023), *Fordon 2022-Trafikanalys Statistik* 2023:3.

[106] Data retrieved 27 April 2023, publicly accessible recharging only with AFIR prescribed standards.

[107] Swedish Environmental Protection Agency (2023) *Underlag till regeringens klimathandlingsplan och klimatredovisning,* NV-08102-22.

calls for proposal have resulted in the granting of aid for recharging points corresponding to an additional 600,000 kW, of which 330,000 kW is for light-duty vehicles. However, whether all these recharging pools will be built is uncertain. The AFIR requirements and the growth forecast of rechargeable light-duty vehicles indicate a need for approximately 1,500,000 kW of publicly accessible recharging capacity by 2025, more than 2,000,000 kW publicly accessible recharging capacity by 2027, and more than 3,500,000 kW of publicly accessible recharging capacity by 2030 (see Figure 12).

Around 2026, the share of electric cars is expected to correspond to 15 percent of the total number of light-duty vehicles in Sweden, which means that Sweden can apply to remove AFIR's capacity requirement. The growth of the vehicle fleet and the deployment of publicly accessible recharging should probably be monitored regularly in order to assess the fulfilment of AFIR's capacity requirement.

The growth rate of the rechargeable light-duty vehicle fleet is an uncertainty vis-a-vis the requirements for deployment of publicly accessible recharging infrastructure in proportion to the fleet of rechargeable light-duty vehicles. The latest short-term forecast by the Swedish Transport Analysis Agency[108] describes growth that is slower than that which formed the basis of the above analysis[109]. If the fleet of plug-in vehicles grows at a slower rate, fewer kW of publicly accessible recharging capacity must be developed at a specific time, and the year in which 15 percent of Sweden's fleet consists of electric cars will occur later.

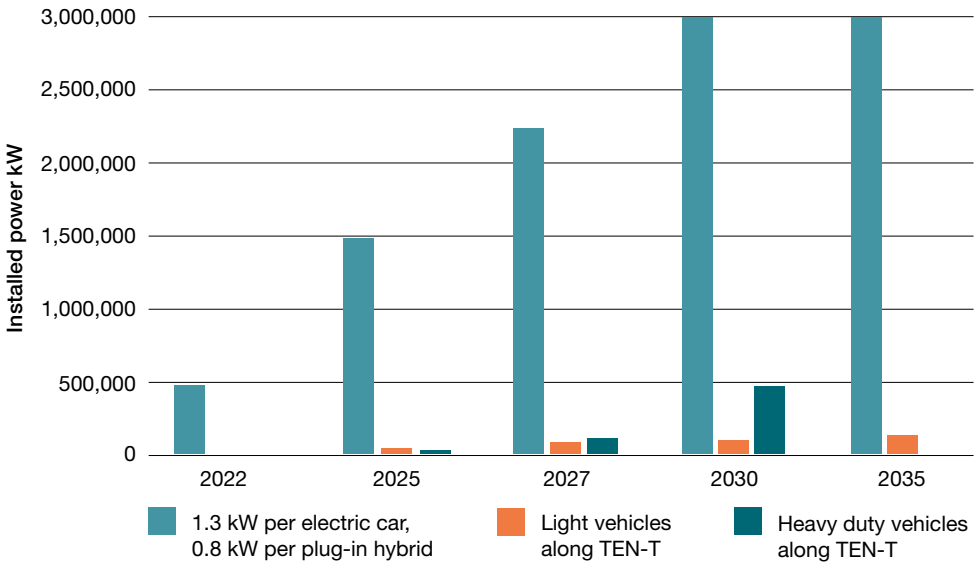

Figure 12. Estimated required publicly accessible recharging capacity, according to AFIR requirements for light- and heavy-duty vehicles in different years.

Requirements for the deployment of recharging infrastructure along TEN-T and in urban nodes

The power and distance requirements along the TEN-T assume that all recharging pools are exactly 60 km apart and have the prescribed capacity at any given time. The spontaneous market process is likely to result in recharging pools being more dense, on certain routes,

[108] Swedish Transport Analysis Agency (2023), *Korttidsprognoser för vägfordonsflottan* 2023–2026.

[109] Swedish Environmental Protection Agency (2023) *Underlag till regeringens klimathandlingsplan och klimatredovisning,* NV-08102-22.

and with higher power than required by AFIR. At the same time, Sweden can apply for an exemption from the capacity and distance requirements along low-traffic parts of the TEN-T road network. While details remain uncertain, it is clear that the most extensive requirement, in kW of deployed recharging infrastructure, is linked to the deployment of publicly accessible recharging in proportion to rechargeable light-duty vehicles, followed by the requirement for heavy-duty vehicles along the TEN-T and in urban nodes. The challenge may be greater for heavy-duty vehicles, as that market is not as advanced as the market for light-duty vehicles.

Requirements for the deployment of hydrogen refuelling stations along TEN-T and in urban nodes

Hydrogen refuelling infrastructure, with capacity requirements of at least one tonne per day at a pressure of 700 bar, shall be located at a maximum distance of every 200 km along the TEN-T core network. Hydrogen refuelling stations must also be deployed in urban nodes. The location of existing and planned hydrogen refuelling stations can help achieve relatively good coverage for the currently designated urban nodes (Stockholm, Gothenburg and Malmö) as well as the core network. The largest area without coverage is Norrbotten. A detailed description and analysis of the location of hydrogen refuelling stations, as well as the traffic situation along the TEN-T road network, is described in section 5.6.

Deployment gaps

Based on data on existing recharging pools and hydrogen refuelling stations, as well as those which have been granted funding but which are not yet operational, the need for further deployment of publicly accessible recharging pools and hydrogen refuelling stations has been analysed.

This analysis has considered a minimum level in line with the density and capacity specified in AFIR. The costs correspond to the accumulated construction costs without taking into account how these are distributed between the State and the market.

Individual recharging pools are analysed individually, and only recharging pools that meet all requirements have been included. The analysis has not taken into account whether two or more recharging pools in close proximity to each other are able to fulfil the requirements together. The impact of these cases is deemed not significant in regard to compliance, as at least one of these recharging pools is likely to fulfil the requirements on its own, especially for light-duty vehicles.

The analysis also assumes that Sweden will apply the exemptions available for low-traffic routes. These include the size of recharging pools and the maximum distance between two recharging pools. It is assumed that existing recharging pools will remain in place and that the subsidised recharging pools will be built before 2025. The cumulative construction value of the recharging points needed to fulfil the requirements of AFIR can be estimated by multiplying the specified power levels by 5,500 kr/kW. This assessment is based on the fact that the average aid amount, under regional electrification pilots and the Climate Leap initiative, corresponded to approximately SEK 5,500 per installed kW of recharging capacity.

The same principles have been applied to hydrogen refuelling stations. The cost of constructing a hydrogen refuelling station is estimated at SEK 20,200 per kg of capacity. This estimate, being based on a few applications from regional electrification pilots, is not certain.

Need for recharging pools for light- and heavy-duty vehicle to fulfil AFIR

For light-duty vehicles (see Table 8) almost 50 new or expanded recharging pools are needed to meet all AFIR requirements along the TEN-T road network by 2035. Charging pools must be expanded or supplemented in stages from 2025. In total, accumulated construction costs through 2035 are estimated at approximately SEK 215 million.

For heavy-duty vehicles, Sweden already fulfils the AFIR requirements along TEN-T for 2025, provided that all subsidised recharging pools are built. By 2027, an additional ten new or expanded recharging pools are needed to achieve 50-percent coverage of the TEN-T road network. The cumulative construction cost for this is estimated to be up to SEK 300 million, depending on where along the road network these recharging points are built. By 2030, when the entire TEN-T road network must be covered and the combined power of the recharging pools will increase and the distance between recharging pools will decrease, around 80 new or expanded recharging pools will be needed to meet the requirements. The accumulated construction cost is estimated at approximately SEK 1,900 million.

The coverage rate for heavy-duty vehicles in 2025 and 2027 has been calculated on the basis that each recharging pool which fulfils the capacity requirement covers a stretch of road of 60 km in each direction of travel from the recharging pool.

Table 8. Gaps in recharging pools along the TEN-T for light- and heavy-duty vehicles

	Light-duty vehicles		Heavy-duty vehicles	
	Number of recharging points	Accumulated construction cost (million SEK)	Number of recharging points	Accumulated construction cost (million SEK)
2025	17	55	0	0
2027	17	95	10	<300
2030	33	120	80	1,900
2035[110]	47	215		

The estimated accumulated construction cost in Table 8 assumes that all recharging pools need to be built from scratch. Along many of the routes, existing recharging pools have too little combined power to meet the requirements of AFIR. If these recharging pools could be supplemented, the total in Table 8 would probably be slightly lower.

Since Sweden already fulfils the 2025 requirements, and most of the 2027 requirements for recharging pools for heavy-duty vehicles along the TEN-T road network, deployment in coming years can be focused on building capacity where market demand for recharging capacity is higher while carrying out limited expansion along TEN-T. Expansion along the TEN-T is important to obtain geographical coverage, but might be carried out in coming years with lower total power per recharging pool than the AFIR requirements. After 2025, greater focus can be placed on expanding capacity along the entire TEN-T in line with AFIR. This could ensure faster deployment of electric heavy-duty vehicles and higher utilisation of recharging pools.

AFIR also requires the deployment of publicly accessible recharging capacity in proportion to the fleet of plug-in vehicles. When the share of light-duty battery electric vehicles reaches 15 percent of the fleet, this requirement may no longer apply. For Sweden, this corresponds

[110] For 2035, there are no requirements for the deployment of recharging pools for heavy-duty vehicles.

to about 1,500,000 kW of publicly accessible recharging capacity. This represents about 500,000 kW more than what is in operation or subsidised today.

The construction cost of additional recharging infrastructure to meet this target is estimated at SEK 2,600 million. This sum includes all additional publicly accessible recharging points across Sweden, i.e., it does not consider the location of recharging pools.

Hydrogen refuelling stations

Most of the TEN-T core network is assumed to be covered by hydrogen refuelling stations through the refuelling stations already subsidised. Several of these are likely to require upgrading to meet capacity requirements. These costs have not been analysed, as data on installed capacity for several of the hydrogen refuelling stations is lacking. Four additional refuelling stations are assumed sufficient to cover the remaining parts of the TEN-T core network, at an accumulated construction cost of SEK 40 million, assuming that Sweden will apply the exemptions available for low-traffic routes.

In addition to deployment along the TEN-T core network, hydrogen refuelling stations must be built at all urban nodes. Under the TEN-T Regulation, which is currently under negotiation, the number of urban nodes in Sweden will increase from three to 18. Half of these nodes already have a hydrogen refuelling station subsidised by regional electrification pilots. The accumulated construction cost for the remaining urban nodes is estimated at SEK 100 million, assuming these need to fulfil a capacity of 500 kg/day.

Deployment of publicly accessible high-power recharging elsewhere

Compliance with AFIR is assumed to cover the TEN-T road network with publicly accessible high-power recharging. AFIR can also provide public fast-charging beyond the TEN-T road network by requiring recharging capacity per rechargeable light-duty vehicle in the country. To achieve fit-for-purpose recharging infrastructure, deployment along other major roads is also likely necessary. However, the recharging capacity requirement is not driven by geographic location, and this requirement is not assumed to directly contribute to fit-for-purpose infrastructure beyond the TEN-T.

Light-duty vehicles

Publicly accessible high-power recharging is relatively well developed along some major roads, mainly in southern Sweden, while access is poorer in other parts of the country. Geographical coverage of publicly accessible high-power recharging for light-duty vehicles is deemed possible through deployment according to the Swedish Transport Administration's analysis and criteria for coverage gaps.

The Swedish Transport Administration's analysis[111] assumes that there should be a recharging point of at least 150 kW every 100 km along the functionally prioritised road network for long-distance passenger travel (FPV)[112] and every 60 km along the TEN-T road network. Figure 13 shows the availability of publicly accessible high-power recharging according to the Swedish Transport Administration's criteria, with white sections showing recharging gaps.

[111] Swedish Transport Administration (2018) *Infrastruktur för snabbladdning längs större vägar – ett regeringsuppdrag*, 2018:172. The analysis in this report is based on a shortage of 50 kW, but the Swedish Transport Administration has since updated the shortage analysis to 150 kW and, in recent years, also updated distances to 60 km on the TEN-T.

[112] Swedish Transport Administration (2023), *Funktionellt prioriterat nätverk*, retrieved 03/10/2023, https://bransch.trafikverket.se/for-dig-i-branschen/vag/funktionellt-prioriterat-vagnat/

Figure 13. Coverage of publicly accessible high-power recharging of at least 150 kW every 100 km along the functionally prioritised road network for long-distance passenger travel and every 60 km along the TEN-T. White sections show recharging gaps. Data from spring of 2023.

Deployment according to the Swedish Transport Administration's analysis and criteria provides an initial geographical coverage of publicly accessible high-power recharging across the country, but this will not be sufficient for recharging infrastructure to be fit in terms of capacity as the vehicle fleet grows. The Swedish Energy Agency and the Swedish Transport Administration deem that the market should primarily determine the need for capacity as well as where, along the road network, deployment is best.

State aid may be needed for a period, especially in low-traffic areas.

Heavy-duty vehicles

Access to publicly accessible high-power recharging for heavy-duty vehicles is currently low, but more than 170 recharging pools have been granted aid by the Swedish Energy Agency and the Swedish Environmental Protection Agency and will be built in the near future[113]. The majority of these recharging pools are located along major roads in southern Sweden as well as some along the coast of Norrland and inland (see Figure 14).

[113] Recharging pools of 350 kW that have been granted aid from the Swedish Energy Agency and the Swedish Environmental Protection Agency according to withdrawals from the Swedish Energy Agency on 5 May 2023 and the Swedish Environmental Protection Agency on 20 March 2023.

Figure 14. Green dots show the distribution of existing recharging pools for heavy-duty vehicles, and recharging pools for heavy-duty vehicles that have been granted State aid and will be built in the near future, along the national core road network. Input data from autumn of 2023.

There are currently no criteria or similar analyses for the expansion of publicly accessible high-power recharging for heavy-duty vehicles such as the Swedish Transport Administration's coverage gaps for light-duty vehicles. AFIR sets requirements for distance and power along the TEN-T, but fit-for-purpose publicly accessible high-power recharging for heavy-duty vehicles also requires deployment along major roads beyond the TEN-T. The functionally prioritised road network for freight transport is relatively fine-meshed, and the corresponding criteria and analysis regarding coverage gaps for light-duty vehicles are not considered fit-for-purpose or cost-effective.

One way to achieve geographical coverage of high-power recharging beyond TEN-T is to base State aid on covering the national core road network[114] and parts of the functionally prioritised road network for freight transport.

Recharging could be deployed along the national core road network according to the requirements of AFIR[115] to start with, and the functionally prioritised road network for freight transport could receive coverage iteratively based on requirements related to distance from the core road network and power at the recharging points. Iterative coverage means covering roads at a certain distance from the core road network as a first step, and, in the next step, re-analysing the distance from the core road network to identify remaining coverage gaps after each new recharging pool. This should permit coverage of roads along the functional priority road network for freight transport at a rate matching growth in the vehicle fleet and development of technology.

[114] Swedish Transport Administration (2022) *Dataproduktspecifikation – Stamväg.* The national core road network is part of Sweden's main road network and consists of public roads of particular importance for the development of the country's welfare and which must therefore maintain a high and consistent standard.

[115] Time, effect, distance and technology (e.g., payment).

A comparison of the distribution of existing recharging pools with subsidised recharging pools to be built along the core road network and functionally prioritised road network for freight transport shows that iterative coverage must likely be concentrated primarily in inland Norrland, Småland and Blekinge (see Figure 15). However, adaptation of capacity requirements and distances between stations should be considered in order to achieve the most economically efficient expansion possible. Analysis and the design of requirements must also consider the forthcoming MCS standard.

To achieve fit-for-purpose high-power recharging infrastructure, capacity must be expanded as the vehicle fleet grows. The market is deemed best placed to determine where the need for capacity is greatest. State aid must be synchronised with these needs. Several private stakeholders work with data on the movement of heavy-duty vehicles, which is very valuable in such analyses.

The need for geographical coverage must be tested against the need for capacity along key freight routes. Just as near-term capacity, rather than geographical coverage of the TEN-T under AFIR should be prioritised, for certain major roads beyond TEN-T capacity may initially be more justified than geographical coverage. As the vehicle fleet grows, geographical coverage may need to increase, and the above model could be applicable.

Figure 15. Distribution of existing recharging pools for heavy-duty vehicles, and recharging pools for heavy-duty vehicles that have been granted State aid and will be built in the near future, along the national core road network. Thin green lines indicate the functionally prioritised road network (FPV) for freight transport. Input data from autumn of 2023.

Deployment of hydrogen refuelling stations beyond European roads

The AFIR requirements provide good initial coverage of hydrogen refuelling stations along main roads (TEN-T core) and in urban nodes for heavy long-distance transport. To ensure fit-for-purpose deployment, comprehensive coverage of TEN-T with hydrogen refuelling stations according to the same requirements[116] as in AFIR should be projected. However, needs must be analysed before any such deployment is undertaken. This needs analysis must also consider the growth of light-duty vehicles. Figure 16 shows coverage of existing and planned hydrogen refuelling stations along TEN-T core and TEN-T comprehensive.

Figure 16. Coverage of existing and planned hydrogen refuelling stations as of June 2023 (purple dots) along the TEN-T core (yellow lines) and TEN-T comprehensive (blue lines)

Deployment gaps

Major roads for recharging pools have, as above, been defined as the functionally prioritised road network for long distance passenger journeys for light-duty vehicles, and as the functionally prioritised road network for freight transport for heavy-duty vehicles. For hydrogen, analysis is based on the TEN-T core network and the TEN-T comprehensive network. In addition, further deployment is needed to build resilience and capacity.

Recharging pools for light-duty vehicles

Based on the Swedish Transport Administration's calls for proposals for aid for high-power recharging for battery electric vehicles along major roads currently lacking high-power recharging, an estimated 40 additional recharging pools will be needed before the entire functionally prioritised road network for long-distance passenger travel can be considered covered. The total construction cost is estimated at just under SEK 70 million. This provides

[116] Time, effect, distance and technology (e.g., payment).

initial geographical coverage of publicly accessible high-power recharging throughout the country, but this will not be sufficient for fit-for-purpose recharging infrastructure in terms of capacity.

Recharging pools for heavy-duty vehicles

For heavy-duty vehicles, there is a significant lack of recharging. According to the coverage proposal in section 5.2.1, the core road network adds about 1,700 km of additional road length compared to the TEN-T road network. To cover those parts of the core road network, where the distance between two recharging pools exceeds 100 km, five new recharging pools would be needed (see Figure 16).

If these new recharging pools are to provide 1,500 kW per recharging pool, fulfilling the AFIR traffic-flow requirements, this entails an accumulated construction cost of approximately SEK 40 million. Existing recharging pools along the core road network may need to be slightly expanded to reach the same size.

For FPV[117] freight transport, it is assumed that a recharging pool covers an area with a diameter of 100 km. To cover FPV beyond the TEN-T and core road networks, an estimated 50 recharging pools are needed to achieve geographical coverage, entailing an accumulated construction cost of SEK 390 million.

However, as described earlier, geographical coverage must be tested against the need for capacity along key freight routes.

Hydrogen refuelling stations

As discussed in section 5.2.1, fit-for-purpose infrastructure should also cover the TEN-T comprehensive network with hydrogen.

There are presently no refuelling stations along much of that road network. In total, ten additional hydrogen refuelling stations are needed along the TEN-T comprehensive network.

All refuelling stations are assumed to have a capacity of 500 to 1,000 kg of hydrogen per day in accordance with AFIR. In total, at least 14 additional refuelling stations for hydrogen are needed, entailing an accumulated construction cost of approximately SEK 140–280 million, of which SEK 40–80 million is along the TEN-T core network.

Deployment for system robustness and redundancy

In addition to sufficient recharging and hydrogen refuelling infrastructure for normal needs, the infrastructure requires robustness and redundancy. This may involve, for example, extra infrastructure at critical locations along high-traffic routes, securing diversion routes with recharging and refuelling infrastructure or temporary reinforcement of high-power recharging along roads with seasonal traffic, as well as ensuring the operational reliability of all recharging pools and refuelling stations for hydrogen. In addition to sufficient infrastructure, robustness and redundancy are also needed in the energy supply of the infrastructure and especially in the electricity supply (see section 5.12).

[117] Swedish Transport Administration (2023), *Funktionellt prioriterat vägnät*, Retrieved 16 Oct. 2023, https://bransch.trafikverket.se/for-dig-i-branschen/vag/funktionellt-prioriterat-vagnat/

Land access

Recharging pools and hydrogen refuelling stations need access to land. There will be a need for such sites on State, municipal and private land. For commercial traffic, it is important that high-power recharging, which currently tends to be located alongside major roads, is available in urban centres.

Societal and market demand for publicly accessible recharging pools, as well as AFIR requirements for the deployment of recharging points, are likely to require land along major roads. For heavy-duty vehicles in particular, rest-stop sites, e.g., truck stops and the Swedish Transport Administration's parking areas for heavy-duty vehicles are important for recharging, but other state-owned land may also be relevant.

Furthermore, private landowners (and property owners) must understand their important role in making land available for recharging and hydrogen refuelling infrastructure.

5.2.2 Socio-economically efficient deployment

The need for recharging and hydrogen refuelling infrastructure will arise in various places and at various times across the country. Regarding the socio-economic efficiency of the implementation programme, it is therefore important to consider both the overall electrification of road transport and the deployment of recharging and refuelling infrastructure.

Home, depot and semi-publicly accessible recharging deemed socio-economically efficient

Slow recharging at low power during off-peak hours is cost-effective for users and helps balance the electricity system. Home and depot recharging are also important factors in the general acceleration of electrification, being cost-effective and enabling more people to adopt battery electric vehicles. Working towards the rapid deployment of home and depot recharging is therefore deemed socio-economically efficient.

Semi-publicly accessible recharging, which mainly takes place at ports, terminals and other loading/unloading points, is deemed important for the electrification of heavy transport. In an initial phase, likely characterised by transport of a more local and regional nature, the need for a well-functioning recharging station at loading/unloading points may be as great as the need for publicly accessible recharging. The cost of semi-publicly accessible recharging is generally considered to be on a par with publicly accessible high-power recharging. For this reason, expanding semi-publicly accessible recharging could have a greater socio-economic benefit than publicly accessible recharging in some cases.

Uncertain socio-economic efficiency of publicly accessible high-power recharging

With regard to publicly accessible high-power recharging, the most highly trafficked parts of the road network are probably the most socio-economically efficient to expand.

Deployment is taking place, but further State aid will likely be required for the deployment of recharging and refuelling infrastructure, pursuant to AFIR, on high-traffic stretches of the road network as well. Among other reasons, aid is needed because recharging and refuelling infrastructure must be developed before the vehicle fleet, entailing that the vehicle fleet and the demand for recharging may be initially limited.

Analyses carried out pursuant to this mission are based on the same methodology as the study 'Case Study of Cost-Effective Electrification of Long-Distance Line-Haul Trucks'[118]. That study examined optimal battery size and evaluated the profitability and use of publicly accessible high-power recharging for a Swedish transport company. It showed that switching to battery-electric trucks is cost-effective, compared to the cost of diesel trucks, unless there is a high proportion of heavy goods carried or longer distances travelled. The study showed that high-power recharging is on par with the cost of diesel operation, but that increasing battery size by 100 percent, without high-power recharging, is significantly cheaper if the price of high-power recharging does not drop significantly from current market prices.

In preparing this implementation programme, extended sensitivity analyses have been carried out on the above study by staff at the Swedish Energy Agency and the Swedish Transport Administration. These analyses mainly focus on the comparison between larger batteries and the deployment of publicly accessible recharging infrastructure. The analyses show similar results to the original study and indicate that larger batteries may be more efficient for heavy-duty trucks (permitting longer driving distances before recharging), rather than building extensive publicly accessible recharging infrastructure along large parts of the Swedish road network. However, these calculations do not include all effects on society, and, e.g., problems linked to mineral supply in the manufacturing of batteries or the effect of battery size on these problems are not included.

For light-duty vehicles, much of the road network has a minimum level of publicly accessible high-power recharging (see section 5.2.1). For some roads without high-power recharging, deployment is expected to continue with the current aid system. For some lengths of road, however, deployment has not been interesting to market stakeholders, despite extensive subsidies. The fact that the market, despite extensive subsidies, does not consider this as economically profitable indicates that the demand for high-power recharging at these points will be low for the foreseeable future, and that it may therefore not be economically justifiable to invest resources in the deployment and possible operation of these recharging pools. From a system perspective, there may be effects which might justify deployment even on parts of the road network where demand is very low. For an electrified road transport system to be functional nationwide, recharging infrastructure must be available in sparsely populated areas as well. Moreover, as a proportion of the total cost of the system, the deployment and operation of these single recharging pools is likely to be low.

Uncertain socio-economic efficiency of hydrogen deployment

At present, hydrogen is deemed largely to be used by heavy-duty vehicles which mainly refuel at public hydrogen refuelling stations along major roads.

Today, there are only a few heavy hydrogen vehicles on the Swedish road network, and the future in this respect is not entirely clear. According to the automotive industry, large-scale production will start in the second half of the 2020s. These vehicles are predicted to have longer ranges compared to battery-battery electric vehicles, and distances between hydrogen refuelling stations may therefore be longer.

It may be cost-effective to locate hydrogen refuelling stations at sites where hydrogen is produced or otherwise already available, but its socio-economic efficiency is more uncertain and often depends on local conditions.

[118] Karlsson and Grauers (2023) *Case Study of Cost-Effective Electrification of Long-Distance Line-Haul Trucks*, Vol. 16 Issue 6 art. no. 2793.

The cost estimates for hydrogen refuelling stations are uncertain and may differ depending on local conditions, making it difficult to assess socio-economic efficiency. In general, production of fossil-free hydrogen at significantly lower costs than today will probably be necessary before hydrogen vehicles can be competitive, except for specialised transport and local clusters. The State's focus should therefore initially be to work primarily to meet the requirements of AFIR, then to monitor development of the vehicle fleet and the need for refuelling infrastructure.

5.3 Grid capacity and shorter connection lead times

Access to grid capacity and reduced lead times for connection to the grid is a key issue for the increased electrification of society as a whole. A number of activities are underway to promote this, e.g., the Climate Law Inquiry[119] includes several proposals aimed at promoting access to the electricity grid and reduced lead times. One such proposal is the Swedish National Board of Housing, Building and Planning's current mission to produce a guideline for the application of the Planning and Building Act to improve municipal awareness of electricity grid needs in planning.[120] The mission of the County Administrative Board of Västra Götaland County and the Swedish Energy Agency to develop regional and local energy planning, described in 1.4.6, is proposed in the inquiry (albeit with slightly different wording).

The ongoing study on removing barriers to the electrification of the transport sector, described in section 1.4.2, aims to develop a knowledge base regarding grid connection of recharging infrastructure and propose possible measures to reduce lead times.

In the deployment of recharging infrastructure, long lead times for grid connection and access to power in the electricity grid are described by several stakeholders as major barriers to the expansion of recharging infrastructure. This challenge is mainly associated with publicly accessible high-power recharging but can also be a challenge if many vehicles must recharge simultaneously at lower power.[121]

The efficient use of electricity grids will become increasingly important. Demand response, i.e., the ability of users to temporarily reduce or shift use, is one of several options that can help address the challenges. Work is underway in the EU to develop new rules for demand response in accordance with the Electricity Regulation.[122] Energy storage can also help here, and GBER now permits State aid for energy storage in connection with recharging infrastructure, as described in section 4.7.

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[119] SOU (2022 *Rätt för klimatet,* 2022:21.

[120] Government (2022) *Regleringsbrev för budgetåret 2023 avseende Boverket*, Fi2022/02388, Fi2022/03444 (partial).

[121] Swedish Energy Agency (2023), *Delrapport inom uppdraget om handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas* , ER 2023:06.

[122] Swedish Energy Markets Inspectorate(2023), Agency for the Cooperation of Energy Regulators (ACER) has submitted framework guidelines for new EU regulations regarding demand response to the EU Commission, Retrieved 16 Oct. 2023, https://ei.se/om-oss/nyheter/2022/2022-12-23-acer-har-lamnat-in-ramriktlinje-for-nya-eu-regler-om-efterfrageflexibilitet-till-eu-kommissionen

5.3.1 Description of barriers and proposals from some stakeholders

According to Swedenergy, one main reason for lead times for connecting recharging infrastructure is a lack of capacity in the electricity grid. Lead time for grid deployment is long and can involve a number of different elements: processing times, delivery times for hardware, grid reinforcement and the competences and resources of different stakeholders. Faster permitting processes for the development of local and regional as well as national electricity grids is essential for the future.[123]

Swedenergy also indicates that high-power recharging of heavy-duty vehicles will be particularly challenging for the electricity grid, as these recharging pools require high-power outputs in places where the electricity grid today is often dimensioned for significantly lower power outputs, and grid reinforcements take a long time.[124] The automotive industry has begun producing maps of logistics routes for heavy-duty traffic, to identify the need for recharging infrastructure as a basis for dialogue with electricity grid companies.[125] This is an example of a planning tool needed for fit-for-purpose deployment.

Partners in the E-charge co-operation project[126] have several suggestions regarding how to improve communication between electricity grid operators and parties seeking new or expanded connection capacity. There is a general desire to facilitate dialogue with electricity grid companies and to require grid companies to have a prescribed response time to a submitted inquiry. Among other things, E-charge highlights a need for greater consensus regarding what a grid/capacity map is, what it should contain and how it should be produced. Conditional agreements are considered important. One proposal to systematically reduce lead times for new cables is to revise the Swedish Environmental Code and some processes in the Planning and Building Act (PBL) to ensure a more comprehensive construction process with a more limited and structured right to appeal.[127]

The parties in E-charge are also discussing building electricity grids based on forecasts and deem it necessary that the Government clarify the conditions for this and, possibly, that the State takes explicit responsibility for producing forecasts. Alternatively, the Swedish Electricity Act (Chapter 2, Section 12) could be amended so that the evaluation of public utility is lifted from individual power lines to a broader perspective.

5.3.2 Assessments and proposals

In December 2022, the Swedish Energy Markets Inspectorate (Ei) reported an analysis of lead times and costs for recharging point connections, assessing a range of potential measures and making several proposals.[128]

Ei deemed prioritisation of the connection of recharging infrastructure unsuitable, given the difficulty in weighing the social utility of different applications. A prescribed time limit for connections was not recommended, as each case requires an assessment of the underlying

[123] Swedenergy, Written submission autumn 2022. ref 2022-11266.

[124] Swedenergy, Supplementary submission after dialogue meetings, ref 2022-11266.

[125] Personal contact with AB Volvo, 19/09/2023.

[126] E-charge, https://www.lindholmen.se/sv/e-charge

[127] E-charge. Submission to the Implementation programme. ref 2022-11266.

[128] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:08.

factors. However, grid operators may impose reasonable application fees to increase the proportion of qualified applications.

Ei made the following proposals, which are developed below: that a public authority be given the mission of producing capacity maps, the possibility of using conditional agreements and that work on grid development plans progresses.

Conditional agreements

According to electricity market regulations, market-based solutions must be used in the first instance, but the Electricity Regulation also states that non-market-based methods, such as conditional agreements, may be used if the conditions for market-based mechanisms are lacking. In such situations, electricity grid operators must demonstrate that the criteria for this exemption are met. Conditional agreements may mean that the recharging operator cannot use the full capacity of the facility during hours when the grid is heavily loaded. The Swedish Energy Markets Inspectorate has investigated the role of conditional agreements in the energy transition.[129]

Ei notes that the regulatory framework for conditional agreements is not clear. Prevailing ambiguities regarding conditional agreements make it even more important to clarify what applies, and the Energy Markets Inspectorate presents its view on conditional agreements as far as possible at present.[130]

In December 2022, the Agency for the Cooperation of Energy Regulators (ACER) submitted a framework guideline on demand response to the European Commission[131]. This framework guideline includes text implying that the role and place of conditional agreements in relation to market-based mechanisms is likely to be clarified. The forthcoming EU regulation on demand response may thus be able to provide a better basis for further clarifying the conditions for conditional agreements in relation to market-based mechanisms.

Capacity maps

The Energy Markets Inspectorate has proposed that the Government consider commissioning an appropriate public authority to investigate how and whether such capacity maps should be produced. Capacity maps involve grid owners identifying locations based on available power and where grid projects are underway or imminent. This could provide recharging operators with, for example, knowledge of suitable locations for the installation of recharging infrastructure.[132]

Grid development plans

Several stakeholders have called for greater opportunities for grid companies to be more proactive in building the electricity grid according to forecast needs.

According to the Energy Markets Inspectorate (Ei), the legislation is deemed to provide the necessary scope, i.e., grid companies can and should make allowances for grid expansion

[129] Swedish Energy Markets Inspectorate (2023) *Villkorade avtal, Ei R2023:08.*

[130] Ibid.

[131] Ibid.

[132] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:08.

to enable proactivity[133]. Grid development plans should be a tool to facilitate the ability of grid operators to motivate proactive grid expansion as well as the coordination and efficiency of grid expansion. The requirement to develop grid development plans is contained in Article 32(3) of the Electricity Market Directive[134] and is implemented in the Swedish Electricity Act[135].

The Energy Markets Inspectorate is currently preparing regulations to be issued in accordance with Chapter 3, Section 17 of the Swedish Electricity Act.[136]

Regulations will, according to plan, be adopted before the end of the year and will enter into force in 2024. In late 2024, grid operators must report their grid development plans for the period 2025–2034.

5.3.3 Demand response and smart control

Demand response is the ability of users to temporarily reduce, increase or shift their use of electricity. A combination of demand response and other measures can help meet the increased demand for electricity and the need for transmission capacity in the grid. Demand response is one of several options to improve the balance between electricity supply and demand.

Smart control technologies can transform appliances, and by extension buildings and facilities, into digital systems which automatically adjust operation to optimise energy consumption while maintaining performance.

Battery electric vehicle recharging is one area with great potential in terms of demand response and smart control, and the increasing number of battery electric vehicles in Sweden is expected to contribute to flexibility in the electricity system.

“Smart recharging” means that consumers benefit from cheaper electricity at off-peak hours, while maintaining functionality. Recharging electric cars at night is one example of this. Smart recharging can reduce the need for grid reinforcements.

In the longer term, bi-directional recharging could also contribute to the flexibility of the electricity system. Examples include vehicle-to-grid (V2G), where energy stored in an electric car’s batteries is used to contribute to the stability of the electricity grid, or vehicle-to-home (V2H), where energy is used in the home. Large-scale implementation of bi-directional recharging requires standardisation work and industry initiatives, and Swedish engagement in the development and updating of necessary standards related to bi-directional recharging is for that reason recommended.[137]

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[133] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:08.

[134] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast).

[135] SFS 1997:857, *Ellag (1997:857).*

[136] Swedish Energy Markets Inspectorate (2023), Sista dag för synpunkter på föreskrift nätutvecklingsplaner, Retrieved 16 Oct. 2023, https://www.ei.se/om-oss/kalendarium/kalendarium/2023-10-05-sista-dag-for-synpunkter-pa-foreskrift-natutvecklingsplaner

[137] Swedish Energy Agency (2023), *Smart styrning av elanvändning, Analys av tekniska förutsättningar för utrustning samt rekommendationer för ökad efterfrågeflexibilitet*, ER 2023:13.

5.4 In-depth analysis of grants

In their interim report of February 2023, the Swedish Energy Agency and the Swedish Transport Administration noted the need for in-depth analysis of two forms of aid and one deduction: investment aid for semi-publicly accessible recharging, operations aid for publicly accessible recharging and hydrogen tank infrastructure, and the green deduction for recharging points at single-family homes. The Swedish Energy Agency and the Swedish Transport Administration have commissioned Trivector Traffic to conduct this in-depth analysis.[138]

5.4.1 Aid for semi-publicly accessible recharging

Semi-publicly accessible recharging refers to recharging points that are only accessible to a defined target group, not to the general public. Such recharging points are found, e.g., at terminals and are accessible to the stakeholders that use the terminal.

Dialogues with the freight transport industry, and written submissions to the mission, showed a great need for semi-publicly accessible recharging. This is mainly to recharge while trucks are stationary for other purposes, such as loading, unloading, resting or when changing drivers.

Trivector estimates that the power requirement for semi-publicly accessible recharging is of the same order of magnitude as publicly accessible high-power recharging. The costs of building semi-publicly accessible recharging are therefore on a par with publicly accessible high-power recharging.

The stakeholders sharing the semi-publicly accessible recharging point could cover these costs themselves. However, aid to semi-publicly accessible recharging reduces logistics costs for companies and allows battery-electric trucks to compete with diesel trucks more quickly. Trivector's assessment is, therefore, that aid for semi-publicly accessible recharging should be a socio-economically efficient way to increase the pace of electrification.

5.4.2 Operational aid for high-power recharging

Trivector deems that the need for operational aid for high-power recharging is low, with the exception of some of the most low-traffic road sections which lack high-power recharging according to the Swedish Transport Administration's definition of coverage gaps.

The low need for operational aid is explained by the fact that relatively little utilisation is required for high-power recharging pools to be economically viable. The Swedish Transport Administration is currently adapting requirements in an effort to reduce operating costs for potential aid recipients.

Trivector recommends investigating whether operational aid can be included in the current aid for coverage gaps, only targeted at low-traffic stretches of road where recharging deployment would not otherwise occur. Regardless, Trivector does not deem operational support for high-power recharging to be economically justified, although it may be justified for other reasons, e.g., nationwide access to high-power recharging. Aid for the operation of recharging pools is not currently permitted under EU regulations[139].

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[138] Trivector (2023), *Behov av stöd till laddning och vätgastankinfrastruktur. Utredning av tre olika förändringar av stöd och avdrag behov – möjligheter – konsekvenser,* TRV2022/90068.

[139] Commission Regulation (EU) 2023/1315 of 23 June 2023 amending Regulation (EU) No 651/2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty and Regulation (EU) 2022/2473 declaring certain categories of aid to undertakings active in the production, processing and marketing of fishery and aquaculture products compatible with the internal market in application of Articles 107 and 108 of the Treaty

5.4.3 Operational support for hydrogen refuelling stations

Publicly accessible hydrogen refuelling stations are needed for the introduction of fuel cell electric trucks. Trivector deems that, initially, when few vehicles are used, operational aid is necessary, but that this need decreases as the number of vehicles increases. Trivector deems operational aid during an initial phase to be one means to introduce fuel cell electric trucks. Any need for aid must be further evaluated based on growth of the vehicle fleet. Aid for the operation of hydrogen refuelling stations is currently not permitted under EU regulations[140].

5.4.4 Green deduction for recharging point for single-family homes

This deduction means that private individuals can deduct up to 50 percent of the costs of installation (material and labour) of a recharging point at single-family homes. Removing the special deduction for recharging points means that a certain amount can be deducted through the ROT deduction. This deduction includes 30 percent of installation costs.

Trivector deems that removing the deduction for recharging points will likely not affect the number of recharging points to any great extent. However, fewer users of rechargeable cars may choose to install a home charger, potentially increasing the risk of fire.

Trivector also indicates fairness as an argument against abolishing the deduction. So far, deductions have mainly been made by high-income households, often in southern Sweden and in large cities. The deduction could benefit more groups as a broader section of society gains access to recharging vehicles when prices fall and the second-hand market grows. At the same time, the cost of a recharging point is a small proportion of the purchase cost, especially if the car is new. A review of used electric car prices by Trivector shows that the price of a home recharging point can be up to 30 percent of the car's price, with an average price of six percent and a median of seven percent.

5.5 Digitalisation

In an electrified transport sector, the energy and transport systems must be connected in a new way through data sharing. The Swedish National Road and Transport Research Institute (VTI), pursuant to a Government mission, analysed the electrification of the transport sector, including the need for digitalisation.[141] Vinnova highlighted, in its final report on the development of data sharing[142], four areas for further work: 1) interoperability, which means that data can be included in more contexts, form part of a larger body of information and work together with other stakeholders' data; 2) open standards, specifications and common technical solutions; 3) increased governance within a sector, group of stakeholders or within a thematic area; and 4) coordination of the development of a national data management infrastructure involving both public and private stakeholders.

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[140] Commission Regulation (EU) 2023/1315 of 23 June 2023 amending Regulation (EU) No 651/2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty and Regulation (EU) 2022/2473 declaring certain categories of aid to undertakings active in the production, processing and marketing of fishery and aquaculture products compatible with the internal market in application of Articles 107 and 108 of the Treaty.

[141] Swedish National Road and Transport Research Institute (2023), *Regeringsuppdrag om elektrifieringen av transporter. Rekommendationer för att underlätta datadelning och nyttiggörande av data för planering, utveckling och drift av laddinfrastruktur och affärsmodeller*, VTI:s ref 2021/0420-1.1.

[142] Vinnova (2022), *Insatser för datadelning – slutrapport i regeringsuppdraget att kartlägga behov av utvecklingsinsatser för datadelning (I2021/02737).*

Digitalisation is necessary to streamline the planning, development and operations of the electrified transport system infrastructure. Data must be shared among stakeholders in the energy system, the recharging system and the transport system in order to work. VTI's report highlights data sharing as a crucial factor, including data availability, sharing and utilisation. However, many services and processes are not yet digitised. One such service, highlighted as an example in the report, is the grid connection process, which currently takes a very long time and is carried out manually. Digitising this process would make it easier for different stakeholders and speed up the process.[143]

VTI's report emphasises that data sharing among stakeholders in the transport sector and the electricity sector is needed for two overall purposes: 1) planning and 2) operation. For planning purposes, data sharing will support stakeholders in the construction of the electrified transport system. Such data include stakeholders' deployment plans and data about new technology or plans for possible transport arrangements. For operational purposes, data sharing involves how different subsystems are to be integrated and communicate with each other continuously, often in real time, in order to operate an electrified transport system. [144]

Five conditions for data sharing are identified in the VTI report: 1) digitalisation, 2) standardisation, 3) legal, 4) business models and incentives, and 5) secure data management. Many of the barriers to data sharing in recharging and hydrogen refuelling infrastructure are related to the fact that these conditions are not met today.[145]

Rather than being of a technical nature, the most significant barriers to data sharing which the VTI report identifies involve organisations which are either unwilling or forbidden to share data, or a combination of both, for a number of reasons. The effects of the above-mentioned barriers can include a slowed pace of electrification and that companies must seek ways to work around certain problems.

5.5.1 Standardisation

Digitalisation of recharging infrastructure requires stakeholders in the energy system, the recharging system and the transport system to be integrated, interact and offer high flexibility. A key component in achieving this is the use of standards.

Standardisation means developing requirements and specifications for products, services and processes. The use of standards contributes to increased quality and safety as well as, in this case, user convenience when recharging or refuelling a vehicle.

A standard produced at the request of the European Commission in support of EU legislation acquires the status of a harmonised standard after being cited in the Official Journal of the European Union (OJEU). Harmonised standards can be used to assess conformity with EU legislation in the internal market.

AFIR highlights the urgent need to develop standards to support the deployment of recharging and refuelling infrastructure in accordance with the Regulation. The lack of common technical specifications constitutes a barrier for harmonised alternative fuels infrastructure. It is therefore necessary to establish common technical specifications for areas where they do

[143] Swedish National Road and Transport Research Institute (2023), *Regeringsuppdrag om elektrifieringen av transporter. Rekommendationer för att underlätta datadelning och nyttiggörande av data för planering, utveckling och drift av laddinfrastruktur och affärsmodeller*, VTI:s ref 2021/0420-1.1.

[144] Ibid.

[145] Ibid.

not yet exist. In particular, such technical specifications should cover the communication between the battery electric vehicle and the recharging point, the communication between the recharging point and the recharging software management system (back-end), the communication related to the battery electric vehicle roaming service and the communication with the electricity grid, while ensuring the highest level of cybersecurity protection and protection of end customers' personal data.

Standardisation can also include business standards, i.e., how companies agree to do business. Such standards are essential to enable data sharing and are considered a greater barrier to data sharing than, for example, technology.[146]

5.6 Hydrogen refuelling infrastructure

As a fuel, hydrogen can be used in fuel cell battery electric vehicles as well as vehicles with internal combustion engines adapted for hydrogen propulsion. Internal combustion engines are less efficient than fuel cells, and cause air pollution that must be eliminated by special emission control devices on board the vehicle. Despite these limitations, some vehicle manufacturers acknowledge that hydrogen vehicles with internal combustion engines may have some advantages over fuel cell vehicles, especially under challenging conditions, such as extremely heavy long-distance transport.

5.6.1 Conditions for hydrogen refuelling infrastructure

Numerous barriers and challenges currently hamper the conditions for efficient and effective hydrogen refuelling infrastructure. Below is a brief summary of these barriers and challenges in various areas.

Regulations and permitting processes

Existing regulations and permitting processes in Sweden are adapted for hydrogen use in certain industrial processes as well as small-scale transport of hydrogen from production sites to industrial processing and research activities. As hydrogen will be needed in larger quantities and for multiple uses, including hydrogen refuelling stations, the regulatory framework must be updated and supplemented to adapt to these new needs. For example, the Swedish Environmental Code[147] is unclear regarding what is considered acceptable hydrogen use in terms of environmental impact. This has brought about requirements that vary depending on the level of knowledge of referral bodies and general attitudes. Another example is the lack of specifications for large-scale hydrogen storage, such as underground storage or similar. Until fairly recently, detailed regulations of non-industrial hydrogen handling were lacking, causing uncertainty among administrators and operators which has slowed introduction of hydrogen in appropriate applications. Work in this area is now underway at the Swedish Civil Contingencies Agency (MSB), which is important for development.[148]

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[146] Swedish National Road and Transport Research Institute (2023), *Regeringsuppdrag om elektrifieringen av transporter. Rekommendationer för att underlätta datadelning och nyttiggörande av data för planering, utveckling och drift av laddinfrastruktur och affärsmodeller*, VTI:s ref 2021/0420-1.1.

[147] SFS 1998:808, *Miljöbalk (1998:808).*

[148] Swedish Civil Contingencies Agency, *Förremiss – samråd kring förslag till anpassning av MSBFS 2020:1 för ökad hantering av vätgas,* ref MSB 2023-04966.

Permitting processes are complex, lengthy and unpredictable, according to analysis by WSP and its references[149]. Obtaining permits takes a relatively long time, which is partly due to unfamiliarity with hydrogen issues as well as, to a much greater extent, due to gaps in the regulatory framework and the lack of regulations and instructions, which together generate uncertainty among the public authorities concerned (emergency services, county administrative boards and municipalities). The Swedish Gas Association has recently published *H2 TSA 2023*, which includes instructions for hydrogen refuelling stations[150].

More details on laws, regulations and manuals can be found in Annex 1.

Standards

Lack of standards is a challenge for the rapid and efficient deployment and use of hydrogen refuelling stations. Standards in the field of hydrogen are intended to provide safe, widely accepted means for the production, quality-assurance, storage and transport of hydrogen, both in compressed and liquid form, and for its safe use. Numerous committees are engaged in standardisation work related to hydrogen refuelling stations, and many of these standards are expected to be finalised in 2023 and 2024. Some areas where standardisation work is ongoing include: Nozzles and dispensers for refuelling, hydrogen tanks on board vehicles, components and tanks for hydrogen fuel systems, hydrogen refuelling protocols, containers for stationary hydrogen storage. International work is also underway to develop a method for determining greenhouse gas emissions in the production, conversion to liquid form and transport of hydrogen.[151] A hydrogen quality standard for refuelling stations has recently been developed at EU level and given the status of a Swedish standard (SS-EN 17124:2022)[152].

Hydrogen production, distribution and storage

At present, the production of fossil-free hydrogen in Sweden is extremely limited and largely takes place in a few individual facilities and with a few gas suppliers. Existing refuelling stations have secured their hydrogen needs through local production and/or supply from gas suppliers with their own hydrogen production. These hydrogen stations are small and can only meet the demand of a few light-duty vehicles per day.

Most of the hydrogen refuelling stations currently planned will produce hydrogen on site via water electrolysis and are also small. A challenge for stakeholders who have commenced construction of hydrogen refuelling stations with larger hydrogen capacity (at least 1.5 tonnes/day) is to secure a supply of fossil-free hydrogen from potential producers. Producing fossil-free hydrogen is expensive, and many potential producers are constrained by lengthy and complex permitting processes. Distribution of hydrogen is also a challenge. Regulations currently require distribution to be carried out by vehicles running on liquid fuels or CNG/LNG. It is more efficient to transport hydrogen over longer distances and in larger volumes using pipelines. Currently, in Sweden this infrastructure or regulations for pipelines and large scale storage are yet in place.

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[149] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[150] Swedish Gas Association, ”Publikationer”, *Anvisningar – tankstationer för vätgasdrivna fordon, H2-TSA 2023,* retrieved 30 Sept. 2023, https://www.energigas.se/publikationer/normer-och-anvisningar/anvisningar-tankstationer-for-vatgasdrivna-fordon-h2-tsa-2023/

[151] Annika Palm, Head of the Engineering Section, Swedish Institute for Standards (SIS), and Annika Koningen, Environment and Energy Section, SIS, project manager for standardisation in the field of hydrogen, e-mail message 19/10/2023.

[152] Swedish standard SS-EN 17124:2022, *Vätgasbränsle – Produktspecifikation och kvalitetssäkring* för tankstationer för vätgas – Proton exchange membrane (PEM) bränsleceller för vägfordon.

The price of fossil-free hydrogen at the pump

Fossil-free hydrogen is currently more expensive than fossil hydrogen. According to WSP's analysis[153], the production cost is estimated to be approximately 1–2.5 $/kg for hydrogen produced from natural gas while hydrogen produced from renewable electricity is estimated to cost about 3–11 $/kg. The price of electrolytic hydrogen is largely determined by the price of electricity and, to a lesser extent, by the cost of the electrolyser and its support systems. In addition to its production cost, there is a distribution cost and other costs. The high price of fossil-free hydrogen prevents many from investing in hydrogen vehicles, especially heavy-duty vehicles, as a large investment is required before fossil-free hydrogen reaches cost parity with fossil fuels, unless appropriate measures are taken to close the cost gap.

5.6.2 Conditions for hydrogen propulsion of vehicles

Compared to battery powered vehicles, fuel cells could better fulfil the requirements for longer range and greater payloads. However, they are less energy efficient than battery electric vehicles. Similarly, in contexts where vehicles are driven in two consecutive shifts by two separate drivers, fuel cell vehicles may be preferable, as they do not need stop for a long time to recharge. In such contexts, it may not be operationally viable to wait for battery vehicles to be charged. Especially for logistics operators, faster and less frequent refuelling is important to hold down personnel costs[154].

The transport sector is a cost-sensitive market, and total cost of ownership (TCO) is an important parameter for truck owners. The price of fuel cell vehicles is currently less competitive than that of battery electric vehicles. This is due to many factors, including a more complex multi-component system and complex technologies (fuel cells with system support components, hydrogen tanks), expensive materials such as precious metals for fuel cell systems and composite materials for hydrogen tanks, and production volumes of fuel cell vehicles, which remain low. Prices for fuel cell vehicles are likely to decrease over time. Technology is constantly evolving, and economies of scale will favour fuel cell manufacturing if demand and production increase.

Another challenge facing hydrogen vehicles (fuel cell as well as internal combustion engine technologies) is the high cost of hydrogen infrastructure. This applies to production, distribution and refuelling stations, all of which are significantly less developed than recharging infrastructure for battery-powered vehicles[155]. Establishing and maintaining hydrogen infrastructure entails high costs which have a direct impact on the hydrogen price at the hydrogen tank. An analysis by the International Transport Forum[156] concludes that financial aid and lower taxes will be needed to bring the total cost of ownership of fuel cell vehicles down to the level of diesel vehicles.

The International Energy Agency considers that the competitiveness of hydrogen fuel cell vehicles in transport depends on fuel cell costs and on the construction and use of refuelling stations. Fuel-cell powered light-duty vehicles are developing to some extent. For these light-duty vehicles, the cost of fuel cells and on-board hydrogen storage must come down. This could make their prices competitive with battery-electric light-duty vehicles. For trucks, the priority is to reduce the price of hydrogen at the pump.

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[153] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

[154] H2Accelerate (2022), *Understanding and Meeting Customer Expectations for Hydrogen Trucking.*

[155] International Energy Agency (2019), *The Future of Hydrogen Seizing today's opportunities.*

[156] International Transport Forum Policy Papers (2022), *Decarbonising Europe's Trucks: How to Minimise Cost Uncertainty*, Nr. 107, OECD Publishing.

5.6.3 Deployment and establishment of hydrogen refuelling networks

The establishment of a network of hydrogen refuelling stations will be crucial for the successful integration of hydrogen-powered vehicles in road transport. At the same time, hydrogen refuelling infrastructure is not economically viable without a sufficient number of hydrogen vehicles and the resultant demand for hydrogen. How to sell hydrogen vehicles in the absence of a refuelling infrastructure, and how to ensure investment in hydrogen refuelling stations without hydrogen-powered vehicles on the road, has been discussed extensively, resulting in measures and aid programmes at global level. Several countries recognise that growth of the hydrogen vehicle market requires at least a certain number of refuelling stations to be operational before vehicles are sold. The profitability of these stations is likely to be low in the early stages, due to low utilisation rates.

5.6.4 Establishment of hydrogen refuelling infrastructure

The establishment of hydrogen refuelling stations presupposes a number of decisions related to technology for stations, whether hydrogen is produced on site or delivered, stations' hydrogen capacity, and the geographical location and the number of stations needed to meet the demand expected from a growing fleet of hydrogen vehicles.

In planning, both supply (e.g., station technology performance and cost) as well as demand (e.g., where and how often refuelling needs will arise) must be considered. Furthermore, planned hydrogen refuelling stations must comply with local safety and land use regulations. Especially given these new infrastructure technologies, permitting and compliance issues must be included early on to reduce the risk of increased costs and delays. Balanced deployment is needed to achieve acceptable hydrogen prices and sufficient availability.

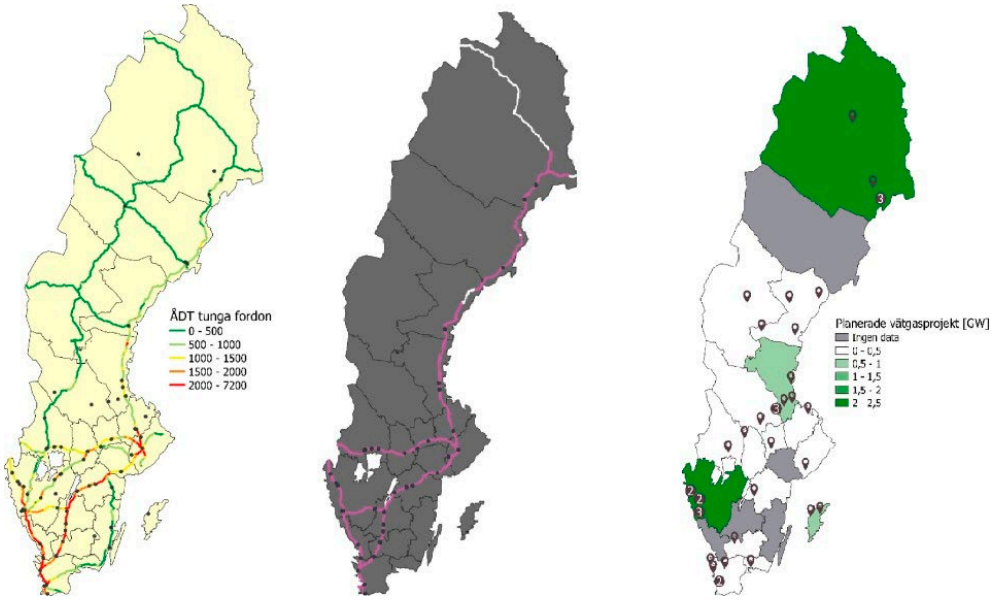

Figure 17. Location of existing and planned hydrogen refuelling stations in June 2023 (black dots) along the TEN-T core network (centre). The image on the left-hand side also shows AADT on major roads, with the different colours representing the number of vehicles. The figure on the right-hand side shows major industrial hydrogen projects providing potential synergies with hydrogen refuelling stations. Data from WSP[157].

[157] WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

Several planned stations (June 2023) will be located along roads with a high number of heavy-duty vehicles, in other words high AADT (annual average daily traffic), as illustrated in Figure 17. WSP[158], which produced the Figure, has obtained traffic data from the Swedish Transport Administration[159]. As shown, routes with more than 500 heavy-duty vehicles per day are well covered by the planned hydrogen refuelling stations. In southern Sweden, the location of the planned refuelling stations is more dense, but AADT is also higher.

Deployment of hydrogen refuelling infrastructure will need to be further developed over time. The next step is to ensure the application of AFIR's requirement to establish hydrogen refuelling stations designed for a capacity of at least one tonne per day and a dispensing pressure of 700 bar at least every 200 km along the TEN-T core network and at all urban nodes by 2030. Figure 17 shows the planned hydrogen refuelling stations that coincide at a maximum distance of 10 km from the TEN-T core network. The remaining planned stations are not located on the TEN-T core network and therefore do not contribute to the fulfilment of AFIR distance requirements. Compliance and non-compliance with AFIR distance requirements are shown in pink and white respectively. Some of these stations also fulfil capacity and dispensing pressure requirements. As shown, coverage of the core network is relatively good.

However, coverage gaps arise along the longest stretch in Norrbotten on the E10, all the way from Överkalix to Riksgränsen with no existing or planned hydrogen refuelling station. Regarding requirements for hydrogen refuelling stations in urban nodes, Stockholm, Gothenburg and Malmö have good coverage. If the TEN-T Regulation is updated, the number of urban nodes may increase, and planned coverage must be reviewed where coverage gaps risk arising.

Industrial hydrogen projects planned across Sweden are expected to increase the demand for heavy goods transport via hydrogen trucks.

The need for hydrogen-powered machinery may also increase. Most of these projects are large-scale in terms of hydrogen production and utilisation. WSP[41] has produced a map of the approximate location of these projects (see Figure 17 right). The projects are planned through 2030 and are based on WSP's mapping. Individual projects are marked on the map, and the numbers on the map represent the number of projects clustered within a smaller area. Production of fossil-free hydrogen in these industrial projects, or production facilities in neighbouring areas for industrial needs, combined with increased demand for heavy transport, creates opportunities for the establishment of hydrogen refuelling stations in these areas.

WSP's analyses show opportunities for supplying hydrogen to hydrogen filling stations from industrial electrolysers[160]. It is worth noting that the capacity needed to supply a hydrogen station is a fraction of the hydrogen volumes produced for major industrial applications. For example, hydrogen refuelling stations designed to meet the AFIR requirement of one tonne of hydrogen per day need about two megawatts of electrolyser capacity, which is low compared to the industrial needs for fossil-free hydrogen.

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158 WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

159 Swedish Transport Administration, *Nya lastkajen finns nu tillgänglig*, retrieved 30 Sept. 2023, https://bransch.trafikverket.se/tjanster/data-kartor-och-geodatatjanster/nyheter-om-trafikverkets-data/2021/nya-lastkajen-finns-nu-tillganglig/

160 WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

A further analysis has been carried out by WSP[161] to investigate the possibility of more widely distributed hydrogen production where existing, approved and planned (under consideration) wind turbines have been mapped, in comparison with existing and planned hydrogen refuelling stations.

5.7 Technological development and behavioural impact

In addition to recharging and hydrogen refuelling infrastructure, other technologies that may impact the demand for recharging and hydrogen refuelling infrastructure include battery swapping, vehicle battery size, car pooling, bi-directional recharging, electric road and plug-in hybrids with extensive electric driving distances. The descriptions below are brief and, on a general level, aim to highlight major trends. More detailed explanations are presented in a background paper[162] and in a memorandum on electric roads[163]. Each development may include niches that are not in line with the larger trend. However, these are not addressed in the current overview.

5.7.1 Battery swapping

Battery swapping involves physically changing the battery in the vehicle. The existing battery is replaced with a new and fully charged battery, rather than recharging the existing battery while it remains in the vehicle. A battery swap takes a few minutes. The swapped battery can then be charged under controlled conditions in the battery swapping station, taking into account, for example, the electrical grid and battery life. Battery swapping cars may have smaller batteries compared to conventional battery electric vehicles, but more batteries are likely to be needed in the system as a whole.

This technology has been around for a long time but has yet to be widely adopted for either passenger cars or heavy-duty vehicles. Commercial battery replacement technologies are available for passenger cars and heavy-duty vehicles, but with a few exceptions these are concentrated in the Chinese market. In China, the battery swapping market is growing rapidly from a low level, especially in the heavy-duty vehicle segment, which could stem from challenges related to grid integration, high population density, high land prices and cheap labour combined with appropriate instruments. A Chinese passenger car manufacturer has launched battery swapping vehicles in the EU, including 26 battery swapping stations, six of which are in Sweden[164]. Some applications with high daily mileage and few or unplanned stops, e.g., taxis, have shown interest in battery swapping.

There are no common standards for battery swapping technology, which in practice means that battery swapping technologies are still chained to a specific vehicle manufacturer. Business models for battery swapping, from vehicle purchase to battery rental and flexibility services to the grid, probably need further development.

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161 WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

162 RISE (2023), *Teknisk utveckling och beteende och påverkan på behov av infrastruktur,* on behalf of the Swedish Energy Agency, ref. 2022–11266.

163 Swedish Transport Administration (2023) *Elvägar – Kunskapsunderlag till hur det kan påverka utbyggnaden av ladd- och tankinfrastruktur*, TRV2022:90068.

164 Nio power Europe, *Chargermap,* retrieved 29 Sept. 2023, https://chargermap.eu.nio.com/sv_SE/pe/h5/static/chargermap?channel=official#/

Battery swapping can improve robustness in the electricity grid, both by decoupling vehicle recharging from the electricity grid and by allowing battery swapping stations to provide various services to the electricity grid in a similar way to battery storage. Such a system resembles the current system of refuelling with liquid or gaseous fuels.

Theoretically, battery swapping can reduce the need for stationary high-power recharging, publicly accessible normal recharging for those without private parking, hydrogen refuelling and electric roads, but information on this is limited. It is also uncertain how the market for battery swapping will develop. In China, these technologies have primarily been introduced in larger cities and along major motorways.

5.7.2 Battery size

The impact of battery size considered here is limited to battery electric vehicles, as increased battery size in plug-in hybrids is addressed under a different technology trend. Historically, the battery size of battery electric vehicles has increased, resulting in more mileage, better performance and faster recharging, as larger batteries can often handle higher power than smaller batteries.

These larger, and often heavier, batteries are not expected to have a significant impact on the energy efficiency of the vehicle. However, larger batteries entail increased resource use across the whole system. Battery production is relatively energy-intensive with current technology, which can give rise to significant climate impacts, depending on emissions from electricity production. The use of renewable energy, emissions trading and the upcoming EU Battery Regulation[165] reduce these challenges, due to, among other things, the requirements for reuse of constituent materials. Other trends may diminish the increase in battery size, including more car models with small batteries, especially in the mass market segment, increased energy density in batteries for the premium segment, and advanced control systems, power electronics and heating and cooling systems. More efficient powertrains in battery electric vehicles can also help reduce battery size while maintaining range.

Larger batteries in vehicles increase the robustness of the transport system by extending ranges and thus the ability to cope with disruptions related to distance or time to recharging infrastructure. Large batteries may also be favourable for bi-directional recharging, if that technology is developed. The potential of bi-directional recharging may be marginally offset by the fact that behavioural research has shown that owners of battery electric vehicles with larger batteries charge less regularly and accept a lower level of charge before commencing recharging. Large batteries can also increase the resilience of the electricity system, as the longer range favours smart recharging and demand response.

Vehicles with larger batteries can complete a greater proportion of their journeys without the need for publicly accessible recharging. This could reduce the demand for publicly accessible recharging. Even for heavy-duty vehicles, with driving distances of around 500 km, studies have shown the benefits of larger batteries and reduced dependence on publicly accessible recharging. Whilst the demand for publicly accessible high-power recharging may decrease with increased battery size, these vehicles will likely require high-power recharging to minimise recharging time once they do recharge at publicly accessible recharging points.

[165] Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC.

5.7.3 Car share

Car sharing refers to a model where users can rent a car near their home or workplace, usually for short periods of time. Users can often unlock the car digitally via an app or similar without the need for a key or physical encounter with a rental company. This overview only considers car sharing of passenger cars.

Car sharing is a widespread phenomenon, especially in larger cities. In stationary systems, cars are linked to a particular neighbourhood or business. In free-floating systems, cars can be picked up in one place and dropped off in another. Both independent operators and operators linked to vehicle manufacturers offer car sharing.

Car sharing is growing in Europe but is developing relatively slowly in Sweden. While data suggest that car sharing can replace several privately owned cars without increasing total mileage, the traffic volume of car-share cars is low compared to the total traffic volume of passenger cars nationally.

Access to mobility by car can be increased through car sharing without increasing car ownership in society. Car sharing could also constitute a mobility resource that can be reserved to maintain various important societal functions.

Car sharing fleets include more electric cars than in society as a whole, and several car sharing operators have exclusively electric cars. This could lead to a slightly faster electrification and thus more demand for recharging. Car sharing organisations mainly require local publicly accessible high-power recharging points, as they rarely have access to normal chargers where they are parked. High-power recharging increases the availability of car shares, as it reduces the time car is held up at a recharging point.

Overall, car sharing is estimated to have only marginal effects on the need for publicly accessible recharging.

5.7.4 Bi-directional recharging

Bi-directional recharging, or “vehicle to everything” (V2X), includes technologies permitting vehicle batteries to be used beyond the vehicle by allowing discharge to other applications. Most commonly, electric power is returned to the grid, but it can also be returned to buildings, other vehicles or other independent loads.

This technology is best suited for vehicles with relatively large batteries and extensive downtime each day, which is primarily in line with how passenger cars are used. The technology is still emerging, and there are currently no large-scale commercial examples, but there are more than 100 ongoing or completed projects globally. Most of this activity takes place in Europe. It is currently uncertain if, when and in which applications bi-directional recharging will become commercially viable.

Bi-directional recharging is not standardised today, but it is mentioned in AFIR. However, there is no requirement in the Regulation for bi-directional recharging to be applied. Its impact on battery life and business models is also uncertain.

Bi-directional recharging could help increase the robustness and flexibility of the electricity system but is likely to have a limited impact on the transport system. Bi-directional recharging can theoretically be used to move energy from different locations in society and restart different electricity systems.

It seems unlikely that bi-directional recharging will have any significant impact on the need for stationary high-power recharging. Bi-directional recharging can increase the time during which vehicles are connected to a recharging point, especially during the daytime when demand for flexibility services in the grid is often higher. This, in turn, may lead to increased demand for recharging points where cars in particular are parked during the day, even if not required to recharge vehicles.

5.7.5 Electric roads

Electric roads include a collection of technologies that allow electricity to be transferred to vehicles while they are travelling on the road, providing a greater range and eliminating the need for recharging stops. Power supply can either be located above the vehicle via an overhead line or below the vehicle, via a contact rail, or wirelessly, via induction. If electricity is supplied from the underside of the vehicle, both light- and heavy-duty vehicles can use electric roads. Overhead lines can only be used by heavy-duty vehicles. Vehicles must be equipped with a pantograph adapted to the electric road technology.

Electric roads could reduce the transport sector's demand for batteries and the challenges associated with batteries. The impact of reduced battery size is greatest for light-duty vehicles, which are assumed to make up around 90 percent of the battery volume in an electrified road transport system. The relatively high cost of building such infrastructure entails a limited road network, with the most heavily trafficked roads being mainly relevant for the development as electric roads.

Technical tests of electric roads have been carried out around the world, including four different electric road technologies demonstrated in Sweden and several overhead line projects in Germany. The results of these trials show that the technology of transferring power to the vehicle's propulsion system and recharging batteries works. The Swedish Transport Administration has been commissioned to build an electric road pilot between Örebro and Hallsberg.

As in Sweden, most electric road projects across Europe are run by stakeholders linked to electric road technology as well as infrastructure administrators, public authorities and ministries. There is currently little interest from the automotive industry, but some vehicle manufacturers are participating in the development of electric roads via demo projects. A need remains to gather knowledge about, among other things, the system perspective and how electric roads interact with other recharging and hydrogen refuelling infrastructure, before any expansion can occur.

To enable cross-border transport, the same electric road technology should be used internationally. AFIR does not require the development of electric roads, but it proposes the development of standards for all types of electric roads. The European Commission will also produce a report on market preferences for different zero-emission technologies for heavy-duty vehicles.

The majority of the road network will not include electric roads, so electric roads alone will not be a robust system permitting nationwide transport. Electric roads could contribute to the robustness of the transport system by providing an alternative to, for example, recharging pools, in terms of electrification.

No significant expansion of electric roads is expected in the next decade. Thus, electric roads will not have any impact on the need for stationary recharging or the rate of electrification during this period. Long-term development is difficult to assess as many factors can affect it, such as energy prices, raw material availability or battery development.

5.7.6 Plug-in hybrids

Plug-in hybrids are already a commercial technology. In the European market, today's plug-in hybrids typically have an electric driving range of 30–60 km. For longer distances, the vehicle can be powered by the internal combustion engine or stop to charge the battery. This section refers to plug-in hybrids with relatively large batteries that enable more than 100 km of electric driving, which have been introduced mainly in the Chinese market. There are no major technical obstacles to this development.

Long-distance electrically powered plug-in hybrids could gain market share in Europe, partly due to the Commission's proposal for a new emissions regulation, Euro 7. A factor working against the growth of plug-in hybrids with long driving distances on electricity is the adopted CO_2 regulations, which, in practice, will only permit first-time registration of zero-emission vehicles from 2035 onwards.

A plug-in hybrid can be considered more robust in the transport system, as it can run on both electricity drawn from the grid as well as a liquid or gaseous fuel that is refuelled. If a shortage of one energy source arises, the vehicle can use the other. It is also easier to store liquid fuels than electricity.

Plug-in hybrids generally need publicly accessible high-power recharging less than electric cars. This is not likely to be significantly changed by a slightly longer electric driving distance for plug-in hybrids. For a limited time, an increased market share for plug-in hybrids could reduce the need for publicly accessible high-power recharging, but in the longer term it will not affect demand. If plug-in hybrids increase at the expense of internal combustion engine cars, the need for AC recharging may increase in the near future.

5.7.7 Summary of technological developments

Overall, recharging pools are deemed to play a primary role in the electrification of road transport, followed by hydrogen refuelling stations. Some trends may affect the need for recharging pools and hydrogen refuelling stations. In particular, increased battery size could increase the number of journeys made without publicly accessible recharging. Car sharing, two-way recharging and electric roads are not expected to have a significant impact on the need for recharging pools or the rate of electrification in the coming decade. Battery swapping may have an impact, but it is uncertain how this market will develop.

5.8 User-friendliness and accessibility

Enabling electrification of the transport sector requires user-friendly technologies to be implemented. This section highlights how recharging and refuelling of the vehicle, at both publicly and non-publicly accessible stations, must be simple, predictable and accessible for the end user.

5.8.1 Payment solutions

Drivers of battery electric vehicles currently face a fragmented landscape of different payment solutions and interfaces when recharging their vehicles at publicly accessible recharging points, causing confusion and frustration.

Payment solutions can be divided into three categories. Ad hoc payment does not require any commitment or agreement between the driver and the service provider before recharging can take place (e.g., card payment or contactless payment). This enables spontaneous recharging,

without regard to nationality or membership agreements. Contract-based payment, on the other hand, requires an agreement between the end-user and the service provider before recharging (e.g., via an app or RFID tag[166]). Automatic authentication (e.g., Plug & Charge) is a process in which the authentication of a vehicle at the recharging point is fully automated, without any interaction from the customer; the driver simply connects the recharging point to the car for the recharging to begin. This solution requires the vehicle to be compatible with the specific Plug & Charge recharging point and is currently not considered publicly accessible as defined by the EU. Drivers must register an account, in advance, linked to a debit or credit card.

It is possible to create a roaming network for battery electric vehicles, similar to the one for mobile phones. Roaming permits drivers connected to one service provider to recharge battery electric vehicles at the recharging pools of various operators, i.e., drivers do not need multiple apps or recharging cards. This improves user experience for drivers of electric cars by offering them more recharging pools through one user account.

Several alliances or collaborations among recharging operators in Sweden permit customers to use the same app, card or chip at different operators' recharging pools. An industry agreement was reached in 2022, which will help facilitate recharging at publicly accessible high-power recharging pools by offering payment solutions without a contract.[167]

AFIR includes regulations intended to improve user experience when paying for recharging an electric car by requiring the possibility of ad hoc recharging as well as, for publicly accessible hydrogen refuelling, ad hoc refuelling.

5.8.2 Ensuring universal accessibility

Recharging points must be non-discriminatory, so that everyone in society is able to use the infrastructure. Today, recharging points are rarely adapted for people with disabilities (e.g., wheelchair users). This represents a concrete barrier for some people to own and drive a plug-in vehicle. Recharging of battery electric vehicles is a new characteristic requirement in the Planning and Building Act (PBL) as of 2020. Since that time, the Swedish National Board of Housing, Building and Planning has drawn up regulations and general advice on equipment for recharging battery electric vehicles, including certain accessibility requirements for the recharging points concerned[168]. However, very few of the recharging points installed today are constructed according to these requirements. The Swedish Transport Administration has also introduced requirements for the recharging pools subsidised by the Swedish Transport Administration's aid for high-power recharging in coverage gaps.[169]

AFIR states that transport infrastructure should enable mobility and accessibility for all users, including elderly people, persons with reduced mobility and persons with disabilities. In principle, the location of all recharging and refuelling stations, as well as the recharging and refuelling stations themselves, should be designed in such a way that they are accessible to and user-friendly for as much of the public as possible, in particular elderly people, persons with reduced mobility and persons with disabilities.

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[166] Radio-frequency identification (RFID) is a technology for reading information at a distance from transponders or memories.

[167] Drivkraft Sverige, Swedenergy and Mobility Sweden (2022) *Svensk branschöverenskommelse för förenklad laddning vid publika snabbladdningsstationer*.

[168] Swedish National Board of Housing, Building and Planning , "PBL Kunskapsbanken – en handbok om plan- och bygglagen", *Regler för laddning av elfordon,* reviewed 10 May 2023, retrieved 30 Sept. 2023, https://www.boverket.se/sv/PBL-kunskapsbanken/regler-om-byggande/laddning-av-elfordon/

[169] Swedish Energy Agency, *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*, ER2021:24 2021.

Examples highlighted in AFIR are the following: that there is sufficient space around the car park, that the recharging pool is not installed on a curb, that the connectors and buttons or screen associated with the recharging point are at an appropriate height and that the weight of the recharging and refuelling cables is such that people with limited strength can easily handle them. In addition, the user interface of the recharging point should be accessible. AFIR states that the accessibility requirements set out in the European Accessibility Act (EU) 2019/882 of the European Parliament and of the Council shall apply to recharging and refuelling infrastructure.

General recommendations and information on accessibility are partly available, but there are no general requirements for recharging points in Sweden and thus no inspection. Nor has responsibility been designated for either a strategic, holistic approach or for ensuring sufficient accessible recharging.

In addition to enabling people with disabilities to use this infrastructure, planning must aim to avoid prioritising or disadvantaging certain groups in society by its location or design.

5.8.3 Predictability and planning

Information on the offerings of recharging pools has been requested by end users to facilitate the planning of vehicle recharging. Examples include the type of recharging offered, the cost of recharging, and whether there is a free space which can be reserved.

Users also requested information on whether the recharging points are designed to enable recharging of passenger cars with trailers or heavy-duty vehicles.[170]

Information on the design of the recharging pool can be entered into the Nobil database, which is the responsibility of recharging operations. Nobil is a Nordic database of recharging points, recharging stations and recharging pools which is used in many map services currently used by drivers of battery electric vehicles. The Swedish Energy Agency is responsible for Sweden's database data. Vehicle manufacturers have expressed a desire for requirements to indicate whether a recharging point is suitable for heavy-duty vehicles. A technical solution for this exists, but the obligation for recharging operators to provide this information is not regulated.

Provisions of the Price Information Act and the Marketing Act currently require that consumers be provided information regarding the type of recharging offered and the price. Price information must be clear and accurate. AFIR regulates how prices must be presented, which will enable users to make active and informed transactional decisions when recharging.

Users also expressed a need to reserve space for heavy-duty vehicles at publicly accessible recharging pools. So far, there are no solutions for this, but several related projects are ongoing[171]. For passenger cars, a need to reserve space is also starting to emerge, which is particularly evident during holiday periods when more long distance journeys are made.[172]

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[170] Swedish Energy Agency and Swedac (2022), *Råd och rekommendationer för att minska hinder för elektrifiering av transportsektorn genom standardisering* , ref 2022-015462.

[171] Lindholmen Science Park and Volvo Technology are working on the issue in the REEL and E-charge projects. Vinnova also runs projects in this area.

[172] Swedish Energy Agency and Swedac (2022), *Råd och rekommendationer för att minska hinder för elektrifiering av transportsektorn genom standardisering* , ref 2022-015462.

Of the numerous challenges to reserving space for heavy-duty vehicles (and partly for light-duty vehicles), the following examples can be cited:[173]

- Recharging sockets may be located on different sides of vehicles, so the length of recharging cables may not be sufficient. This entails that information regarding the location of recharging points must be included when making a reservation.
- Vehicles arriving late/early must be addressed.
- If a recharging point is out of order, alternate recharging points must be clearly identified and indicated.
- Fees for cancellation or "no shows" must be addressed.
- Drop-in users must be informed that a recharging point is reserved.
- Open platforms reduce the risk that recharging operators reserve space for their own operations first, before making recharging space publicly accessible.
- Recharging customers failing to make way for subsequent bookings must be addressed.

It is worth bearing in mind that, if many requirements are imposed on recharging, most recharging may take place non-publicly, where no corresponding requirements are imposed. This is because it is easy to organise recharging but expensive to connect recharging to different types of services, e.g., visibility in apps with publicly accessible recharging networks, payment solutions, etc. [174]

5.9 Roles and responsibilities of stakeholders

Some stakeholders have a more significant role than others and thus a greater responsibility in the deployment of recharging and hydrogen refuelling infrastructure. This must be emphasised to permit clarifying the role of each stakeholder in deployment. Stakeholder maps are presented below in order to clearly and simply visualise stakeholders identified as part of deployment and the degree to which they are involved.

The maps show the assessment made by the Swedish Energy Agency and the Swedish Transport Administration of the present status of stakeholders. The maps are dynamic; stakeholders may move among different fields and new stakeholders may appear while others may disappear.

Figure 18 assumes that a recharging point is already established and aims to visualise the distribution of involved stakeholders to describe how active they are, primarily in the operation and management of the established recharging point. All stakeholders represented in the figure are involved, but to varying degrees.

[173] Swedish Energy Agency and Swedac (2022), *Råd och rekommendationer för att minska hinder för elektrifiering av transportsektorn genom standardisering*, ref 2022-015462.

[174] Ibid.

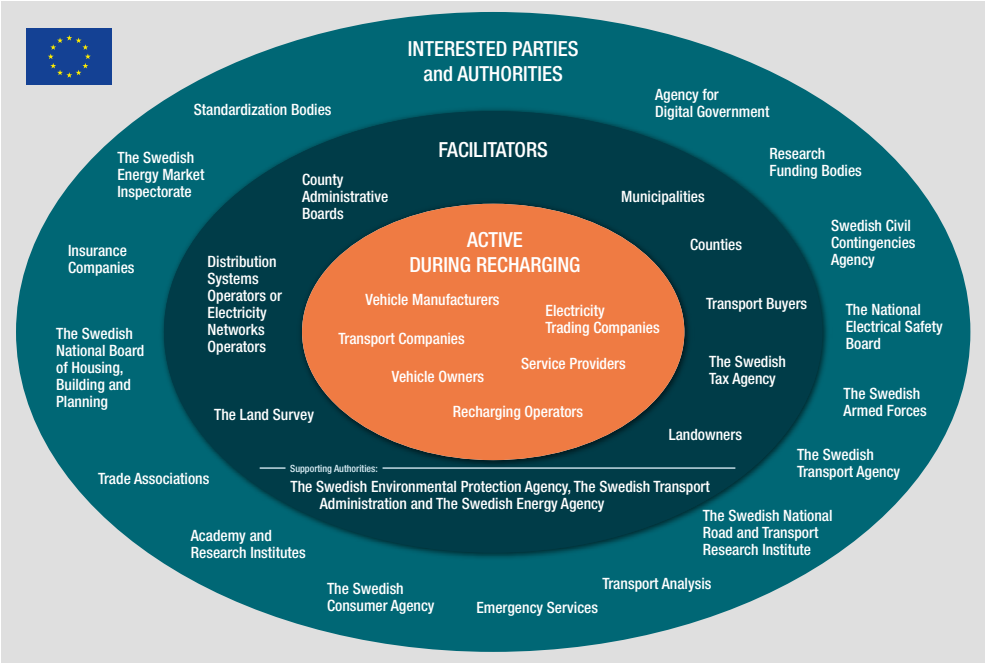

Figure 18. Visualisation of stakeholders involved when a recharging point is established.

Stakeholders have been divided into three categories. The innermost circle is categorised as “active during recharging” and brings together those stakeholders who have a more active role when recharging takes place. These may be, for example, transport companies or vehicle owners using their vehicles and generating recharging demand, electricity trading companies providing electricity to be transferred to the vehicle, or recharging operators responsible for management and operation of recharging points.

The intermediary circle is categorised as “facilitators” and describes stakeholders with an important role in enabling recharging to take place. These stakeholders may have established the recharging point with the help of aid, or they may be landowners who provided a location for the recharging point.

The third category, “interested parties and authorities”, are those stakeholders who impact the operation and management of the established recharging point based on an interest or by applying requirements. Several national authorities are identified in this category. For example, the Swedish National Board of Housing, Building and Planning, which sets requirements for recharging points in buildings.

This division of stakeholders is a simplified view of reality, and various stakeholders may serve different roles and responsibilities, moving among the categories from situation to situation.

This stakeholder map represents all types of recharging, i.e., publicly, semi-publicly and non-publicly accessible recharging of both light- and heavy-duty vehicles. The degree of involvement of each stakeholder varies. For example, service providers may be less relevant at a non-publicly accessible recharging point.

When a recharging point is not yet established, the distribution of stakeholders in each category changes, with several moving to the innermost and intermediary circles and taking on a more significant role. This is visualised in Figure 19. The stakeholders described as key stakeholders are best positioned to accelerate the deployment of recharging points. Meanwhile, stakeholders defined as “facilitators” support establishment.

Among key stakeholders, municipalities, regional stakeholders, property owners and electricity grid companies are identified as particularly important, as they have a major impact on the electrification of the transport sector. The roles and responsibilities of these stakeholders are discussed in greater detail in section 5.9.1.

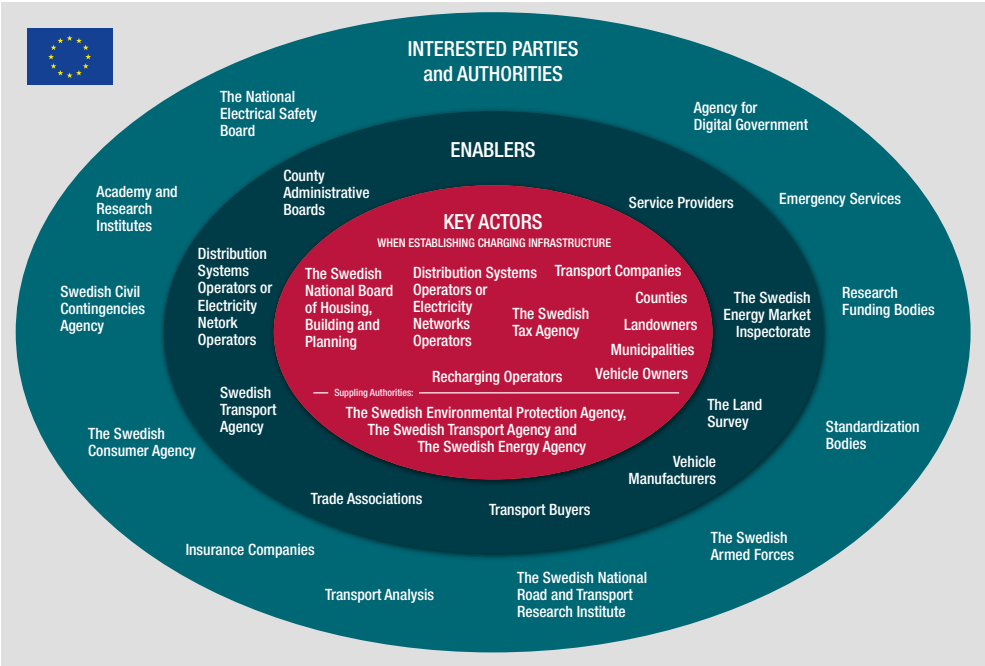

Figure 19. Visualisation of stakeholders involved before a recharging point is established.

Stakeholder maps have also been developed for the establishment and operation of hydrogen refuelling stations. Figure 20 describes the stakeholders involved in the establishment of a hydrogen refuelling station.

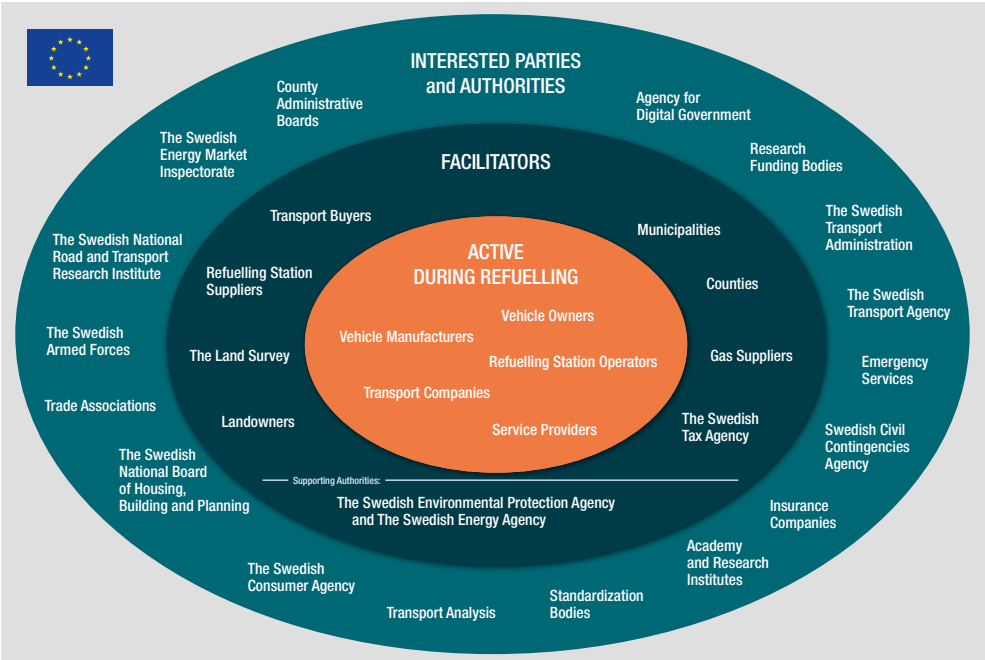

Figure 20. Visualisation of stakeholders involved in the deployment and operation of a hydrogen filling station.

Figure 21 describes the stakeholders involved before a hydrogen refuelling station is established. Authorities, emergency services, municipalities, regions, landowners, land surveyors and refuelling station operators are key stakeholders with an important role in accelerating deployment of hydrogen refuelling stations and are also seen as facilitators of established hydrogen refuelling stations.

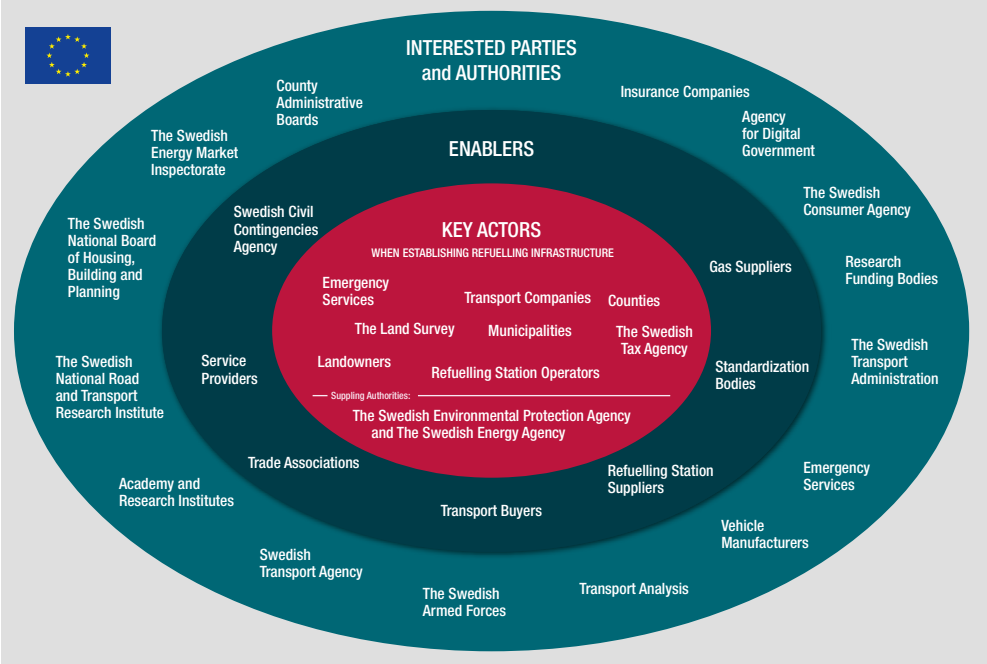

Figure 21. Visualisation of stakeholders involved before a hydrogen filling station is established.

5.9.1 Clarify and strengthen key stakeholders

An electrified transport system will grant some stakeholders changed or new roles. These stakeholders must design their roles, find a context in a new industry and gather knowledge.

Municipalities

Municipalities have been identified as a key player in the deployment of recharging infrastructure. Industry stakeholders expect much of municipalities due to their ability to influence local issues and contribute to national objectives at the local level.

Municipal planning and land use is governed by the Planning and Building Act[175]. Planning is also linked to the Swedish Environmental Code[176] and must conform to a number of environmental concerns in order to promote sustainable development. In addition to these two pieces of legislation, numerous other laws affect planning. Land use must safeguard and balance public interests in the municipality. Municipalities have a responsibility to ensure that planning processes are democratic, i.e., that participation, dialogue and empowerment are promoted.

[175] SFS 2010:900, *Plan och Bygglag (2010:900)*

[176] SFS 1998:808, *Miljöbalk (1998:808)*

Municipalities set objectives based on local conditions and challenges. National and regional objectives can provide support and improve conditions. These must be interpreted and adapted to local conditions. In these cases, municipalities must identify their role and what they can contribute nationally and regionally so that the objectives are grounded in their own strategies. In the work of transforming the transport system, numerous conflicting objectives must be managed in municipal land use, and different interests must be balanced to create healthy and attractive communities.

For many municipalities, the development of recharging infrastructure is an urgent issue with regard to electrifying the transport system, meeting resident needs and creating the necessary conditions for retaining and attracting visitors and businesses. At present, municipalities are at different stages of this process and have adopted different roles, based on local conditions (organisation, geography, local industry, market conditions, etc.), local priorities and legal interpretations.

Under the Act on Municipal Energy Planning (1977:439)[177], each municipality must have an up-to-date plan for the supply, distribution and use of energy. The County Administrative Board of Västra Götaland and the Swedish Energy Agency have been commissioned[178] to develop regional and local energy planning, as described in 1.4.6. This mission contributes to guidance and methodological support for the Act on Municipal Energy Planning (1977:439)[179], which can help municipalities.

Although municipalities do not currently have a designated responsibility in the deployment of recharging infrastructure, they can assume a role and contribute to development in several ways.

It is important to distinguish the opportunities and responsibilities of the municipal administration from those of the municipal companies. Municipal property companies can work on increasing access to recharging for tenants and other residents.

In local government, they can act as promoters by providing information and support, designing local recharging strategies, contributing to regional coordination and providing public land for the establishment of recharging points.

Below are some areas which have been identified as particularly important for municipalities to actively work on.

Formulate recharging strategies

Industry actors have, in their submissions[180] and dialogues[181], expressed a need for municipalities to clarify local recharging needs, identify suitable areas and locations for recharging infrastructure and describe municipal ambitions for deployment as well as how this should be managed and organised. This information can provide a long-term perspective and transparency to the local business community and can encourage stakeholders to invest in recharging infrastructure. The municipality's residents also benefit from the transparency of the municipality's development ambitions, as they can increase the incentive to purchase

[177] SFS 1977:439, *Lag (1977:439) om kommunal energiplanering.*

[178] Ministry of Climate and Enterprise (2023), *Uppdrag att utveckla regional och lokal energiplanering för elektrifiering,* ref KN2023/03646, KN2023/01462 (partial).

[179] Ibid.

[180] Written submission, autumn 2022.

[181] Dialogue meetings with industry, spring 2023.

an electric car. Such documentation can create the conditions for private and municipal companies to build infrastructure.

Enabling the establishment of recharging infrastructure

Municipalities can enable the establishment of both publicly accessible and non-publicly accessible recharging infrastructure on municipally owned land. Establishment can then be carried out by, for example, private operators, municipal companies or the municipal administration.

Municipal companies can provide recharging on municipal land, in municipal buildings and in homes. Municipal parking companies can also establish recharging infrastructure in their own car parks. Since the vast majority of all recharging takes place at non-publicly accessible chargers, the municipality has an important role in expanding home recharging for public housing residents.[182]

The municipal administration can establish recharging points at target sites under the auspices of the municipality, e.g., sports facilities, care homes, etc.[183] The administration has the opportunity to formulate clear guidelines for how establishment can take place, both in the municipal organisation and at municipally owned companies, in order to clarify issues of ownership, procurement, financing, payment and customer offerings.

Municipal administration can also promote electrification by procuring plug-in vehicles in their activities.

Municipalities can also drive the deployment of recharging infrastructure by ensuring that recharging infrastructure is established to a sufficient extent in all future developments and land grants as well as the design of streets and parking areas. Just as municipalities presently set requirements for the number of parking spaces in a car park, municipalities can set requirements for the number of recharging points.[184] Municipalities can also proactively make land available for future deployment of recharging infrastructure. However, electrification of the transport sector is one of many tasks assumed by municipalities, and objectives may conflict with other important land uses.

Promoting electrification among local stakeholders

Municipalities can work to promote electrification among other stakeholders, such as local businesses, private property owners and cooperative housing associations. This can be done through various initiatives. For example, supporting and disseminating knowledge, offering clear and simplified routines and processes (e.g., for land grants and building permitting), providing a forum for dialogue between stakeholders or, as previously mentioned, ensuring transparent and long-term recharging strategies. Municipalities already offer energy and climate counselling[185] to provide local stakeholders and private individuals with guidance in areas such as the establishment of recharging points.

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[182] Dialogue meetings with industry, spring 2023.

[183] SALAR's written input to the reference group in spring 2023.

[184] Swedish Association of Local Authorities and Regions (2017) *Ladda för framtiden – laddinfrastruktur för elfordon.*

[185] Swedish Energy Agency, *Energi- och klimatrådgivning,* retrieved 30 Sept. 2023, https://www.energimyndigheten.se/energieffektivisering/jag-vill-energieffektivisera-hemma/energi--och-klimatradgivning/

Municipalities work with these activities to varying degrees today. Like other stakeholders, they face several challenges in their role:

- Lack of skills and resources, in terms of both staffing and funding.
- Uncertainty about the future and the trade-off required for electrification at an appropriate pace.
- Lack of transparency between municipalities and grid owners.
- Conflicts between deployment of recharging and refuelling infrastructure and other important issues for which municipalities are responsible.
- Local variations in how municipalities work and lack of a standardised approach.

Regional stakeholders

County administrative boards

Regional coordination and leadership are requested in the electrification of the transport sector, e.g., to navigate among various types of aid and to coordinate stakeholders at regional level. Several local stakeholders have approached county administrative boards with questions and to request regional aid. The county administrative boards serve to link national authorities with municipalities and the business community at local level, pursuant to the coordination mission outlined in the appropriation directions for 2023[186]. The county administrative boards have established networks in the field of energy and climate issues and have already established an energy and climate coordination body (LEKS). LEKS indicates a strong demand for regional coordination and leadership on several issues.[187]

Regions

The regions are responsible for creating sustainable regional growth and development in Sweden pursuant to the Regional Development Responsibility Act[188]. The deployment of recharging infrastructure is essential for sustainable regional development. Access to publicly accessible recharging infrastructure for passenger cars, for example, is already crucial for the development of the tourism industry. As part of their regional development responsibilities, several regions are working to accelerate the deployment of recharging infrastructure. Many regions also work through the regional energy agencies[189] to further deployment by, for example, allocating funds and providing various support to municipalities in deployment of recharging infrastructure.

Regions can also establish recharging points and electrify vehicle fleets in their own activities, including hospitals, health centres, folk high schools and regional public transport.[190]

Regions can work with municipalities to oversee municipal recharging and energy needs and establish a region-wide perspective on the issue. The strategic position of regions permits them to monitor developments within municipalities and thus coordinate and target efforts to support those municipalities which require expertise and support in developing strategies.

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[186] Government (2022) *Regleringsbrev för budgetåret 2023 avseende länsstyrelserna,* Fi2021/02746 et al.

[187] LEKS – The county administrative boards' energy and climate coordination body. *Länsstyrelsernas roll inom elektrifiering av transportsektorn.* 22/09/2023. Swedish Energy Agency ref 2022-11266.

[188] Lagen om regionalt utvecklingsansvar (Ds 2017:61).

[189] Energikontoren Sverige, https://www.energimyndigheten.se/energieffektivisering/jag-vill-energieffektivisera-hemma/energi--och-klimatradgivning/

[190] SALAR's written submission to the reference group, spring 2023.

Property owners

The Swedish Energy Agency and the Swedish Transport Administration have identified a greater need for property owners to define their new role and what it entails. Property owners can include private property companies, cooperative housing associations or municipal housing companies, which own residential, commercial or industrial properties. Property owners decide on the installation of recharging points.

Residents without authority over their own parking depend on property owners to provide recharging. This means that property owners play an important role in home and depot recharging, since vehicle owners must resort to publicly accessible recharging infrastructure if recharging facilities cannot be provided by property owners. Users only able to access publicly accessible recharging infrastructure may entail higher costs and more planning requirements, possibly reducing incentives to purchase plug-in vehicles.

Electricity grid operators

Electricity grid operators provide grid connections, making their role in development crucial. There is a desire for electricity grid operators to be more proactive. The activities of electricity grid operators are regulated by the Swedish Electricity Act to ensure that the charges levied for the transmission and connection of electricity are reasonable. The revenues of electricity grid operators are regulated by Ei, which imposes a ceiling for the company's total revenues[191]. Regulation of the market makes electricity grid operators dependent on the profitability and cost recovery of their investments. For grid operators to work proactively, incentives must encourage investment in grid deployment that aligns with the forecast and which is not explicitly ordered. To accelerate the deployment of electricity grids, communication between customers and network operators must be improved.

Among other things, municipalities, property owners and recharging operators must work to clearly communicate the need for future recharging infrastructure. This supports grid operators in their efforts to produce grid development plans as well as increasing the incentives to work proactively, which is a prerequisite for accelerating the electrification of the transport sector.

Regarding work to streamline deployment of electricity grids for connection to recharging infrastructure, several initiatives are underway. The Swedish Energy Markets Inspectorate has delivered a report[192] pursuant to its mission to review how lead times can be reduced. Capacity maps, grid development plans and conditional agreements are further described in section 5.3.

5.10 Skills supply

Electrification creates a broad and extensive need for expertise, from permit management to the construction and operation of different types of power, infrastructure and industrial investment. The electrification of society will contribute to the development of entirely new industries which will require new skill profiles. The Swedish Energy Agency has

[191] Swedish Energy Markets Inspectorate, *Elnätsavgiften och anslutning till elnätet,* retrieved 30 Sept. 2023, https://ei.se/konsument/el/elnatsavgiften-och-anslutning-till-elnatet

[192] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:08.

been commissioned by the Government to coordinate a national effort to provide skills for electrification.[193] The first part of the mission focuses on mapping the short-term skills needs of electrification (five years).

This analysis focuses on direct employment-level effects rather than recruitment needs arising downstream, so-called indirect or induced effects in the form of, e.g., public services or employment-level effects resulting from increased production and consumption in a given geographical area.

Below are some initial conclusions regarding skills needed for the establishment of recharging infrastructure. This analysis, published in October 2023, provides a snapshot of the short-term impacts and occupational shortages resulting from the electrification of society.[194]

Transforming the vehicle fleet requires a range of new skills, not least in the automotive industry, where more engineers, technicians and specialists with expertise in electrification are needed. Industry stakeholders report needs related to a range of skills, from service technicians to micro-mobility skills.

Sufficient labour must also be available to install recharging points. Design and installation are important parts of the deployment of recharging infrastructure. For publicly accessible recharging, design, project management and installation are steps where employment-level effects can be expected.

The Swedish Energy Markets Inspectorate also highlights a shortage of labour resources to process grid connection applications, prolonging lead times for processing.[195]

The production of recharging infrastructure also has an employment-level impact. Around 10–20 companies design their own products, mainly for home and office recharging units. Swedish stakeholders are also found in the high-power recharging segment. For recharging infrastructure in public environments, wear and tear can be significant, placing greater demands on maintenance work. Property owners also have a role in operating and maintaining recharging infrastructure and require expertise in real estate economics and related areas. This places demands on suppliers as well as municipalities responsible for infrastructure planning.

In summary, the employment-level effects of recharging infrastructure are mainly seen in establishment, planning, installation and maintenance, and, to some extent, during production (see Figure 22).

Figure 22. Employment-level effects of recharging infrastructure.

[193] Ministry of Rural Affairs and Infrastructure (2022), *Uppdrag att samordna kompetensförsörjning för elektrifieringen,* ref I2022/01665.

[194] Swedish Energy Agency (2023), *Kompetensförsörjning för elektrifiering*, ER2023:21.

[195] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:8

5.10.1 Installers – a crucial role

The need for recharging is expected to increase in coming years, and the establishment of new recharging infrastructure requires sufficient expertise in several stages of the life cycle, including design, analysis, land preparation and cable laying. To a large extent, the professions for which a need is forecast are designers and project managers as well as excavator and machine operators to prepare ground.

This process is expected to be even more complicated in urban environments, where more permits are required and more factors must be considered (traffic, other infrastructure, etc.). In more sparsely populated areas, work may be less complex, but excavators and machine operators are still required to prepare the ground.

Recharging pools must be properly connected to the electricity grid. These tasks will be added to the existing work of installers, who are needed across the electricity system, where there is already a labour shortage. Electricians also have a key role in this context.[196] According to Installatörsföretagen, installers will be required to have expertise in handling load balancing and power problems in individual properties. This also requires knowledge of the electricity system as whole, in order to advise customers and build effective and safe recharging facilities.[197]

5.10.2 Expertise in hydrogen refuelling infrastructure

Skills requirements for hydrogen refuelling infrastructure were not specifically included in the first interim report for the mission on skills supply for electrification, and thus need to be further analysed and mapped[193]. In general, it can be stated that traditional skills must be broadened and deepened while new needs for skills are arising.

5.10.3 Further work

The mission to coordinate a national effort on skills supply for electrification runs over two years and is divided into two sub-projects. The initial mapping of skills needs is followed by work to identify potential barriers and challenges for the energy sector, and related sectors, in terms of skills supply, as well as to propose measures to address short- and long-term skills needs. The need for expertise linked to hydrogen will also be mapped and evaluated. The entire mission will be reported to the Government Offices by 1 December 2024.

5.11 Statistics, monitoring and reporting

The development of statistics and indicators for recharging and hydrogen refuelling infrastructure is necessary for several reasons:

- Demand for information from the public and businesses.
- Monitoring and reporting requirements. According to AFIR, progress reports must be produced monitoring, for example, fleet-dependent and distance-dependent requirements, as described in 4.1.
- Documentation enabling the design of calls for proposals and monitoring of grants.

[196] Installatörsföretagen (2019) *Kompetensbristens klimatkonsekvenser – Hur underskottet på installatörer påverkar klimatomställningen*.

[197] Installatörsföretagen (2022) *Installationer i en ny värld En trendspaning för installationsbranschen*.

National statistics and statistics showing the geographical distribution of recharging and hydrogen refuelling infrastructure are both needed.

There are presently no official statistics on recharging or hydrogen refuelling infrastructure. Statistics on recharging and hydrogen refuelling infrastructure are being developed pursuant to the mission on joint monitoring of the electrification of society (as described in section 1.4.1). Method development to quantify the number of non-publicly accessible recharging points in Sweden is also ongoing. Part of this work involves developing appropriate indicators to monitor progress.

In official energy statistics, the majority of products are designed to provide a statistically accurate picture at a national aggregate level. The breakdown of statistics at a geographical level, such as by municipality or county, is less frequent and more subject to statistical confidentiality. This is because a detailed geographical breakdown of risks revealing data subjects. It is deemed that the official statistics for recharging and hydrogen refuelling infrastructure should only include national statistics, for confidentiality reasons.

Statistics and indicators at regional and local level are also needed. At present, the Nobil database is a main source for the development of statistics on recharging infrastructure, and the Swedish Energy Agency is continuing its work to further develop the Nobil database or equivalent tools. One important aim is to produce statistics at regional and municipal level. A database, such as Nobil, must also be a main source of official statistics.

5.11.1 Development of statistics and indicators

Official statistics will be derived from several sources and, while Nobil or an equivalent tool will be the main source, official statistics will also be complemented by other sources.

Nobil[198] is a Nordic database, and the Swedish Energy Agency is responsible for its Swedish part. Nobil provides aggregated data for recharging points at national, county and municipality level in terms of number, power and type. Those receiving State aid must register their recharging points in Nobil, otherwise registration is voluntary. In the spring of 2023, Nobil started using OCPI (Open Charge Point Interface), which enables automatic linking and updating from informants to the register. One strength of this register is its standardised collection of information. As submitting information to the register is voluntary, undercoverage is a risk.

Complementary sources include the statistics product Statistik i lokaler[199], which examines the energy use of the building stock. This will be supplemented to obtain data on recharging points and their utilisation.

Another source is Småhusundersökningen[200], which is a part of the official energy statistics. Optional variables regarding recharging points have been added to that survey. The variables added include whether the property has a recharging point and its utilisation rate. Work is underway to develop regulations to make this item mandatory.

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198 Swedish Energy Agency, *Registrera din laddstation,* retrieved 30 Sept. 2023, https://www.energimyndigheten.se/klimat--miljo/transporter/laddinfrastruktur/registrera-din-laddstation/

199 Swedish Energy Agency, *Energistatistik för lokaler*, retrieved 3 Oct. 2023, https://www.energimyndigheten.se/statistik/den-officiella-statistiken/statistikprodukter/energistatistik-for-lokaler/

200 Swedish Energy Agency, *Energistatistik för småhus*, retrieved 3 Oct. 2023, https://www.energimyndigheten.se/statistik/den-officiella-statistics/statistical-products/energy-statistics-for-premises/

Collection of statistics on hydrogen refuelling infrastructure can be incorporated into the existing statistical product Leverans av fordonsgas[201]. Leverans av fordonsgas measures deliveries to final consumers of natural gas and biogas in gaseous or liquid form. Such deliveries are also registered in terms of geographical distribution.

Statistics Sweden has, in a request to the Government[202], proposed the introduction of a new statistical area: Energy infrastructure, for which the Swedish Energy Agency will be responsible. Statistics Sweden writes that: "The Swedish Energy Agency recognises the great need for official statistics on energy infrastructure, including recharging infrastructure, storage, batteries, etc., in order to monitor achievement of energy and climate goals. This must be ensured, as such statistics are only partly provided at present."

5.12 Implications for total defence and preparedness

Successful electrification of the transport sector requires analysis of its impact on society's total defence and emergency preparedness. This work must be done during the build-up phase, in which Sweden is currently, as well as on an ongoing basis as new technologies are developed, new patterns of behaviour are discerned and new threats and opportunities emerge.

Total defence and emergency preparedness require a transport system which can function even during a crisis. Essential transport can include home-care services and conveyance of patients, transport of food and water, transport of military forces and much more. At present, the transport sector is largely dependent on liquid fuels. Based on this dependence and these conditions, resilience has been built at different levels of society. As society moves towards a more electrified transport sector, new measures must be put in place to ensure that the transformed vehicle fleet is also able to function during a crisis.

Society is thus dependent on the robustness of the transport system, and this robustness must be adapted to the different phases of the transport system during its transition. The measures adopted today will need to be maintained for some time, while new measures and technologies will need to be added during the transition phase as an increasing proportion of the vehicle fleet is converted. Future security of supply must commence now, to ensure a robust transport system able to cope with various problems and challenges.

In this section, a number of risks and consequences are highlighted. Several may require further investigation in order to develop appropriate solutions and management.

[201] Swedish Energy Agency, *Ny statistik: Stor andel förnybart i fordonsgasen 2021* , Retrieved 18 Oct. 2023, https://www.energimyndigheten.se/nyhetsarkiv/2022/ny-statistik-stor-andel-fornybart-i-fordonsgasen-2021/

[202] Statistics Sweden (2021) *Hemställan om ändring i förordning (2001:100) om den officiella statistiken* (annex), A2021:2077.

5.12.1 Heightened risks

Sweden's energy supply is subject to numerous threats. These range from natural disasters and technical failures to antagonistic attacks. As more of society's essential functions become increasingly sensitive to disturbances in the electricity system, risks must be continuously analysed and updated.[203]

Threats can be divided into antagonistic, i.e., deliberate, and non-antagonistic threats. The consequences of antagonistic and non-antagonistic events can be equally serious, but their management and likelihood may be different. In the transport sector, both types of threat must be addressed. Risk and vulnerability assessments should address all risks and threats deemed relevant to the object of analysis.

Risk and vulnerability assessment

Ongoing societal changes, including rebuilding total defence, the transition and digitalisation, will bring about risks and vulnerabilities for all kinds of energy. Therefore, more analyses are needed in general, and these must be done systematically to avoid resource-intensive and market-invasive measures at a later stage.[204]

When installing hydrogen refuelling and recharging infrastructure, risk and vulnerability assessments as well as impact analyses must be carried out. Analyses are needed both by local stakeholders, such as owners of recharging or refuelling infrastructure, and at municipal, regional and national level.

Furthermore, analyses must adopt short- as well as long-term perspectives. For example, now during the transition phase, diversification of vehicles used in a municipal activity can improve security of supply, providing a different risk and vulnerability assessment for the activity compared to just a few years later. In the long term, the diversification of the vehicle fleet will probably decrease again while technological developments may create new opportunities to ensure robustness, and this must be considered.

Non-antagonistic threats

Most of the non-antagonistic threats listed below, which are considered to be of particular importance for recharging and refuelling infrastructure, are weather-related and in many cases climate change is expected to increase threats or their potential consequences.

Climate change is increasing the risk of cloudbursts and flooding in Sweden. Floods and cloudbursts can cause washed-out roads and water-filled tunnels, limiting accessibility. Some locations are particularly vulnerable, such as along rivers and coasts. This should be considered when siting recharging and refuelling infrastructure.

Large areas of Sweden are at risk of snowstorms during the winter season. In areas where this risk is considered high, the minimum accepted distance between recharging pools may need to be less than in the rest of Sweden.

The expected rise in average temperatures in Sweden may prolong the fire season. Forest fires can have a major impact, not least on accessibility and infrastructure.

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[203] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* ref 2023-008891.

[204] Ibid.

Society is likely to be impacted by new pandemics in the future, although their severity may vary. A study on changes in travel patterns during the COVID-19 pandemic showed that travel by Swedes decreased on the whole by 13 percent, between March 2020 and August 2021, compared to 2019. The study also showed that it was mainly public transport which decreased, which led to an increase in the proportion of journeys by car.[205] A rapid change in travel habits during a pandemic can place new demands on access to recharging infrastructure in particular.

Power outages are a threat which can quickly impact electricity-dependent transport, at least for longer periods of time. The most common cause of power outages is weather, including storms, thunderstorms or heavy snowfall. Technical faults, lack of power or antagonistic attacks can also cause power outages.[206] Analyses and implementation programmes are necessary to ensure that transport, especially essential transport, can function even during power outages by, e.g., providing back-up power.

Antagonistic threats

Risk and vulnerability assessments should also take into account antagonistic threats. Here are some examples of antagonistic threats that can be assumed to be particularly important to consider when analysing recharging and refuelling infrastructure.

Sabotage of recharging infrastructure and theft of lithium batteries is already occurring today, which could increase with the expansion of recharging infrastructure and increased use of lithium batteries for backup power. Theft of lithium batteries can make recharging infrastructure and backup power batteries subject to sabotage, with a subsequent repair time. The shifting price of lithium batteries can make theft more or less attractive.[207]

Increased electrification is linked to information management and cyber attacks are now the norm. Many targeted attacks are successfully prevented, but when they are not, the consequences can be severe. For example, in 2022, the municipality of Kalix was hit by a cyber attack with serious consequences for the entire organisation. As the transition and digitalisation proceed, with more businesses becoming ever more dependent on electricity and greater consequences in the event of damage, vulnerability can increase if such issues are not addressed. In the future, recharging infrastructure is assumed to be highly dependent on functioning digital systems, placing extensive demands on active cyber security work.[208]

The properties of hydrogen gas make it explosive. That makes future large hydrogen storage facilities potential targets for military attacks. This must be taken into account when siting large hydrogen storage facilities.

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[205] Swedish Transport Analysis Agency (2022) *Resmönster under coronapandemin 2020–2021*, 2022:5.

[206] Kristinformation.se (2023) Power outages, Retrieved 16 Oct. 2023 , https://www.krisinformation.se/en/hazards-and-risks/power-outages

[207] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* ref 2023-008891.

[208] Ibid.

5.12.2 Vulnerability and resilience

Increased vulnerability to electricity supply disruptions

At present, society is completely dependent on electricity to function. This is a vulnerability which must be constantly addressed and worked with, both in the electricity system as a whole and on the individual level.

Society's transition may increase vulnerability to disruptions in electricity supply. The electricity system differs from a liquid fuel system in that supply occurs from one moment to the next. Liquid fuel systems are 'slower', so that a disruption in the supply chain does not necessarily have a direct impact on supply. In the event of a major disruption to the electricity supply, battery electric vehicles risk coming to a standstill more quickly, compared to a similar disruption in fuel imports. A major disruption in the electricity supply will, of course, also affect vehicles running on liquid fuels, as traditional petrol stations are also powered by electricity. Nevertheless, liquid fuel is still present and can be accessed, in addition to the fact that it is easier to quickly move liquid fuel to an affected area.

A fully electrified fleet is more vulnerable than a diversified one. During the transition, the vehicle fleet may be more diversified than before, which is generally positive from a preparedness perspective. However, as we achieve full transition of the electrified vehicle fleet, diversification decreases again. When that occurs, more stakeholders and vital societal functions risk being affected by disruptions, and the consequences may be more extensive compared to at present.[209] Examples of such vital societal functions can include transport services and conveyance of patients, which, following total electrification of municipal vehicles, may be negatively affected by a disruption in the electricity supply, if appropriate contingency measures have not been taken in advance.

During electricity shortages, a process is activated called Styrel, which is maintained by the Swedish Energy Agency. Styrel is the "direction of electricity to prioritised users during shortages". The aim is to systematically identify and prioritise critical electricity users and facilitate critical infrastructure in the event of manual load shedding. Electrification of the vehicle fleet may require certain recharging pools and refuelling stations to be prioritised as critical infrastructure, and this needs to be included in assessments by municipalities and county administrative boards during Styrel planning work. The challenge may lie in a municipality's ability to prioritise which recharging pools or hydrogen filling stations are deemed critical.

Measures to increase resilience

Diversified electricity production is one way to increase the robustness of the electricity system. Decentralised electricity production, which can also enable island-mode operation, is also beneficial in terms of security of supply.

Various forms of backup power may become more important as society increasingly relies on electricity, not least at recharging pools or refuelling stations identified as particularly important to preparedness. At present, fossil fuels are widely used for backup power, which can increase vulnerability if fossil fuels are less available. However, there are various alternatives to fossil fuels for backup power, including batteries, hydrogen, biogas and solid and liquid biofuels. Issues that need to be addressed for these alternatives include storage

[209] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* ref 2023-008891.

stability and efficiency.[210] Several projects are currently investigating hydrogen-powered fuel cell technology for the operation of backup power generators.[211]

Hydrogen may become increasingly important to society in the future, not least for energy storage. Hydrogen gas can be stored for longer periods of time, e.g., to store the surplus energy produced during favourable weather conditions. The implementation, finances and safety of hydrogen storage for preparedness purposes must be further investigated.

Many potential measures to improve transport resilience in an electrified society also need further investigation to better clarify their role and potential.

Resilience measures should be taken both at system level and locally, at recharging pools.

5.12.3 Emergency stocks decrease with reduced use

In Sweden, diesel, petrol, kerosene and heating oil, as well as some crude oil and blended biofuels, are currently stored in what is known as the emergency stockpile, as regulated both by national law and by international agreements. Under international agreements with the IEA and the EU, Sweden has committed to having access to fuel stocks equivalent to 90 days of oil imports based on previous years' use. This means that if use changes, the amount of fuel stored in the emergency stocks in the coming years will also change.[212]

Emergency stocks are part of the regular supply chain. This means that stocks are held as reserves by commercial operators, which is not the case in many other countries. The Swedish Energy Agency monitors the proper maintenance of stocks by operators, and the costs of maintaining stocks are passed on to end users.[213]

Since the amount of fuel stored in the emergency stockpile is a function of previous years' use, the amount stored will decrease as society transitions away from fossil fuels. The commercial stakeholders that provide emergency storage today are expected to pursue their financial interest, and the transition may lead to a low willingness to invest and to divestment of storage capacity. The development of the volume of emergency stockpiles is probably not linear, but is expected to first decrease in line with use and then rapidly decrease when profitability decreases and operators choose to close down their operations.[214] This may place new demands on the Swedish State to act to maintain the requirements of the agreements with the IEA and the EU to which Sweden has committed.

Once the majority of the vehicle fleet has switched to electricity, the need for fuel reserves will decrease. However, it will not disappear completely. Much backup power today runs on fossil fuels, bringing an increased need for fossil fuels in the event of disruptions to the electricity supply. This can increase vulnerability. There are vehicles which cannot convert in the near future and which are expected to be dependent on liquid fuels for a long time to come, e.g., in the Swedish Armed Forces. Based on current regulations, biofuels cannot be stored in emergency stockpiles instead of fossil fuels, but this possibility should be further investigated.

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[210] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* ref 2023-008891.

[211] Vattenfall. (2022) *Så kan vätgas ge grön reservkraft*, Retrieved 11 July 2023 from https://energyplaza.vattenfall.se/blogg/sa-kan-vatgas-ge-gron-reservkraft

[212] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* on behalf of the Swedish Energy Agency, ref 2023-008891.

[213] Ibid.

[214] Ibid.

Regulatory frameworks adapted to new energy carriers need to be developed and must take into account changing global conditions and supply chains.[215] Work in this area is ongoing, but at national level it must be ensured that Sweden's commitments can be maintained.

Furthermore, the consequences for those critical activities which today, and at least during the transition, may depend on liquid fuels must also be considered, in the event that the current emergency stockpile is discontinued.

Future stockpiles

Various forms of stockpiles will remain necessary to ensure long-term continuous storage of fuels during crisis and war, even if today's fuel stockpiles are discontinued.

The contents of future emergency stockpiles will be influenced, among other things, by technological developments. Key issues to consider in the design of any future stockpile include organisation and funding.

5.12.4 Impact on critical transport

The deteriorating security situation and the rebuilding of total defence place increased demands on military and civil defence. At the same time, the passenger car fleet and parts of the commercial vehicle fleet are increasingly electrified.

Transition of the vehicle fleet will have a direct impact on infrastructure. The need for traditional filling station services, i.e., refuelling of petrol and diesel, will decrease while the need for recharging facilities will increase.[216]

While electrification of the transport sector can bring benefits for several critical transport services, it poses a challenge for other critical transport services, both civilian and military, which are currently dependent on fossil fuels and will be so for a long time. The transition may result in a limited and less flexible supply of fuels as civil society's demand for fossil fuels decreases, which may lead to resource-intensive market interventions at a later stage. In addition, there are challenges in further accelerating the transition of critical transport to keep pace with civil society. For example, larger emergency vehicles must be able to idle for a longer period of time for continuous operation. Vehicles of the Swedish Armed Forces also pose challenges that need to be addressed, e.g., the high performance of fossil fuels in terms of range, storage stability, climate resilience and (today) accessibility. The Swedish Armed Forces also have a longer vehicle turnover time than civilian stakeholders.[217]

Another challenge is a potential reduction in the number of resources which are subject to application of the Disposal Act[218] following electrification, at least during a transitional period. For example, public transport buses may be electrified, while being included in local or regional preparedness planning. The Swedish Armed Forces deems electricity production facilities a highly prioritised target in the event of an armed attack on Sweden,

[215] Ramboll (2023), Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas, ref 2023-008891.

[216] Ibid.

[217] Ibid.

[218] Förfogandelagen (1978:262) (the Disposal Act) is one of the enabling acts which come into force during a state of war or by decision of the Government in other crises. Under the Disposal Act, e.g., holders of means of transport can be required to arrange transport to meet the needs of total defence or public supply.

and the vehicles which would be needed under the Disposal Act must be operable under the conditions that prevail during a crisis or war.[219]

5.12.5 National and international cooperation

When society undergoes major changes in several areas at once, such as the transformation of transport and energy systems, digitalisation and the rebuilding of total defence, these changes interact. The deteriorating security situation also highlights the importance of international cooperation and host nation support. The need for cooperation and coordination is therefore great when major social transformations occur simultaneously yet partly independently of each other.[220]

Energy systems depend, to varying degrees, on open borders and cross-border trade. For example, spare parts, review and inspection staff are often located abroad. Overly localised solutions can also create barriers to interoperability and, ultimately, international cooperation. Interoperability here refers to the ability to work effectively together on a multinational basis. This can be done by exchanging services between, and utilising, systems or military forces.[221]

Sweden's ability to provide host nation support has been brought up to date during the NATO application process. Host nation support is the ability to provide support, civilian or military, to the military units of other nations or organisations present in the territory of a host nation. Both transport services and electricity supply are examples of host nation support. It is therefore important that the Swedish transition also takes into account other nations' transitions, not least as regards military vehicles.[222] This may require alternative technologies for Armed Forces vehicles to assure synchronisation with other countries' military units.

The development and deployment of new recharging and refuelling infrastructure should ensure international interoperability so that our ability to give and receive support from other nations is not negatively affected. Sweden should therefore avoid overly specific national/local systems, standards, technologies and infrastructure at refuelling stations and on roads in order to avoid the risk of reduced compatibility between Sweden's defence forces and those of NATO countries.[223] There must also be an international outlook to ensure that Sweden, regardless of its own transition process, can provide the expected host nation support to military units that have not made the same transition choices as Sweden.

Interoperability must also be ensured within Sweden to enable effective collaboration across municipal and county borders.

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[219] Swedish Armed Forces (2022) Yttrande avseende Trafikanalys förslag som leder till transportsektorns klimatomställning, FM2022-22012:2.

[220] Ramboll (2023), *Konsekvenser för totalförsvaret av nationellt handlingsprogram för laddinfrastruktur och tankinfrastruktur för vätgas,* on behalf of the Swedish Energy Agency, ref 2023-008891.

[221] Ibid.

[222] Swedish Defence Research Agency (FOI) (2023) *Svenskt värdlandsstöd – Kunskapsunderlag för civilt försvar med fokus på energi*, FOI-R--5441--SE.

[223] Ibid.

6 Implementation programme for recharging and hydrogen refuelling infrastructure

This implementation programme describes a number of measures which the Swedish Energy Agency and the Swedish Transport Administration consider important to achieve a rapid, coordinated and socio-economically efficient deployment of fit-for-purpose recharging and hydrogen refuelling infrastructure.

The measures are numbered serially but not in order of priority. The measures are not listed in order of priority as a holistic and systemic approach is needed for the measures to enable and accelerate electrification. Some of the measures can be implemented individually, while others are more interdependent and build on each other.

The proposed measures are primarily based on conclusions from the analysis chapter, but proposals are also based on the vision and background information. For some of the measures, the public authority appropriate for the mission is indicated. An investigation to identify which public authority should be responsible could not be carried out within the term of the mission.

6.1 Measures for recharging infrastructure

6.1.1 National responsibility for coordination of recharging infrastructure

In order to meet society's increased need for recharging and to achieve a fitting and socio-economically efficient deployment of recharging infrastructure, improved coordination and greater collaboration are required among, e.g., the State, business community, municipalities, regions and academia. In addition to clarity and a long-term approach, flexible planning which is continuously adapted to new conditions, requirements and opportunities is needed.

Measure 1 Appoint the Swedish Energy Agency as national coordinator for recharging infrastructure

To accelerate the electrification of the transport sector and promote the development of fit-for-purpose recharging infrastructure, the Swedish Energy Agency and the Swedish Transport Administration jointly propose to appoint the Swedish Energy Agency as the national coordinator for Sweden's recharging infrastructure. This coordination role will help ensure that the continued deployment of recharging infrastructure is based on a holistic approach and that efforts are concentrated where they are most beneficial.

This responsibility should be included as a new task in the Swedish Energy Agency's terms of reference. In the long term, the coordination role is deemed to require an organisation similar to that described in section 5.1.2. To deal with the additional task as national coordinator for recharging infrastructure, long-term governance and funding in accordance with resource needs must be assured.

A successful transition of the transport sector and rapid electrification of the vehicle fleet requires joint efforts and good cooperation. Even if the Swedish Energy Agency is given responsibility for nationally coordinating the deployment of recharging infrastructure, appropriate public authorities must be given missions and resources to assist the Agency in this work.

Measure 2 Develop knowledge support and information

Coordinated efforts to inform and support stakeholders in a coherent and effective way are needed to facilitate and accelerate the transition. The proposed coordination responsibility should include overall responsibility for market intelligence and knowledge sharing. The coordinating authority should develop informational material and carry out awareness-raising activities aimed at different parts of society. There must be close cooperation among stakeholders such as municipalities, property owners and trade organisations, so that knowledge and information reach the right target group.

Measure 3 Work with market intelligence

Tracking developments and understanding how trends and technologies change and impact infrastructure requires market intelligence. Within the framework of the coordination responsibility, a group should be formed to conduct external monitoring and analyses, develop expert knowledge, monitor and participate in regulatory work and participate in national and international forums. The knowledge developed will be disseminated to the right target groups, internally and externally, to ensure proactive and efficient deployment.

Measure 4 Create platforms for dialogue and collaboration

Collaboration among different stakeholders in society has also been identified as a key factor in accelerating the deployment of the necessary infrastructure. The coordinating authority should work actively to promote and facilitate meetings of, and the sharing of knowledge, experiences and plans among, stakeholders. Dialogue platforms aimed at creating a common understanding among stakeholders and contributing to increased knowledge and action on current issues should be developed. Such dialogue should involve stakeholders from the entire value chain, such as national public authorities, county administrative boards, trade organisations, companies, innovation and education stakeholders and researchers.

The dialogue platforms are also expected to provide important input for development of policies, support, measures and research efforts.

Measure 5 Increase support to municipalities

Municipalities are a stakeholder repeatedly identified as important in the transition. Both as an administrative organisation and with municipal companies, municipalities can facilitate recharging for residents and employees. A well-developed recharging infrastructure can also increase the attractiveness of municipalities for visitors and businesses.[224]

To clarify the work of municipalities in this area, they are encouraged to formulate strategies for recharging infrastructure clarifying the deployment's ambitions, organisation and management as well as local recharging needs. This recharging infrastructure strategy should be updated regularly to ensure that the information is up to date and targets can be monitored. Such a strategy is best coordinated with municipal energy planning.

[224] SALAR – Written submission 16 Oct. 2023.

The national coordination responsibility, together with the proposed regional coordination via the county administrative boards, should actively work to support municipalities in their work to develop strategies for recharging infrastructure. This support can take the form of knowledge sharing, assistance in interpreting regulations and laws or facilitating dialogue platforms for the exchange of experiences. Municipal energy and climate counsellors may also be a suitable partner on these issues.

Measure 6 Assign county administrative boards responsibility for regional coordination

Regional coordination on issues related to the transition of the transport sector is requested by several stakeholders. The county administrative boards serve to link national authorities with municipalities and the business community at local level. As a result, LEKS deems the county administrative boards well-suited to this type of task.[225]

In order to increase regional coordination and assist the coordination function, the county administrative boards should be given a clear and funded mandate to become a regional party to the national coordinating authority and assist with the coordination of recharging infrastructure in the counties.

Measure 7 Collect and coordinate grants

Aid and instruments should be designed to maximise their benefits. To achieve this, aid must be continuously analysed, developed and coordinated in dialogue with the stakeholders impacted by the aid.

Given that this will lead to an increased rate of deployment, all State investment aid for recharging infrastructure should be gathered under the proposed coordination responsibility of the Swedish Energy Agency. This can help ensure the uniform assessment of needs, more efficient grants and simple, clear processes for aid applicants.

Taking over existing aid from other authorities must be done over time and must be carefully planned and executed in cooperation with the authorities concerned so as not to affect the pace of deployment. However, shifting aid geared towards recharging infrastructure for heavy-duty vehicles, should be prioritised.

Measure 8 Ensure participation in work at EU level

It is important that Sweden actively participates in the work at EU level. The main forum for this is the European Commission's expert group, the Sustainable Transport Forum[226]. The mandate of the expert group has been extended[227] through 31 December 2030. Its tasks are supporting the Commission in developing policy initiatives in the area and preparing delegated acts as well as implementing acts in an early phase. The expert group also promotes interaction among Member States, the Commission and various stakeholders as well as the exchange of best practices.

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[225] LEKS – The county administrative boards' energy and climate coordination body. *Länsstyrelsernas roll inom elektrifiering av transportsektorn.* 22/09/2023. Swedish Energy Agency ref 2022-11266.

[226] European Commission, Sustainable Transport Forum (STF), https://transport.ec.europa.eu/transport-themes/clean-transport/sustainable-transport-forum-stf_en

[227] Commission decision of 9.12.2020 on renewing the group of experts on alternative transport fuels ('the Sustainable Transport Forum'). C(2020) 8535 final.

One example of an analysis to which Sweden should contribute is the market readiness report on the electrification of heavy-duty vehicles which the Commission must produce by 31 December 2024 as required by AFIR.

The public authority participating in the European Commission's expert groups will require support from other authorities and this work should be carried out within the coordination task.

6.1.2 Deployment of fit-for-purpose recharging infrastructure

Foundation of fit-for-purpose recharging and hydrogen refuelling infrastructure

The February 2023 interim report identified some barriers to home, depot and semi-publicly accessible recharging. Some of these, in turn, were based on the Swedish Energy Agency's previous Government mission: *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*[228].

Since the February interim report, several initiatives have been launched to remove barriers. The Swedish Transport Agency has been tasked with reviewing and simplifying certain rules relating to public land (see section 1.4.4) and a Government inquiry has been appointed to remove barriers to the electrification of the transport sector where, among other things, barriers for residents in community properties are identified (see section 1.4.2). GBER has now been updated, and the previous condition for public accessibility of recharging infrastructure has been removed, permitting the possibility of subsidising non-publicly available recharging (section 4.7). Negotiations are underway concerning a revised EPBD which may impose more stringent requirements in this area.

The new initiatives must be monitored and any additional measures implemented. Below are some suggestions for additional measures to facilitate home, depot and semi-publicly accessible recharging. The current aids for home and depot recharging, Ladda bilen and Grönt avdrag, should also be maintained to support recharging when other barriers are removed.

Measure 9 Assess the need for improved legislation on residents' access to recharging

The European Commission's proposal for a revised EPBD includes proposals for access to recharging, strengthening the rights for those currently lacking the authority to install recharging points (e.g., residents of cooperative housing associations and rental properties). When the outcome of the EPBD negotiation is finalised, the needs and conditions related to clarifying Swedish legislation regarding residents' right to plug should be examined on this basis.

Measure 10 Evaluate the need for publicly accessible recharging for those without access to private parking

Residents without access to private parking may find it difficult to access home recharging. Some can recharge at other destinations, such as at work, but many rely on publicly accessible recharging. The need for publicly accessible recharging needs to be mapped, and tests are

[228] Swedish Energy Agency (2021), *Analys och förslag för bättre tillgång till laddinfrastruktur för hemmaladdning oavsett boendeform*, ER2021:24.

being carried out in a project funded by Strategic Vehicle Research and Innovation (FFI)[229]. Within the coordination responsibility, models should be evaluated and, if appropriate, knowledge should be disseminated to municipalities.

Measure 11 Introduce dedicated aid for non-publicly accessible recharging for heavy-duty vehicles

Separate aid for non-publicly accessible recharging for heavy-duty vehicles from the Climate Leap initiative, similar to the Ladda bilen aid for passenger cars. Achieving this will require a review of the regulatory framework for grants.

Measure 12 Extend aid to large property owners who wish to install numerous recharging points

Large property owners wishing to install many recharging points for home recharging are quickly reaching the limit of maximum aid within Ladda bilen. This proposal includes a review of how grants to large property owners may be designed.

Measure 13 Prepare investment aid for semi-publicly accessible recharging

Semi-publicly accessible recharging is considered central to accelerating the electrification of heavy-duty vehicles in particular. Investment aid for semi-publicly accessible recharging is therefore deemed to be socio-economically efficient. The proposal is to prepare regulations and requirements to support semi-publicly accessible recharging.

Fit-for-purpose deployment along the EU core road network

Measure 14 Maintain aid for deployment as required by AFIR

According to the analysis of the status of existing and planned recharging pools and hydrogen refuelling stations in relation to the AFIR requirements, some gaps must be covered (see section 5.2.1). It is proposed that State aid be included in overall aid within the coordination responsibility, and that such aid can be granted to new recharging pools or for the upgrading of existing recharging pools along the designated road network. The focus of aid for geographical coverage or capacity increase must be analysed, and the appropriate level of aid must be investigated in connection with its design. Input to the implementation programme indicates that aid level should be lower than 100 percent.

Measure 15 Assign the Swedish Energy Agency to develop policy frameworks according to AFIR

AFIR requires Member States to develop national policy frameworks, which must include an assessment of the current situation and future development of the market for alternative fuels in transport, national objectives and targets for recharging pools and hydrogen refuelling stations, and measures to meet these objectives and targets.

Member States must report a draft national policy framework to the European Commission by 31 December 2024. These drafts are reviewed by the Commission, which communicates comments to each Member State. The final version of the policy framework is then reported to the Commission by 31 December 2025.

[229] RISE and Lindholmen Science Park (2023) *El för fler.*

The Government should assign the Swedish Energy Agency to develop policy frameworks according to AFIR. This work should be carried out under the coordination responsibility. The need for contributions from other public authorities, such as the Swedish Transport Administration and the Swedish Transport Agency, is also important to emphasise.

Fit-for-purpose deployment beyond the EU core road network as well as to ensure robustness and redundancy

Measure 16 Target aid for publicly accessible high-power recharging for light-duty vehicles in coverage gaps along major roads

Publicly accessible high-power recharging is relatively well developed along some major roads, mainly in southern Sweden, while access is poorer in other parts of the country. Fit-for-purpose publicly accessible high-power recharging is deemed possible through deployment according to the Swedish Transport Administration's analysis and criteria for coverage gaps.

State investment aid should continue to be targeted with a focus on covering major roads with high-power recharging for long-distance passenger journeys according to the Swedish Transport Administration's criteria for coverage gaps. This focus provides initial geographical coverage of high-power recharging for light-duty vehicles throughout the country. Capacity needs to be replenished as the number of vehicles increases, but the need for aid decreases as the number of vehicles increases.

It is proposed that State aid be included in overall aid within the coordination responsibility, and can be granted to new recharging pools or upgrading of existing recharging pools along the designated road. The appropriate aid level needs to be investigated in connection with the design of the aid, but input to the implementation programme suggests that the aid level should be less than 100 percent.

Measure 17 Further develop aid for publicly accessible high-power recharging for heavy-duty vehicles

The availability of publicly accessible high-power recharging for heavy-duty vehicles is currently low. More than 170 recharging pools have been granted aid, with the majority of these recharging pools located along major roads in southern Sweden. In order to achieve fit-for-purpose infrastructure, targeted State investment aid is proposed to cover the national core road network according to the same requirements as AFIR, followed by, as a starting point, iterative coverage of the functionally prioritised road network for freight transport based on the national core road network. This iterative coverage would be based on distance from the national core road network and requirements for number of recharging points, their power and recharging standard. This focus provides initial geographical coverage of high-power recharging for heavy-duty vehicles throughout the country.

In the near future, however, the need to increase capacity along important freight routes may be more urgent, and any focus on aid for geographical coverage or capacity increase must be analysed in the design of the aid. It is proposed that State aid be included in overall aid within the coordination responsibility, and can be granted to new recharging pools or upgrading of existing recharging pools along the designated road. The appropriate aid level needs to be investigated in connection with the design of the aid, but input to the implementation programme suggests that the aid level should be less than 100 percent.

Measure 18 Launch study to identify critical sites

In addition to geographical coverage and sufficient capacity in a normal situation, the system also needs robustness, reliability and redundancy. Specific locations may need to be designated critical where, for example, extra recharging points, islanding in the electricity system, etc. are established. An appropriate public authority should be tasked with identifying these sites.

Measure 19 Assess land needs for recharging

There may be a need for new land for recharging infrastructure. To analyse the needs and opportunities for new land, the appropriate authority should be tasked with investigating this need. This investigation must consider the need for existing and new land in terms of home and depot recharging, semi-publicly accessible recharging and publicly accessible high-power recharging.

Measure 20 Use public right of way to make land available for charging

The societal and market demand for publicly accessible recharging pools, as well as the requirements of the AFIR, implies a need for land along major roads. The Swedish Transport Administration has investigated the legal basis for making land used for roadway facilities, such as rest areas, available for recharging and has concluded that this is possible. The proposal is to give the Swedish Transport Administration, and other authorities that have asserted right of way on land along major roads, the task of preparing the necessary installations for new construction and, where conditions permit, making existing land available to external operators to establish publicly accessible recharging pools.

6.1.3 Grid capacity and shorter connection lead times

Long lead times for grid connection and access to power in the electricity grid are described by several stakeholders as major barriers to the expansion of recharging infrastructure. A Government inquiry has been appointed to examine barriers and opportunities and propose measures to shorten lead times, and the scope of this inquiry is described in section 1.4.2.

Section 1.4.6 describes the mission of the County Administrative Board of Västra Götaland and the Swedish Energy Agency to develop regional and local energy planning. This includes, among other things, methodological support in calculating future electricity and power needs to support local and regional stakeholders.

Measure 21 Assign suitable public authority to investigate whether and how to create capacity maps

With this measure the Government commissions the appropriate authority to investigate how and whether capacity maps should be produced in accordance with the proposal from the Energy Markets Inspectorate.[230] Capacity maps involve grid owners identifying locations based on available power and where grid projects are underway or imminent. This could provide recharging operators with, for example, knowledge of suitable locations for the installation of recharging infrastructure.

[230] Swedish Energy Markets Inspectorate (2022) *Kortare ledtider för anslutning av nya laddningspunkter till elnätet*, Ei R2022:08.

Measure 22 Monitor EU regulations on demand response and assess conditional agreements

A conditional agreement is a contract granting grid operators the possibility to limit customer use of the grid in certain situations in order to manage overload. The Swedish Energy Markets Inspectorate deems that there are situations where conditional agreements can contribute to the work of grid operators and efficient grid utilisation, but also notes that the regulatory framework for conditional agreements is not clear.[231]

Work is currently underway in the EU to develop new rules for demand response in accordance with the Electricity Regulation. These rules should clarify the conditions for conditional agreements. Once the new regulatory framework is in place, a new assessment should be made regarding how to address conditional agreements.

Measure 23 Assess the need for additional measures after network companies have reported their grid-development plans

Grid development plans are a tool to facilitate the ability of grid operators to motivate proactive grid expansion as well as the coordination and efficiency of grid expansion. The requirement to develop grid development plans is contained in Article 32(3) of the Electricity Market Directive[232] and is implemented in the Swedish Electricity Act[233].

The Energy Markets Inspectorate is currently preparing regulations to be issued in accordance with Chapter 3, Section 17 of the Swedish Electricity Act. Ei's regulations state what a grid development plan must include and how it must be produced, as well as the publication of the grid development plan and information to be published together with the plan.

In late 2024, grid operators must report their grid development plans for the period 2025–2034. After this reporting, monitoring should be carried out and the need for additional measures should be assessed.

Measure 24 Assign the Swedish Energy Agency to assess how battery electric vehicles can contribute to the flexibility of the energy system

By 30 June 2024 and every three years thereafter, Member States must, under AFIR, assess how the deployment and operation of recharging points could enable battery electric vehicles to further contribute to the flexibility of the energy system, including their participation in the balancing market, and to the further absorption of renewable electricity. The Government should commission the Swedish Energy Agency to develop this documentation. The Energy Markets Inspectorate should be commissioned to assist.

Measure 25 Monitor the development of bi-directional charging

Bi-directional recharging, or "vehicle to everything" (V2X), includes technologies permitting vehicle batteries to be used beyond the vehicle by allowing discharge to other applications.

It is currently uncertain if, when and in which applications bi-directional recharging will become commercially viable. The technology is emerging and there are no large-scale commercial examples. However, many projects and pilots exploring the technology and its potential to contribute to electricity system flexibility are ongoing.

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231 Swedish Energy Markets Inspectorate (2023) *Villkorade avtal*, R2023:08.

232 Directive (EU) 2019/944 of the European Parliament and of the Council on common rules for the internal market for electricity and amending Directive 2012/27/EU.

233 SFS 1997:857 Ellag.

The coordinating authority should, in collaboration with the Swedish Energy Markets Inspectorate, the National Electrical Safety Board and other relevant stakeholders, monitor developments in the area of bi-directional recharging to ensure that this technology, if it achieves a commercial breakthrough and proves to have positive effects, also has the right conditions to contribute to the electrified transport system and society as a whole.

Measure 26 Assign the Swedish Energy Markets Inspectorate to assess how bi-directional recharging can reduce costs

AFIR requires that, on the basis of input from transmission system operators and distribution system operators, the regulatory authority of each Member State shall assess, by 30 June 2024 and every three years thereafter, the potential contribution of bidirectional recharging to reducing user and system costs and increasing the renewable electricity share in the electricity system. The Swedish Energy Markets Inspectorate should be commissioned to produce this information. The Swedish Energy Agency should be commissioned to assist in this work.

6.1.4 Digitalisation

Vinnova and VTI have been commissioned by the Government to analyse the challenges of data availability, data management and data sharing. Read more about this in section 5.5. The following measures are based in whole or in part on the conclusions and proposals from the final reports of these missions.

Measure 27 Appoint appropriate public authority supervisory responsibility for provision of static and dynamic data via the national access point

Operators of recharging points and refuelling stations for alternative fuels are required by the AFIR to provide certain static and dynamic data via the national access point. Such data may include physical characteristics, opening hours, operational status, whether the point is used or not, prices and whether it uses renewable electricity.

A prerequisite is that requirements for information security and personal data protection can be maintained and that this does not pose a risk to Sweden’s security. Similarly, it may not grant illegal competitive advantages.

An appropriate authority is designated as the regulator of the provision of static and dynamic data.

Measure 28 Examine legislation to promote data sharing

Open standards should be promoted and developed at EU level. Open standards and frameworks allow stakeholders to use and connect to a common mode of exchanging data. This increases interoperability. Avoiding proprietary technologies requires active governance and promotion of open solutions.

A mission to investigate possibilities to adapt or clarify legislation in order to remove barriers to data sharing and to develop new laws that support digitalisation and data sharing for electrification purposes should be given to the appropriate authority.

6.2 Measures for hydrogen refuelling infrastructure

This section describes proposed measures aimed at encouraging efficient and effective hydrogen refuelling infrastructure. Developments in the deployment and use of hydrogen refuelling stations are strongly linked to the development of hydrogen infrastructure at national level based on the demand for fossil-free hydrogen from user sectors, as well as the availability and costs of production, transmission and distribution of fossil-free hydrogen as the hydrogen value chain develops. These factors are complex and require numerous inquiries which are beyond the scope of this mission. However, most of these inquiries are included in the government assignment to coordinate the work on hydrogen in Sweden[234], which is also under the authority of the Swedish Energy Agency. The results of this mission should be further used to investigate, together with the relevant authorities, the deployment of hydrogen refuelling stations for the period after 2030. The measures below are also numbered in this section by number in no particular order of priority.

6.2.1 National coordination for hydrogen refuelling infrastructure

Measure 29 Develop national coordination for deployment of hydrogen refuelling infrastructure

During the mission, the great need for national coordination for the effective deployment of hydrogen refuelling infrastructure has emerged, including collaboration among authorities, exchange of information and experience among all stakeholders, and a number of investigations and analyses. A large part of this work will take place in a broader perspective, within the government assignment to coordinate the work on hydrogen in Sweden[235], which commenced at a later date. It is therefore proposed that the coordination of hydrogen refuelling infrastructure, and its implementation, be investigated within that mission.

Measure 30 Develop investment aid for hydrogen refuelling stations

Investment aid for hydrogen refuelling stations may be a prerequisite during a transitional period, as the refuelling stations need to be in place before the vehicles arrive. This mission will investigate how aid levels can be harmonised with the development of the hydrogen vehicle market. It will also propose how investment aid for refuelling infrastructure can be adapted to new EU regulations, AFIR and GBER, with a plan for how long the aid will be in place to avoid major changes in the conditions for stakeholders. This mission should summarise information on available national and EU aid with guidance on application processes and procedures.

Furthermore, necessary aid to upgrade planned stations which do not fulfil AFIR capacity and pressure requirements needs to be evaluated.

[234] Ministry of Climate and Enterprise (2023). *Uppdrag att samordna arbetet med vätgas i Sverige.* Ref KN2023/02715

[235] Ibid.

Measure 31 Monitor the need for operational aid to hydrogen refuelling stations

Operating costs may initially be a barrier to operating hydrogen refuelling stations. The Swedish Energy Agency must monitor developments and, if necessary, prepare a regulatory framework for time-limited operating aid for hydrogen refuelling stations. If operating aid is needed, the European Commission must be notified of an exemption from State aid rules for aid to the operation of hydrogen refuelling stations.

6.2.2 Enabling safe handling of hydrogen

Measure 32 Supplement the relevant regulatory framework for handling of hydrogen

Existing regulations, such as the Environmental Impact Assessment Regulation[236], the Swedish Environmental Code[237] and the Act on Certain Pipelines[238], partly fail to address the production, storage and distribution of hydrogen.

The Environmental Code, unlike the Act on Flammable and Explosive Articles, lacks clarity regarding what is considered acceptable and what must be addressed concerning hydrogen, so the requirements vary greatly depending on the level of knowledge of referral bodies and general attitudes.

It is proposed that the MSB and the Environmental Protection Agency be commissioned to analyse and identify areas where the acceptable risk level vis-a-vis flammable and explosive articles also constitutes an acceptable risk level under the Swedish Environmental Code. This assignment shall also include a sub-assignment to the MSB to analyse the possibility of updating the ADR-S 2023 regulation (MSBFS 2022:3 regarding the transport of dangerous goods by road and off-road)[239] to remove the limitation on fuels for transportation of hydrogen on a truck trailer.

Measure 33 Streamline permitting processes for the establishment of hydrogen refuelling stations

In general, the market suffers from complex, long and unpredictable permitting processes that delay the deployment of hydrogen refuelling stations[240]. To reduce the complexity and duration of the permitting processes, clear directives at a national level and better coordination among permitting bodies are needed, such as consultation processes for facilities that affect the public, when a new detailed development plan is required for the establishment of a hydrogen station and upon connection to electricity grid for local hydrogen production.

The Swedish Energy Agency should be commissioned to, in consultation with the MSB, develop clear guidelines or supplement existing processes for handling matters regarding hydrogen filling stations in order to quicken the permitting process.

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236 SFS 2013:251, *Miljöprövningsförordning.*

237 SFS 1998:808, *Miljöbalk.*

238 SFS 1978:160 *Lag (1978:160) om vissa rörledningar.*

239 MSBFS 2022:3 *om transport av farligt gods på väg och i terräng (ADR-S 2023).*

240 WSP (2023), *Vätgasens roll i transportsystemet,* ref 2022-11266.

Measure 34 Disseminate knowledge in relation to hydrogen refuelling station safety

In order to quicken permitting processes and strengthen the knowledge of hydrogen among the responsible authorities that process permits for hydrogen filling stations, it is proposed that the MSB be commissioned to develop training material on hydrogen safety. The target audience for the training material should be emergency services and municipalities dealing with hydrogen refuelling stations, as well as other market stakeholders with roles in the deployment of hydrogen refuelling stations.

Measure 35 Develop knowledge base for planning and building permits

To improve security and facilitate planning by municipalities and companies linked to hydrogen, clear rules are needed. Several municipalities feel that they lack the time, knowledge or resources to manage hydrogen initiatives. Thus, they request more information and assistance in dealing with hydrogen infrastructure.

Emergency services, county administrative boards and municipalities are, naturally, unaccustomed to dealing with hydrogen, which means that case processing can take longer.

The coordinating authority, with the assistance of other relevant stakeholders, should produce a handbook for municipalities with the purpose of

- providing knowledge regarding hydrogen refuelling stations and hydrogen infrastructure,
- addressing land access issues for hydrogen refuelling infrastructure and building permit applications for hydrogen refuelling stations.

Measure 36 Recommend stakeholder participation in standardisation work on hydrogen refuelling stations

The purpose of standards is to create uniform and transparent practices that stakeholders can agree on. Standardisation work is ongoing in a variety of committees related to hydrogen refuelling stations. Standards and standardisation provide an important and essential basis going forward. This work can help detect areas where existing standards can be utilised and implemented as well as areas where the development of wholly new standards may be proposed.

Affected companies, such as vehicle and petrol station manufacturers, petrol station operators and gas suppliers, as well as public authorities, are well-situated to contribute to standards through active participation in their development within SIS[241].

The Swedish Energy Agency and the Swedish Transport Administration recommend that stakeholders contact SIS for information and to participate in standardisation work.[242]

[241] The Swedish Institute for Standards, SIS, is a non-profit association appointed by the Government as the Swedish standardisation body within the areas of responsibility of ISO (the International Organization for Standardization) and CEN (the European Committee for Standardization). SIS brings together networks of experts in different fields to create and influence international standards (Swedish Institute for Standards, SIS).

[242] Annika Palm, Head of the Engineering Section, Swedish Institute for Standards (SIS), and Annika Koningen, Environment and Energy Section, SIS, project manager for standardisation in the field of hydrogen, e-mail message 19/10/2023.

6.2.3 Strategic localisation of hydrogen refuelling stations

Measure 37 Monitor deployment of planned hydrogen refuelling stations and compliance with EU regulations

It is proposed that statistics on hydrogen refuelling stations be included in the statistics on vehicle gas filling stations (see section 5.11).

The Renewable Energy Directive (RED III) requires Member States to introduce a voluntary labelling scheme for products made from renewable energy. EU Member States must also report the amount of RFNBO (including hydrogen) which each country imports or exports. It is proposed that the Swedish Energy Agency remains the responsible authority for reporting under the Renewable Energy Directive. The preparation of AFIR progress reports is described in Measure 47.

Measure 38 Monitor aid granted

It is proposed that the Swedish Energy Agency, in collaboration with the Swedish Environmental Protection Agency, be commissioned in 2024 to develop a plan for monitoring and evaluating planned refuelling stations, with a particular focus on the stations that have received funding from regional electrification pilots and the Climate Leap initiative.

This evaluation should also include knowledge building and dissemination of information from the programmes.

Measure 39 Investigate robust deployment of hydrogen refuelling infrastructure

It is important that refuelling stations be developed with robustness in mind, especially in the early stages before the technology is fully mature, which can help avoid disruption and inefficiency for end users. The requirements of AFIR are considered to achieve a certain robustness, as they would enable refuelling at another station along the TEN-T network if one station is out of service.

This measure means that the Swedish Energy Agency, within the framework of its coordination responsibility in 2025/2026, will investigate how to achieve redundancy that is socio-economically beneficial in terms of time and the growing vehicle fleet, and propose how the conclusions of this investigation can be applied to the development and deployment of hydrogen refuelling infrastructure.

6.3 Joint measures

6.3.1 User-friendly

Measure 40 Assign appropriate public authority to monitor AFIR 'recharge/refuel on an ad hoc basis' requirements

Users currently face a fragmented landscape of different payment solutions, particularly in the area of vehicle recharging, where agreements often need to be concluded between drivers and the provider of recharging (e.g., via apps, RFID tags[243]). AFIR requires that end users are able to recharge or refuel on an ad hoc basis at publicly accessible recharging stations or hydrogen refuelling stations.

[243] Radio-frequency identification (RFID) is a technology for reading information at a distance from transponders or memories.

Implementation of AFIR's 'recharge/refuel on an ad hoc basis' requirements must be monitored by the appropriate authority.

Measure 41 Assign appropriate public authority to ensure compliance with price transparency

AFIR regulates requirements that the ad hoc price and any usage fee for recharging with an output of at least 50kW, or pricing components for recharging with an output of less than 50 kW, must be displayed or made easily accessible to the consumer before recharging starts in order to facilitate price comparisons. Prices charged by operators of publicly accessible recharging points must be reasonable, easily and clearly comparable, transparent and non-discriminatory.

The appropriate public authority is commissioned to ensure compliance with price transparency.

Measure 42 Assign appropriate public authority to monitor accessibility of recharging infrastructure

There is currently no uniform standard regarding what constitutes accessible recharging infrastructure which is inclusive and accessible to all.

The appropriate authority needs to monitor the implementation of AFIR and how Sweden intends to ensure compliance with the Accessibility Act (EU) 2019/882. Any necessary additional regulations must be developed.

6.3.2 Skills development

Electrification impacts industries in different ways and gives rise to different skills needs. As the transport sector moves towards an increasingly electrified, digitalised and complex transport system, new skills will be required.

Measure 43 Monitor continued work within the Government mission to analyse skills supply in the electrification of society

The Government has commissioned the Swedish Energy Agency to coordinate a national effort to ensure skills for electrification. The interim report identifies a number of skills that will be necessary for the deployment of recharging and hydrogen refuelling infrastructure. Further work in the mission will extend this analysis, and measures will be proposed. The proposed coordinators for recharging and hydrogen refuelling infrastructure should participate in the work and provide knowledge and input. Monitoring of skills supplies and cooperation with the education system are necessary to counteract skills shortages in the long term.

6.3.3 Statistics and monitoring

There are several challenges in planning for the deployment of future recharging and hydrogen refuelling infrastructure. The rapid development of technology and changes in user acceptance and behaviour increase complexity and uncertainty. To capture new and changing needs, developments must be continuously monitored. AFIR has a number of monitoring and reporting requirements, which are described in section 4.1.

Some of the measures involve continuing the work of the mission on joint monitoring of the electrification of society[244], including the production of statistics on recharging and hydrogen refuelling infrastructure and the development of methods to quantify the number of non-publicly accessible recharging points in Sweden, as described in section 1.4.1. This work should be carried out under the coordination responsibility.

The Swedish Transport Analysis Agency[245] is also currently completing a mission to develop electrification statistics in the transport area, within the Agency's present subject area for statistics, as described in section 1.4.3.

Measure 44 Appoint the Swedish Energy Agency as the authority responsible for energy infrastructure statistics

Statistics Sweden has, in a request to the Government[246], proposed the introduction of a new statistical area: Energy infrastructure, for which the Swedish Energy Agency will be responsible.

The Swedish Energy Agency has begun work to develop official statistics (Measure 45) and must be appointed as the public authority responsible for energy infrastructure statistics to ensure a clear mandate for this work.

Measure 45 Produce official statistics on recharging and hydrogen refuelling infrastructure at national level

The Swedish Energy Agency is continuing its work on producing official statistics and indicators. This work covers both publicly accessible and non-publicly accessible recharging and hydrogen refuelling infrastructure. The official statistics are deemed to cover the national level. Statistics at regional and municipal level are considered difficult to include in the official statistics for reasons of confidentiality.

Measure 46 Develop a database to, e.g., produce statistics at regional and local level

Currently, the Nobil database is a main source for the development of statistics on recharging infrastructure. The Swedish Energy Agency is continuing its work to further develop the Nobil database or an equivalent tool. One important aim is to produce statistics at regional and municipal level. These statistics will not be part of the official statistics. However, a database such as Nobil needs to be a main source of official statistics.

Measure 47 Assign the Swedish Energy Agency to produce progress reports for AFIR

The requirements of AFIR state that, by 31 December 2027 and every two years thereafter, each Member State shall submit to the Commission a standalone national progress report on the implementation of its national policy framework. It is appropriate for the Government to commission the Swedish Energy Agency to produce these progress reports and to emphasise that several authorities need to contribute, such as the Swedish Transport

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[244] The Ministry of Rural Affairs and Infrastructure (2022), U*ppdrag att genomföra en myndighetsgemensam uppföljning av samhällets elektrifiering*, ref I2022/01060.

[245] The Ministry of Rural Affairs and Infrastructure (2023), *Uppdrag att utveckla statistik avseende elektrifiering*, ref I2023/02047.

[246] Statistics Sweden (2021) *Hemställan om ändring i förordning (2001:100) om den officiella statistiken* (annex), A2021:2077.

Administration and the Swedish Transport Agency. This work should be carried out under the proposed coordination responsibility.

Measure 48 Assign the Swedish Energy Agency to produce annual reports on the development of plug-in vehicles, recharging infrastructure and recharging power output

An additional reporting requirement under AFIR is to report to the Commission by 31 March 2025, and thereafter on the 31st of March each year, the total aggregated recharging power output and the number of publicly accessible recharging points deployed and the number of battery electric vehicles and plug-in hybrid vehicles registered on their territory on 31 December of the previous year. The Government should commission the Swedish Energy Agency to produce this report, and the work should be carried out within the coordination responsibility. The Swedish Transport Analysis Agency should assist in this work.

Measure 49 Assign the Swedish Energy Agency to be the Identification Registration Organisation ("IDRO") in Sweden

AFIR requires Member States to establish an Identification Registration Organisation ('IDRO') for managing unique identification ID codes for recharging points. The IDRO must issue and manage unique identification ('ID') codes to identify, as a minimum, operators of recharging points and mobility service providers. The ID codes are needed to identify the organisations for national and international data exchange.

The Government should commission the Swedish Energy Agency to be the Identification Registration Organisation in Sweden.

6.3.4 Robustness, reliability and redundancy

An electrified transport system must be characterised by robustness, reliability and redundancy. These guiding principles need to be present throughout the transition phase, and achieving them will require various measures, in the short as well as the long term.

Measure 50 Conduct risk and vulnerability assessments continuously and at multiple levels

Sweden's energy supply is subject to numerous threats. Ongoing societal changes, including rebuilding total defence, the transition and digitalisation, will bring about risks and vulnerabilities for all kinds of energy. This entails a need for continuous risk and vulnerability assessments at national, regional and local level by stakeholders establishing recharging or refuelling infrastructure in order to identify relevant risks, both now and in the future. Risk and vulnerability assessments should assess and address all types of threats, both antagonistic and non-antagonistic, which may be relevant to the object being analysed.

Measure 51 Investigate increased resilience of recharging and hydrogen refuelling infrastructure

The Swedish electricity system must be robust to ensure that transport, especially critical transport, can always operate. At both national and local level, various measures are needed to ensure the operation of particularly important recharging pools and hydrogen refuelling stations, such as backup power solutions which are not dependent on fossil fuels. How the robustness of hydrogen recharging pools and refuelling stations can be ensured, and what measures might be appropriate, should be investigated.

Measure 52 Investigate the consequences of diminished emergency stocks

Sweden is obliged by commitments to the IEA and the EU to maintain emergency stocks of liquid fuels and may face sanctions if this commitment is not maintained. Sweden's fuel stocks are equivalent to 90 days of oil imports based on previous years' use. This means that if use changes, the amount of fuel stored in the emergency stocks in the coming years will also change.

Even if road transport, particularly passenger cars and heavy-duty vehicles, will, after electrification, no longer be dependent on current stockpiles, other needs in society rely on these stockpiles. Much backup power runs on fossil fuels, bringing an increased need for fossil fuels in the event of disruptions to the electricity supply. This may increase vulnerability as the size of the stockpile decreases.

The consequences of diminished emergency stocks must be investigated.

Measure 53 Investigate the need for and design of future emergency energy stockpiles

As the vehicle fleet becomes electrified, the use of current emergency stocks will decrease. However, the need for some form of centralised energy stock adapted to the design of the vehicle fleet and ready for use in a crisis may remain. How such an energy stock can be designed to best meet the needs of the vehicle fleet must be investigated. Furthermore, the organisation and financing of such an energy stock needs to be investigated.

Measure 54 Swedish Energy Agency to develop directives for Styrel to prioritise recharging infrastructure and hydrogen refuelling stations

To ensure that municipalities receive the support necessary to effectively prioritise which recharging pools or refuelling stations are critical under Styrel, the Swedish Energy Agency will develop directives that can form the basis for such work. Such a directive will ensure that recharging infrastructure is not overlooked in the prioritisation process while avoiding inclusion of all a municipality's recharging pools without prioritisation.

Measure 55 Provide funding for improved knowledge regarding future preparedness

It is of great importance that measures aimed at creating robustness in recharging and refuelling infrastructure be implemented in concert with the overall transition. Many ideas exist today, but additional research projects should be carried out in this area to increase the chances of diversification in measures to assure security of supply as well.

Annex 1: Laws, etc., for hydrogen refuelling stations

This annex summarises Swedish laws and ordinances, regulations, manuals and guides which are relevant to hydrogen filling stations and associated hydrogen storage and distribution infrastructure (see Table 9 through Table 11).

Table 9. Swedish laws and ordinances relevant to hydrogen refuelling stations and associated hydrogen storage and distribution infrastructure.

Law	Description and any shortcomings
Act on Flammable and Explosive Articles[247]	The Act on Flammable and Explosive Articles (LBE) aims to prevent and limit accidents and damage to life, health, the environment and property which may result from a fire or explosion caused by flammable or explosive articles. The Regulation on Flammable and Explosive Articles[248] clarifies and specifies what is stated in the LBE.
Act on the Transport of Hazardous Goods[249]	The aim of the Act is to prevent, hinder and limit damage caused by the transport of hazardous goods.
The Act on Certain Pipelines[250]	The Act on Certain Pipelines does not address the storage and distribution of hydrogen.
Planning and Building Act[251]	The Act describes provisions on land use and water planning and construction with the aim of promoting societal progress
The Work Environment Act[252]	The aim of the Act is to prevent ill health and accidents at work.
The Natural Gas Act[253]	This law contains provisions on natural gas pipelines, storage facilities and gasification plants as well as on natural gas trading in certain cases. A similar law could be developed for hydrogen.
The Swedish Environmental Code[254]	The purpose of the Environmental Code is to promote sustainable development. More detailed rules can be found in the regulations of the Environmental Code. Several other laws are linked to the Environmental Code. The Environmental Code concerns all types of actions, whether part of an individual's daily life or some form of economic activity.

[247] SFS 2010:1011 Lag (2010:1011) om brandfarliga och explosiva varor.

[248] SFS 2010:1075 Förordning (2010:1075) om brandfarliga och explosiva varor.

[249] SFS 2006:263 Lag (2006:263) om transport av farligt gods.

[250] SFS 1978:160 Lag (1978:160) om vissa rörledningar.

[251] SFS 2010:900 Plan- och bygglag.

[252] SFS 1977:1160 Arbetsmiljölag.

[253] SFS 2005:403 Naturgaslag.

[254] SFS 1998:808 Miljöbalk.

Table 10. Swedish regulations relevant to hydrogen refuelling stations and associated hydrogen storage and distribution infrastructure.

Regulation	Description and any shortcomings
MSBFS 2020:1 Regulations on the handling of flammable gas and aerosols	The MSB is in the process of updating these regulations, and proposals have been submitted for consultation[255] through 5 May 2023. In the pre-consultation, the MSB sought views on this early proposal for regulatory changes concerning hydrogen handling. A detailed consultation is expected late 2023/late 2024.
Regulations on permits for the handling of flammable gases and liquids (MSBFS 2013:3)[256]	There is also an amending regulation, MSBFS 2023:1[257]
Regulations on explosion hazards when handling flammable gases and liquids[258]	These regulations apply to the handling of flammable gases and liquids where an explosive atmosphere may arise, possibly risking fire or explosion
Regulations on the transport of dangerous goods by road and off-road (ADR-S 2023)[259]	See also the Ordinance on the transport of dangerous goods (2006:311)
Regulations on transportable pressure equipment (MSBFS 2011:3)[260]	These regulations include requirements for the assessment, inspection and labelling of transportable pressure equipment, as well as provisions on the obligations of operators.
SÄIFS 1998:5 Regulations and general advice on refuelling stations for methane powered vehicles[261]	Regulations for refuelling stations for methane powered vehicles, a potential source of information for hydrogen refuelling stations

[255] Förremiss – samråd kring förslag till uppdatering av MSBFS 2020:1 för vätgas (retrieved 19/10/2023).

[256] MSBFS 2013:3 föreskrifter om tillstånd till hantering av brandfarliga gaser och vätskor.

[257] MSBFS 2023:1 om ändring av MSBFS 2013:3 om tillstånd till hantering av brandfarliga gaser och vätskor.

[258] SRVFS 2004:7 föreskrifter om explosionsfarlig miljö vid hantering av brandfarliga gaser och vätskor.

[259] MSBFS 2022:3 om transport av farligt gods på väg och i terräng (ADR-S 2023).

[260] MSBFS 2011:3 föreskrifter om transportabla tryckbärande anordningar.

[261] SÄIFS 1998:5 föreskrifter och allmänna råd om tankstationer för metangasdrivna fordon.

Table 11. Swedish manuals and guides which can be considered relevant for the establishment and operation of hydrogen refuelling stations and related infrastructure.

Handbook/guidance
Handling of flammable gas in professional activities[262]
Permits to handle flammable gases and liquids[263]
Risk assessment for SMEs [264]
Swedish Rescue Services Agency's handbook on explosion hazard areas when handling flammable gases and liquids[265]
Instructions: Refuelling stations for hydrogen powered vehicles (H2-TSA 2023)[266]
Guidance on risk management in planning and construction[267]
Guidance on Seveso sites in risk management[268]

[262] Hantering av brandfarlig gas för yrkesmässig verksamhet : handbok (msb.se).

[263] Handbok – Tillstånd till hantering av brandfarliga gaser och vätskor (msb.se).

[264] Riskutredning för mindre och medelstora verksamheter : vägledning (msb.se).

[265] Brandfarliga vätskor (msb.se).

[266] Anvisningar – tankstationer för vätgasdrivna fordon, H2-TSA 2023 – The Swedish Gas Association.

[267] Vägledning om riskhantering i planläggning och byggande – PBL kunskapsbanken – Swedish National Board of Housing, Building and Planning.

[268] Vägledning om Sevesoverksamhet i riskhantering – PBL kunskapsbanken – Swedish National Board of Housing, Building and Planning.

Annex 2: Terms

Term	Definition
Fuel cell vehicles	An battery electric vehicle powered by a fuel cell which supplies power to an electric motor. The fuel cell usually converts hydrogen into electricity, heat and water vapour.
Depot recharging	Recharging points which are accessible to businesses that rent parking, such as a haulage contractor that rents premises with associated parking.
Destination recharging	This term is used quite broadly, but usually refers to recharging at slightly higher powers than home recharging, and which may be open to others, e.g., in commercial areas or at freight terminals for loading and unloading.
Digitally connected	According to AFIR, a recharging point should be able to send and receive information in real time, communicate bi-directionally with the electricity grid and the battery electric vehicle, and be remotely monitored and controlled.
Dynamic recharging	In this report, it refers to an electric road, i.e., a road together with its peripheral equipment (electric power supply, site monitoring, etc.) which, regardless of its specific technology, enables the transfer of electric energy to vehicles while travelling.
Battery electric vehicle	A vehicle that runs solely on electricity and charges its battery from the electricity grid.
Home recharging	The source texts define home recharging as recharging that takes place at the vehicle's place of residence, i.e., where the vehicle is usually parked for an extended period of time. This could be, for example, near a home, for private vehicles, or at a workplace, for commercial vehicles.
Non-publicly accessible recharging pool/refuelling station	A recharging pool or refuelling station that is not accessible to all.
Recharging power	The amount of energy per unit of time transferred from the electricity grid to the vehicle's battery when recharging a plug-in vehicle. The unit for recharging power is kilowatt, kW.
Plug-in vehicle	Electric cars and plug-in hybrids that charge their battery on-board via the grid.
Plug-in hybrid	Rechargeable vehicles which use electricity as well as an internal combustion engine for propulsion.
Recharging pool	One or more recharging stations at a specific location.
Recharging point	A fixed or mobile, on-grid or off-grid interface for the transfer of electricity to an battery electric vehicle which, although it may have one or more connectors to accommodate different connector types, is capable of recharging only one battery electric vehicle at a time, and which excludes devices with a power output less than or equal to 3.7 kW the primary purpose of which is not the recharging of battery electric vehicles.
Recharging station	A physical facility at a specific location, consisting of one or more recharging points.
Recharging operator	A recharging operator is a company that offers operation, maintenance and other services. A recharging operator can measure electricity consumption and charge the user.

Term	Definition
Load balancing	Load management or load balancing means reducing or equalising power demands. Either the power which the recharging equipment supplies to the recharging vehicle, or the power of other electricity consumers in the property, can be managed. Load management can often be selected as a feature in recharging equipment.
Megawatt charging system (MCS)	Recharging connector under development for large battery-powered battery electric vehicles. The connector will be rated for recharging at a maximum rate of 3.75 MW.
Normal recharging	When a vehicle is recharged with a power of no less than 3.7 kW and no more than 22 kW.
Official statistics	Official statistics are required by law to be available for public information, investigation and research. Statistics must be objective and publicly available. Statistics Sweden is responsible for coordinating official statistics. Official statistics of Sweden (scb.se).
Publicly accessible recharging pool/refuelling station	A recharging pool or refuelling station for alternative fuels to which users have non-discriminatory access throughout the Union (non-discriminatory access may include different conditions for authentication, use or payment).
RFNBO	Renewable Fuels of Non-Biological Origin.
Semi-publicly accessible recharging	Charging points which are only available to a defined target group and not accessible to the general public. Semi-publicly accessible recharging points differ from non-publicly accessible recharging points in being accessible to people or organisations outside the organisation itself.
Smart recharging	As per AFIR, it refers to a recharging event where the intensity of electricity transmission can be adjusted in real time through digital communication.
High-power recharging	Recharging with a power of more than 22 kW. A recharging point with a 3-phase, 32 A connector is considered a high-power recharging point according to EU classification. High-power chargers are often found along major roads and permit, for example, recharging while stopping for a meal.
TEN-T	The Trans-European Transport Networks Consists of European roads and some designated national roads.
TEN-T core network	The most prioritised sections of the Trans-European Transport Networks.
TEN-T comprehensive network	The lower-priority sections of the Trans-European Transport Networks.
Urban node	A metropolitan area where the transport infrastructure of the Trans-European Transport Network, such as ports, passenger terminals, airports, railway stations, logistics platforms and freight terminals in and outside urban areas, connects to other parts of this infrastructure as well as to regional and local transport infrastructure. Defined by the TEN-T Regulation EU 1315/2013.
Vehicle-to-grid (V2G) / bi-directional charging	Bi-directional charging. A smart recharging operation where the direction of the electricity flow can be reversed, allowing electricity to flow from the battery to the recharging point it is connected to.
AADT	Annual Average Daily Traffic refers to a statistical parameter describing a characteristic (the annual daily average flow) of traffic on a road section or at a point (actually a section) of road.

Affordable and Clean Energy

Our assignment is to unite sustainability, competitiveness, and security of energy supply for cost-efficient energy systems with minimum impact on health, environment and the climate.

We contribute with data, knowledge, and analyses regarding energy use and supply in Sweden. We are also dedicated to maintaining a secure energy supply on a national level.

We support and fund national research on innovative energy technologies, smart grids, vehicles, and fuels of the future. Furthermore, we support business development, commercialisation, and export of cleantech innovations.

Official statistics and support schemes, such as the Electricity Certificate System and the EU Emission Trading System, are some of our responsibilities. We participate in international collaboration and provide information on efficient energy use to households, industries, and public authorities.

The Swedish Energy Agency also holds the overall responsibility for the energy sector due to civil preparedness.

Swedish Energy Agency

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