

An aerial photograph of a parking lot filled with numerous semi-trucks. The trucks are arranged in several rows, with their long trailers pointing towards the bottom of the frame. The trailers are mostly white, but some have red or blue accents. The ground is a dark, paved surface. The lighting suggests it might be late afternoon or early morning, as there are long shadows cast by the trucks.

# ENABLING CO2 STANDARDS

## A "POLICY TOOLKIT" TO FOSTER THE IMPLEMENTATION OF AFIR IN EUROPEAN MEMBER STATES

October 2023



## EXECUTIVE SUMMARY

Zero-emission vehicles (ZEVs) will have a central role to play in achieving the requirements set by the Regulation on CO<sub>2</sub> Standards to **reduce the emissions from heavy duty vehicles by 45%** by 2030 (from 2019-2020 levels). Hydrogen vehicles are expected to be a significant percentage of zero-emission heavy duty vehicles manufactured in 2030, as well as a portion of light duty vehicles. To achieve these targets, **the mass deployment of hydrogen vehicles must start no later than 2026** in order to give the sector sufficient time to scale up and increase the maturity of the technology and its supply chains. This deployment relies on **the pre-existence of a network of large-scale hydrogen refuelling stations (HRS)** across Europe, reliably providing hydrogen at an acceptable price.

A strategy for the deployment of HRS must be established for **efficient and comprehensive cover of TEN-T networks** to fulfil the Alternative Fuels Infrastructure Regulation (AFIR). AFIR stipulates that HRS must be deployed on all urban nodes and every 200 km along the TEN-T core network. Hydrogen Europe have estimated that 657 HRS<sup>1</sup> in EU territory will be required by 2030 to meet AFIR, an extremely tight timeline which requires rapid implementation. A **systematic approach to territorial coverage**, ‘planification’ of HRS deployment, is the **most efficient use of time and financial resources** to meet AFIR requirements and achieve CO<sub>2</sub> reduction targets. If we want to deploy several hundreds of HRS by 2027 (each Member State will have to set **intermediary HRS deployment targets** as part of its “national policy framework”), this means that projects must be started in 2025 and that relevant support mechanisms must be in place by 2024. **We are already late.**

**HRS must be deployed before a commercial ramp-up of hydrogen vehicles** can be coordinated, which will lead to a **short-term underutilisation**. To mitigate short-term financial losses, specific support schemes must be implemented during the deployment phase, else the rollout will be delayed, and decarbonisation targets set by the European Commission will be missed. CAPEX grants which have been previously employed for HRS demonstration projects will not be adequate for deployment at this pace and scale. Specific short-term support mechanisms should be implemented to support the anticipated deployment of the HRS network. A **‘Capacity Payment’ mechanism** (a fixed rent based on the capacity of the HRS, disbursed over 8-10 years under the condition of continued high performance of the stations) **is seen as an optimal solution** to remove short-term bottlenecks and enable rapid and comprehensive deployment. Total funding to enable the AFIR network would amount to circa €1.8 billion (discounted value), spread across ten years and covering all EU Member States.

In addition, **other financial supports could be used in conjunction with capacity payments** to reduce the total amount, such as: mandates on fleets (to incentivise the purchase of ZEVs), transposing RED III (to improve the economics of utilising renewable hydrogen), or directly subsidising hydrogen vehicles (to reduce the total cost of ownership).

For some countries, **extra-budgetary tools could be used** as an alternative to capacity payments. A small increase in toll price on concessioned motorways would act as a virtual capacity payment (but is restricted to countries where concessioned motorways already exist). Member

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<sup>1</sup>Based on Hydrogen Europe’s [initial estimates](#). There are still some uncertainties regarding the interpretation of AFIR and the final number of refuelling stations per country. However, it is essential to underline that AFIR will only represent a **minimum target** and should not be considered as an end point.

States could also introduce an obligation for fuel retailers to deploy HRS, which could be offset by increasing slightly the petrol/diesel selling price.

Although **significant collective commitments will be required** for the rollout of a dense and reliable HRS network, **delivery can be achieved by 2030** if a coordinated approach is taken today. As underlined, the **implementation of AFIR must start now** if we want to reach the ambitious HRS deployment targets set by the European Commission. A **collective approach to AFIR implementation** – which could materialize in the creation of a public/private working group at EU level – will strongly support the build-up of a comprehensive and reliable HRS network. This will unlock billions of euros of investment in the hydrogen and vehicle supply chains (some of which has already been taken), and enable HRS to be deployed beyond 2030 with a viable business case independent of state support.

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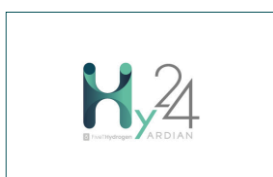
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## ACKNOWLEDGEMENT

This document is the result of several months of common work, bringing together financiers, vehicle original equipment manufacturers and infrastructure providers. The document aims to highlight the short-term challenges identified regarding the development of the AFIR HRS network, and propose schemes that could foster a fast and smooth implementation of hydrogen mobility.

The report was prepared by Hy24 to stress the urgency of deploying the HRS network if we are to achieve the ambitious objectives set by AFIR and, more importantly, the decarbonisation targets for the transport sector.

### Author



In addition, the preparation of the document mobilised several key players in the sector. The final document strongly benefits from their expertise and extensive market experience. However, it is important to stress that the following content does not necessarily fully reflect their position.

### Contributors



This document was prepared with the support of ERM (Environmental Resources Management) and Delta H teams.

<sup>2</sup> The H2Accelerate Collaboration brings together hydrogen suppliers Shell, Linde, TotalEnergies and bp, and vehicle OEMs Daimler, Iveco Group, and the Volvo Group. The parties are working together to enable the use of hydrogen to decarbonise long-haul, heavy duty trucking across Europe.

## TABLE OF ACRONYMS

**ACEA** European Automobile Manufacturers Association

**AFIF** Alternative Fuels Infrastructure Facility

**AFIR** Alternative Fuels Infrastructure Regulation

**ASFA** French Motorways Companies Association

**BEV** Battery Electric Vehicles

**CAPEX** Capital expenditures

**CEF** Connecting Europe Facility

**EC** European Commission

**EU** European Union

**GHG** Greenhouse Gas

**HDV** Heavy Duty Vehicles

**HRS** Hydrogen Refuelling Station

**IPCEI** Important Project of Common European Interest

**LCV** Low Carbon Vehicles

**MOU** Memorandum of Understanding

**NPF** National Policy Framework

**OEM** Original Equipment Manufacturer

**OPEX** Operating expenses

**RED** Renewable Energy Directive

**TCO** Total Cost of Ownership

**TEN-T** Trans-European Transport Network

**ZEV** Zero-Emission Vehicle

## INTRODUCTION: HYDROGEN HAS A SIGNIFICANT ROLE TO PLAY IN THE DECARBONISATION OF THE TRANSPORT SECTOR

At European level, decarbonising the transport sector will represent a critical challenge to achieving net zero GHG emissions targets by 2050. Indeed, the exhaust emissions<sup>3</sup> of greenhouse gases from the transport sector increased by **33% between 1990 and 2019**, while the EU's overall emissions fell by 24%.

In this context, the EU has set ambitious targets to progressively decarbonise the sector. As part of the "[Fit For 55](#)" package, the ambition is to **reduce GHG emissions by at least 55% by 2030**, and to reach climate neutrality by 2050. Thus, these objectives will only be reached by introducing more ambitious support policies to **reduce transport's reliance on fossil fuels** without delay and in synergy with zero pollution efforts. Immediate action is needed if we are to achieve these extremely ambitious GHG reduction targets.

Road transport accounts for **more than 70%** of total GHG emissions<sup>4</sup> from the transport sector. ZEVs will be critical to meet GHG reduction targets. In this context, hydrogen and battery-electric vehicles (BEVs) will have a central role to play in the transition of fleets. Hydrogen vehicles and BEVs should be seen as **complementary options to facilitate the transition**. The priority is to allocate the appropriate technology to the right end-use, to ensure a smooth transition. To stimulate the deployment of ZEVs in the short-term, the Commission proposed a **revision of the Regulation on CO<sub>2</sub> standards** for heavy-duty vehicles<sup>5</sup>. If adopted, vehicle manufacturers would have to decrease CO<sub>2</sub> emissions per kilometre from new heavy-duty vehicles **by 45% by 2030**, as compared to the reference period (1 July 2019 – 30 June 2020).

Consequently, vehicle OEMs will have to sell **tens of thousands of ZEVs by 2030** to achieve the target. Hydrogen vehicles are therefore expected to play a major role, notably for fleets with **constrained operational profiles**, for which BEVs do not represent a satisfactory alternative. According to the impact assessment by the European Commission, hydrogen powered vehicles will represent between 7% and 18% of new heavy-duty lorries (above 16 tonnes) sold in 2030, and between 21% and 69% in 2040, depending on the scenario, which means the **deployment of a hydrogen refuelling network must be anticipated**. Insufficient network coverage of HRS would constrain the deployment of the hydrogen mobility market, as fleet operators will not switch to hydrogen powered vehicles if they are not fully confident that their operational needs will be met.

The first HRS deployed in Europe targeted **mostly light-duty vehicles** and the network is not ready for HDVs. Some HRS have been linked to demonstration projects or are provided for bus fleets and therefore not publicly accessible. 236 HRS<sup>6</sup> were deployed in Europe by the end of 2022, which are mostly small-sized. As an example, a 200 kgH<sub>2</sub>/day refuelling station (which is the most common HRS capacity deployed today) would be **able to support only 7 trucks**.

It is critical to **coordinate the rollout** of HRS to unlock regional and transnational zero emissions road transport and meet the indicative 2027 national targets that deliver 'sufficient coverage of the

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<sup>3</sup> [European Environment Agency, Transport and environment report, 2022](#)

<sup>4</sup> *ibid*

<sup>5</sup> [European Commission, Reducing CO<sub>2</sub> emissions from heavy-duty vehicles](#)

<sup>6</sup> [IEA Technology Collaboration Programme](#)

TEN-T core network with a view to meeting developing market demands<sup>7</sup>. HRS must be deployed **ahead** of the vehicles and guarantee high reliability and quality standards. The rollout of a **dense and reliable** refuelling network is a priority in urban nodes and the main transport corridors. The objective is to offer refuelling solutions to **all types of vehicles** (long-distance trucks, regional distribution trucks, but also vans and passenger cars).

In addition, the development of hydrogen mobility at scale will require an **increase in renewable and low-carbon hydrogen production capacities**. Indeed, it will be essential to **guarantee availability** of low-carbon and renewable hydrogen for the mobility sector, and not to reserve it for the decarbonisation of industrial applications. The production of hydrogen should therefore also be well anticipated.

The main objective of this document is to provide governments with an actionable **“policy toolbox” to guide the deployment of the HRS network** in the short-term. The aim is to support the deployment of a comprehensive and reliable network of HRS, in anticipation of the vehicles. Of course, the focus on HRS through this report should not overshadow the need to develop and support other key parts of the hydrogen value chain which will be required to support hydrogen road mobility, such as hydrogen production, midstream applications (tube-trailers, filling centres, liquefaction facilities, etc.), and vehicles.

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<sup>7</sup> [Alternative Fuels Infrastructure Regulation](#)



## ALTERNATIVE FUELS INFRASTRUCTURE REGULATION (AFIR): AN AMBITION TO ENABLE HRS DEPLOYMENTS AT EUROPEAN LEVEL

The Alternative Fuels Infrastructure Regulation (AFIR) requires each Member State to set out a National Policy Framework (NPF) which outlines a linear trajectory to meet 2030 targets. The NPF must have clear indicative targets to deliver HRS with a sufficient coverage of TEN-T core networks by 2027. HRS that can serve both cars and lorries (at least 1 tonne per day of dispensing capacity) must be deployed from 2030 onwards in **all urban nodes and every 200 km along the TEN-T** core network. Based on this agreement<sup>8</sup>, Hydrogen Europe estimated that **657 HRS** would have to be deployed on the EU territory by the end of the decade (**424** in urban nodes and **233** along the TEN-T network<sup>9</sup>). Consequently, this represents a first step for enabling a hydrogen mass-market for mobility at EU level.

However, while AFIR sets a clear and ambitious objective on a minimum deployment of HRS by 2030 (with the requirement to set national targets for 2027), it **does not indicate how Member States might reach or even exceed this objective**. Member States will have to prepare a **HRS deployment plan** by 2025, which contains an indicative target for the deployment of a network that provides sufficient coverage of the TEN-T core network to meet developing market demands by 2027, to enable the subsequent commercialisation of hydrogen vehicles by the end of the decade.

Consequently, it is clear that the timeline between now and 2030 is extremely tight. If Member States are to comply with CO<sub>2</sub> standards, coordination of the deployment of HRS must be commenced immediately. The adoption of AFIR is a first significant achievement, however there is now urgency to **rapidly move on to the implementation phase**, in order to support a quick and dense roll-out of HRS well before 2030.

Last but not least, AFIR provides for a minimum network of HRS, in order to accelerate the deployment of hydrogen mobility across Europe. However, the stakes are much higher than the deployment of this first network. The development of hydrogen mobility at scale will have **significant spillover effects** for the EU economy. The EU and Member States have integrated hydrogen as a central part of their industrial policy by supporting hydrogen equipment manufacturers, including the mobility sector. The successful development of the HRS network will **strengthen Europe's industrial leadership in hydrogen distribution technologies** and avoid wasting the support already given to vehicle manufacturers and suppliers, whose success depends heavily on the presence of a well-developed HRS network.

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<sup>8</sup> [Alternative fuels infrastructure: Council adopts new law for more recharging and refuelling stations across Europe](#)

<sup>9</sup> It could be fewer if a station is located in a place that qualifies simultaneously as "along the TEN-T network" and as "urban node".

## UNDERSTANDING THE RAPID DEPLOYMENT TIMELINE AHEAD

CO<sub>2</sub> standards create an obligation to sell a **very high proportion (c.50%) of ZEVs** by 2030.

**Table 1:** extract from European Commission impact assessment on the expected proportion of different vehicle types by weight required to meet the Heavy-Duty Vehicle CO<sub>2</sub> Standards

2030					
Type	Diesel	Gas	PHEV	BEV	H <sub>2</sub>
[5-7.5] t	54.5%	11.0%	19.5%	<b>13.0%</b>	<b>2.0%</b>
[7.5-16] t	45.5%	9.5%	13.5%	<b>27.5%</b>	<b>4.0%</b>
> 16 t	60.5%	11.0%	0.5%	<b>12.5%</b>	<b>15.5%</b>

A large proportion of zero emissions trucks are expected to run on hydrogen, and a proportion of LCV and cars will also run on hydrogen<sup>10</sup>. This proportion of hydrogen vehicles sales cannot be achieved in one year. Vehicle manufacturers need several years to **organise a commercial ramp up**. Hence the sales of vehicles should start as soon as possible, i.e. ideally today and certainly no later than 2025-2026.

Vehicle manufacturers **cannot sell hydrogen vehicles if there is no pre-existing refuelling infrastructure**. Hence, the first network of HRS should be available very soon and certainly by 2025. In concrete terms, it takes between 1.5 and 2 years to commission a new station (including permits, subsidy, procurement, construction, testing, etc.), which means **there is little flexibility left in the timeline to roll out the minimum network**, essential to unlock the development of hydrogen mobility at scale.

Consequently, it is urgent to **start the implementation of the AFIR immediately**, to coordinate the deployment of HRS and to identify support schemes which suit the specificities of HRS and that can be used immediately without lengthy discussion around state aid rules. The current organic approach of existing funding schemes (such as the Connecting Europe Facility's AFIF call) requests that HRS providers submit applications for their locations of choice, without **knowledge of where other HRS are planned and where gaps exist in the network**. The lack of network planning means that it **is unlikely that a network capable of meeting maximum spacing requirements under AFIR will spontaneously materialise**. Consequently, once the first deployment of stations is achieved, further efforts from Member States will be needed

<sup>10</sup> There is some variation in the number, but studies agree that a substantial share of hydrogen trucks will be required to comply with CO<sub>2</sub> standards by 2030. ACEA anticipates 70,000 hydrogen trucks will be required by 2030 ([CO<sub>2</sub> standards for heavy-duty vehicles, ACEA](#)). For reference, 256,000 heavy trucks were registered across the European Union in 2022 ([New Commercial Vehicle Registrations, European Union, ACEA](#)). This proportion is likely to grow consistently after 2030.

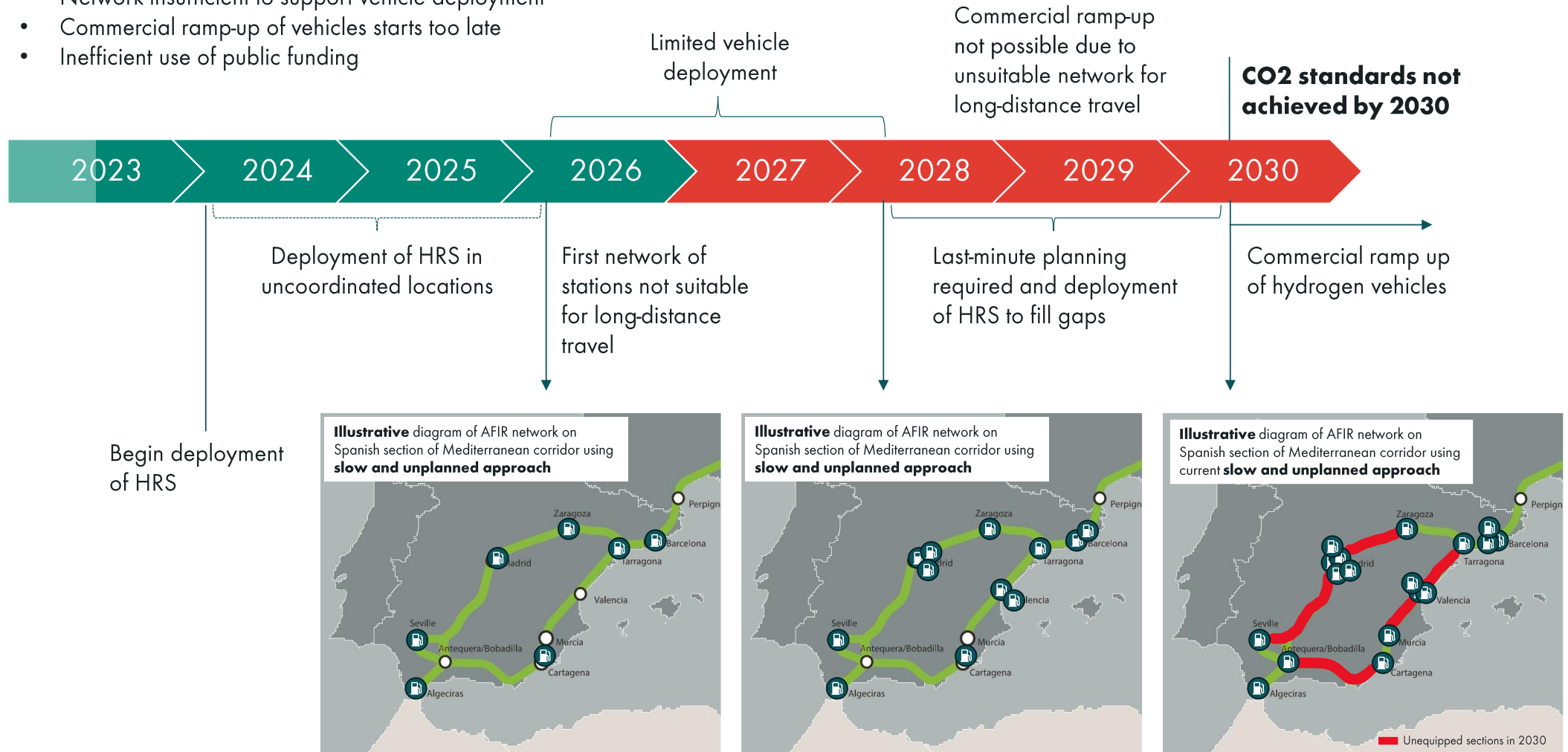
to increase deployment and ensure that gaps in the network with over 200km spacing between stations are filled. This will result in a failure to meet the AFIR coverage requirement by the 2027 target and cause delay to the commercial ramp-up of hydrogen vehicle deployment, meaning the **HDV CO<sub>2</sub> standards cannot be met**. This approach is also an **inefficient use of public funding**, as it allows funding to be used to build multiple HRS in one location rather than an efficiently spaced network along major corridors and in urban nodes.

The below figures show the challenges of the slow and unplanned approach as compared to the simplicity and efficiency of a “planification” approach, which enables AFIR requirements to be met in one step.

**Figure 1:** Organic approach to HRS deployment: current unplanned and slow approach

### Slow and unplanned approach

- Network insufficient to support vehicle deployment
- Commercial ramp-up of vehicles starts too late
- Inefficient use of public funding

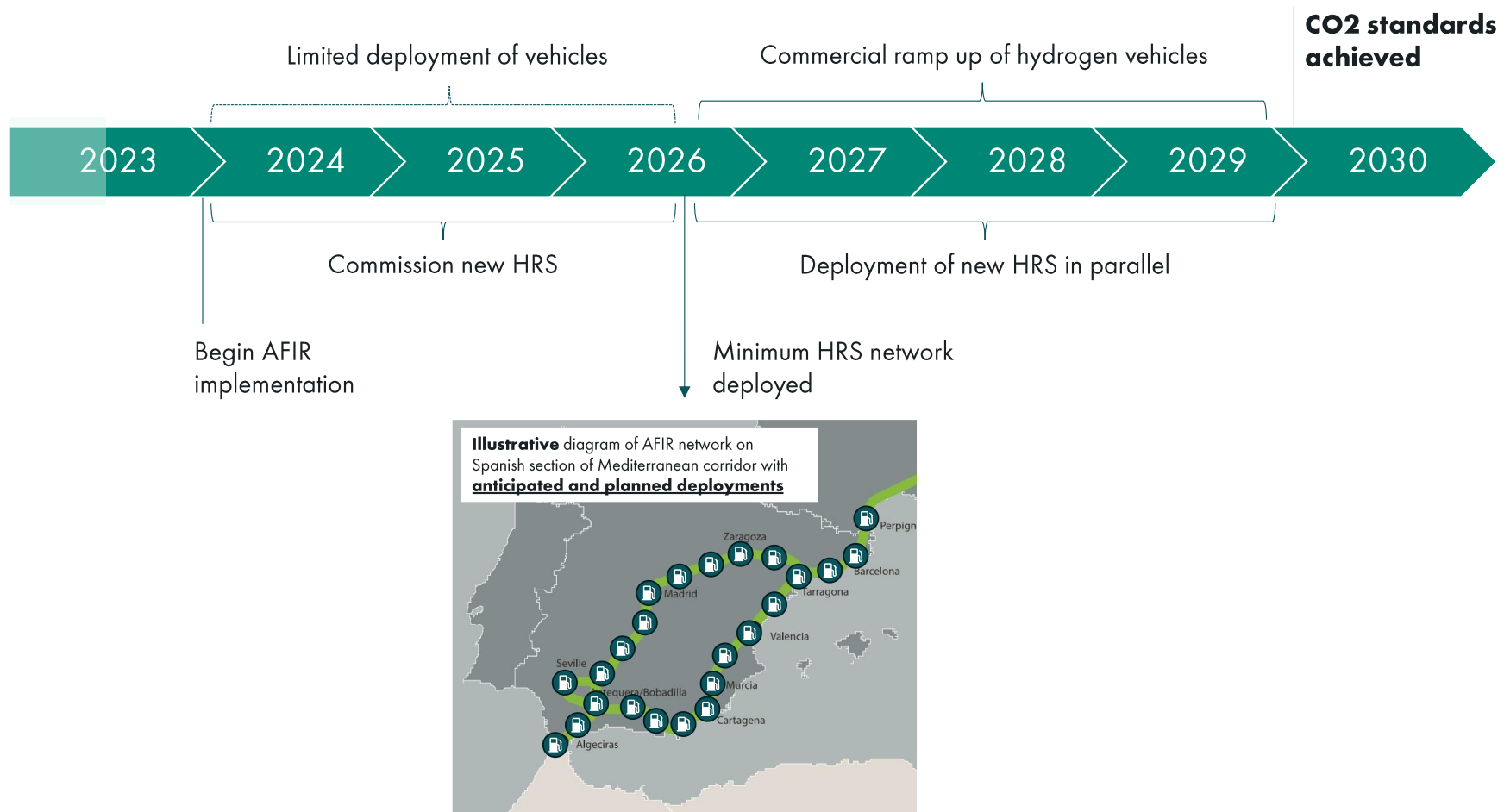




**Figure 2:** Planification of HRS deployment

### Immediate and planned approach

- AFIR fulfilled in one step
- Commercial ramp-up starts by 2027
- Efficient use of public funding

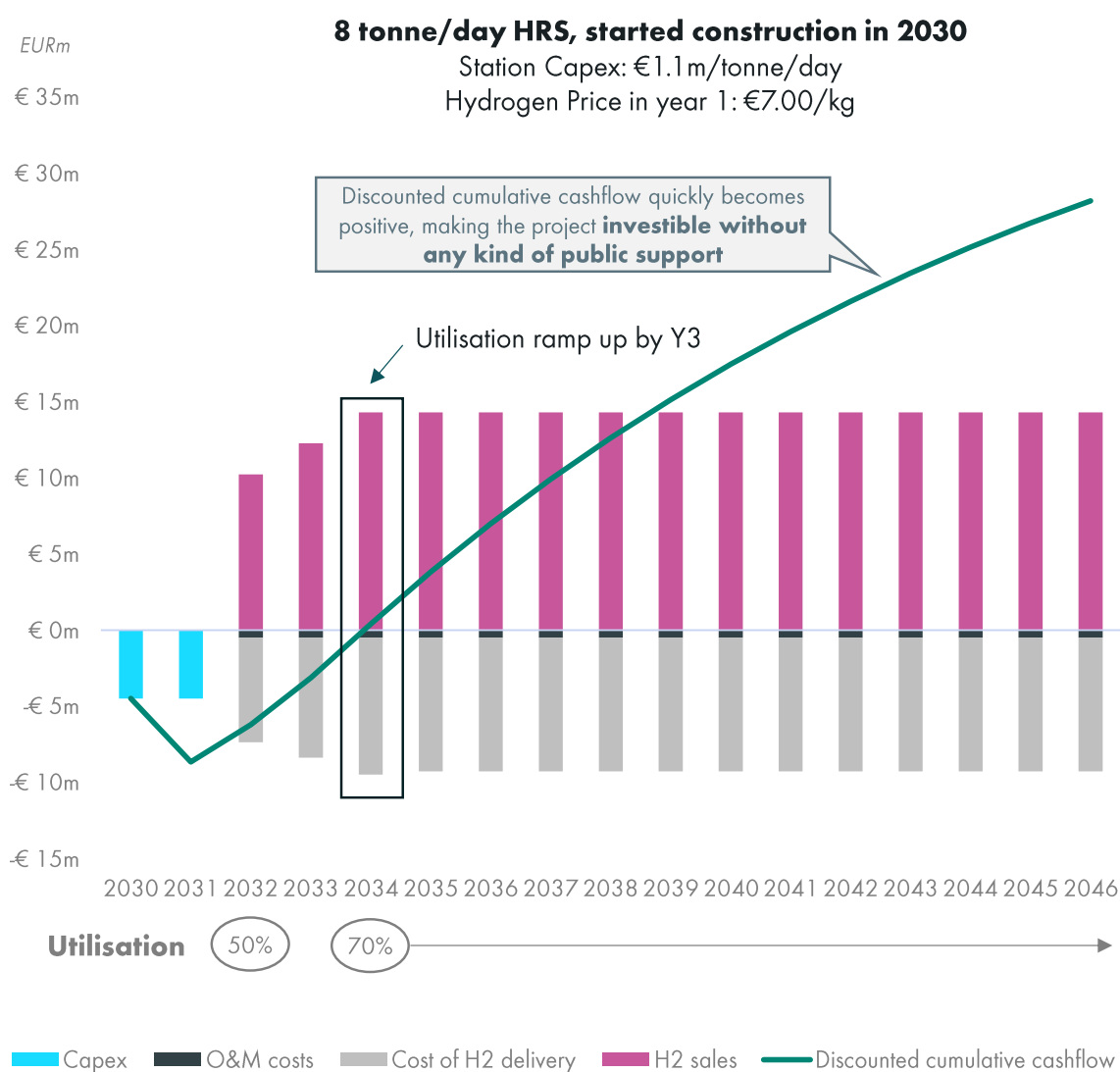


## A CHALLENGING SHORT-TERM BUSINESS CASE FOR THE FIRST HRS DEPLOYED

When looking at the economics of HRS and the need of support it is essential to distinguish between **different periods of time**. In the **maturity phase**, when there will be a substantial volume of hydrogen vehicles and HRS, the HRS will be operated in a profitable way with a business model very similar to the one that exists today with diesel and petrol stations. It is therefore expected that additional HRS installed during that phase **will have a substantially improved business case with minimal need for support**. Consequently, the main challenges highlighted in the following sections must be considered as short-term issues.

The following graph gives a simplified representation of the economics of an HRS that would be **deployed during maturity phase**.

**Figure 3:** financial forecast for an 8 tonne/day HRS, started construction in 2030 (see example data in Table 2, Supplementary Information)



**However, in the deployment phase,** when the first network of HRS is deployed (corresponding to the AFIR target) and vehicles manufacturing is scaling up, an adequate support mechanism is needed to overcome short-term bottlenecks:

- › **Temporary underutilisation:** the main economic challenge of HRS<sup>11</sup> is that **they need to be deployed before there is enough vehicles to ensure a rate of utilisation sufficient to ensure the profitability** of the stations. Indeed, from a financial perspective, the cash flows generated in the first years of operation are much more valuable than the cash flows generated in 10 years' time. Consequently, even if a significant increase in the utilisation of the network is observed in the high utilisation period, **this will not compensate for the short-term losses**. This unavoidable underutilisation dictates the nature of the support scheme: the minimum revenues of the stations **need to come from its capacity to offer refuelling and not only from its actual sales**<sup>12</sup>.
- › **Temporary high CAPEX:** the first generation of HRS will be more costly as they will not have yet benefited from economies of scale and learning curves. As a consequence, as HRS operators seek to minimise financial risk, they continue to **deploy small-scale HRS**, which means the initial network will not be adapted to the period of strong growth. It is likely that the market will very quickly move from underutilisation of the HRS network (over-capacity) to undercapacity, which could block the deployment of hydrogen vehicles.
- › **Temporary high cost of hydrogen:** it will still take a few years before low-carbon and renewable hydrogen is accessible in large quantities, and at a low price. Hydrogen cost reductions will strongly benefit HRS business cases, but the initial network will have to support high costs thus making the business case more challenging.
- › **Reliability of the HRS network:** full confidence in the consistent performance of the stations is a pre-requisite to convince users to purchase hydrogen vehicles. A support mechanism which is disbursed over several years and on the basis of the continued performance of the stations is an efficient way to ensure performance and generate confidence among vehicle manufacturers and fleet operators.
- › **Ensure bankability and reduce the cost of capital:** A capacity payment mechanism would enable visibility on future cash flows, thus facilitating access to debt finance.

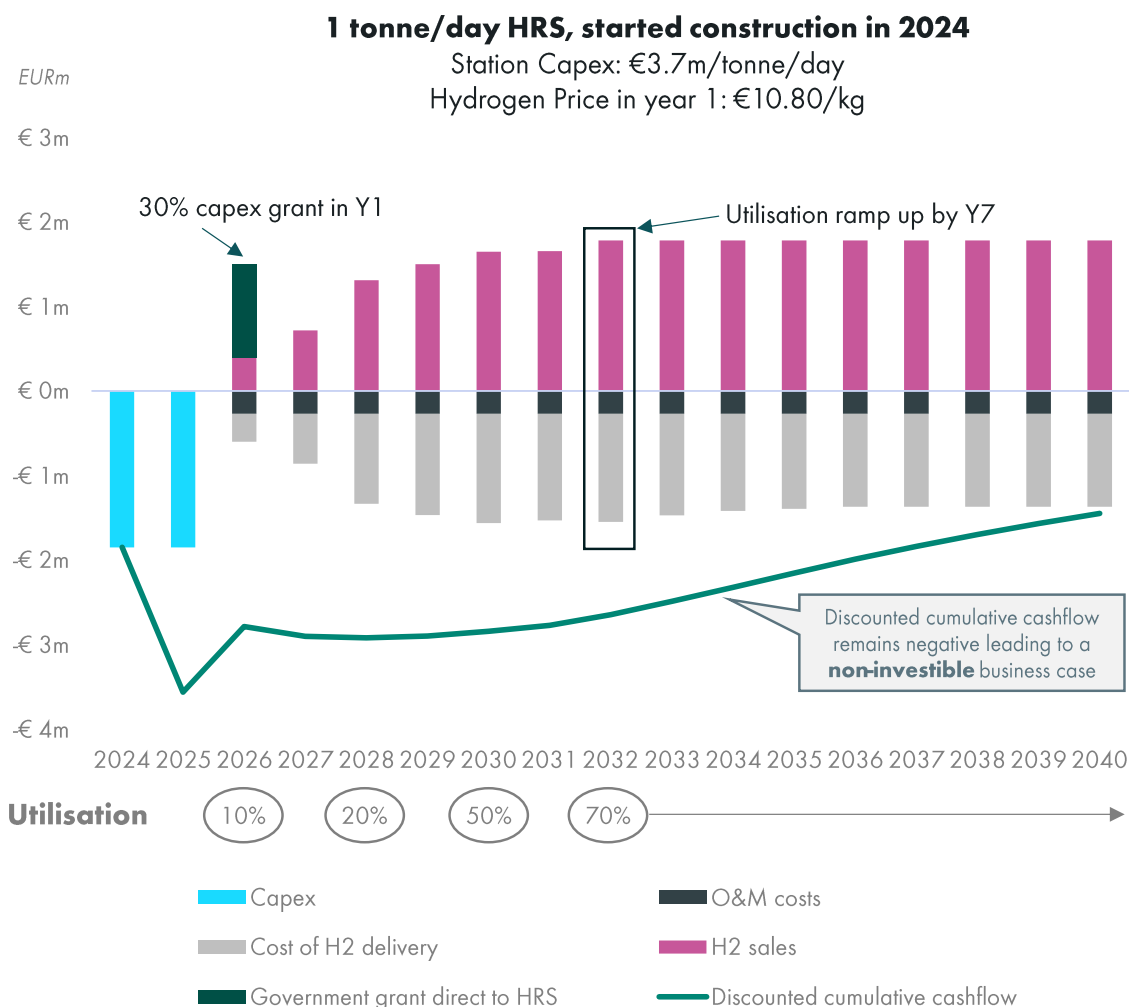
The below graph gives a simplified representation of the economics of an HRS with construction starting in 2024 and suffering from high capital costs, high hydrogen costs, and underutilisation.

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<sup>11</sup> The same underutilisation problem could also apply to hydrogen logistics between the production center and the hydrogen refuelling station.

<sup>12</sup> This situation is well-known in other sectors, notably power plants which acts as a backup when there is not enough renewable electricity. As their number of operating hours is not sufficient to ensure profitability, they are remunerated by a capacity payment (to complement sales revenues).

**Figure 4:** financial forecast for a 1 tonne/day HRS, started construction in 2024 (see selected data in Table 3, Supplementary Information)



In this context, deploying a large-scale HRS network in anticipation of the arrival of the vehicles is not feasible without public support. All these challenges are temporary and justify the use of **specific support schemes** during the deployment phase, to support the effective implementation of AFIR. They also suggest that in the maturity phase, new HRS will no longer need support to be profitable.

Without clear public support for the HRS network, there is a risk of **delaying the network's rollout and missing the comprehensive coverage target set by AFIR for 2030** (and therefore the ambitious decarbonisation targets set by the European Commission). In current market conditions, private investors are likely to suspend or delay their investments, pending better market visibility.



## EXISTING PUBLIC SUPPORT MECHANISMS FOR HRS HAVE BEEN INSTRUMENTAL IN INITIATING A PRE-DEPLOYMENT, HOWEVER NEED TO BE RESTRUCTURED TO REMOVE SHORT-TERM BOTTLENECKS

A number of stations (236 HRS<sup>13</sup>) have already been deployed on the European territory. These stations have mainly been supported through calls for proposals with two key characteristics:

1. The **support takes the form of investment aid** (the recipient receives a grant corresponding to 20-80% of the CAPEX).
2. The successful **applicant decides where the stations will be located**.

These calls for proposals were implemented at EU level (mainly through the CEF program), but also at national levels through **dedicated schemes** (e.g. call for proposals from the "Federal Ministry for Digital and Transport" in Germany, the "French Agency for Ecological Transition" in France, or the "Ministry of Infrastructure and Transport" in Italy). Furthermore, additional schemes could be announced as part of AFIR, notably because Member States will have to release a **NPF by the end of 2025**.

These support schemes have been instrumental during the pre-deployment phase. This has enabled pioneers and believers in hydrogen technologies to deploy a first wave of HRS, **despite the fragile economics** (even after the grant). They have also been key to **demonstrate the technology** and to operate successfully small fleets of vehicles (buses, taxis, vans, a few trucks). It is therefore **essential to recognise that this form of support encouraged** the early deployment of HRS. As an example, more than **half a billion euros** have been committed by HRS developers and investors under AFIF. The AFIF program has already awarded **funding to about 140 HRS** (as of July 2023), which represents 20% of the AFIR deployment target. CAPEX grants worked either because the industrial partners were ready to support a loss for the sake of demonstrating the technology and/or because the pre-deployment of some stations could be coordinated with early **captive fleets of vehicles** (e.g. buses and taxis). Provided that there is no time pressure, this "slow and unplanned approach" could probably continue.

However, CAPEX grants are no longer adequate for the deployment phase because:

1. the number and the size of the necessary stations require large investments and **financial losses that cannot be absorbed by industrials**;
2. the deployment of stations must **take place rapidly and before there is a sufficient volume of vehicles to ensure the utilisation and profitability of the stations**.  
These CAPEX grants do not compensate for the low utilisation in the first years of operation.

In addition, calls for proposals **without systematic territorial coverage are no longer acceptable in the deployment phase**. Consequently, complementary tools are urgently needed to overcome short-term challenges. This must be seen as a **continuation of efforts already initiated by Member States**.

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<sup>13</sup> [IEA Technology Collaboration Programme](#)

## **'CAPACITY PAYMENT' MECHANISMS REPRESENT AN OPTIMAL SHORT-TERM SOLUTION TO REMOVE THE BOTTLENECKS IDENTIFIED AND FOSTER THE DEPLOYMENT OF A RAPID AND COMPREHENSIVE HRS NETWORK AT EU LEVEL**

If Member States are tempted to stick to the slow and unplanned approach, they are likely to miss the indicative targets for 2027 for sufficient coverage of TEN-T networks, and struggle to meet the AFIR requirements for comprehensive coverage by 2030. **Ambitious CO<sub>2</sub> standards for vehicles will never be met if the network is not deployed well ahead of the vehicles** (notably for long-distance trucks). Heavy-duty vehicle CO<sub>2</sub> standards require vehicle OEMs to sell tens of thousands of ZEVs by 2030 (meaning the HRS network must be well developed at this point). Consequently, there is urgency to move very quickly to the implementation phase of AFIR and to adapt support mechanisms to account for the short-term bottlenecks identified.

Several potential support mechanisms have been analysed by an industrial and commercial coalition with the aim of identifying a mechanism with the potential to overcome short-term bottlenecks and to enable the deployment of the HRS network by the 2027 target, **contributing therefore to the achievement of AFIR, but also of the heavy-duty vehicles CO<sub>2</sub> standards**. The objective was therefore to identify a mechanism that will:

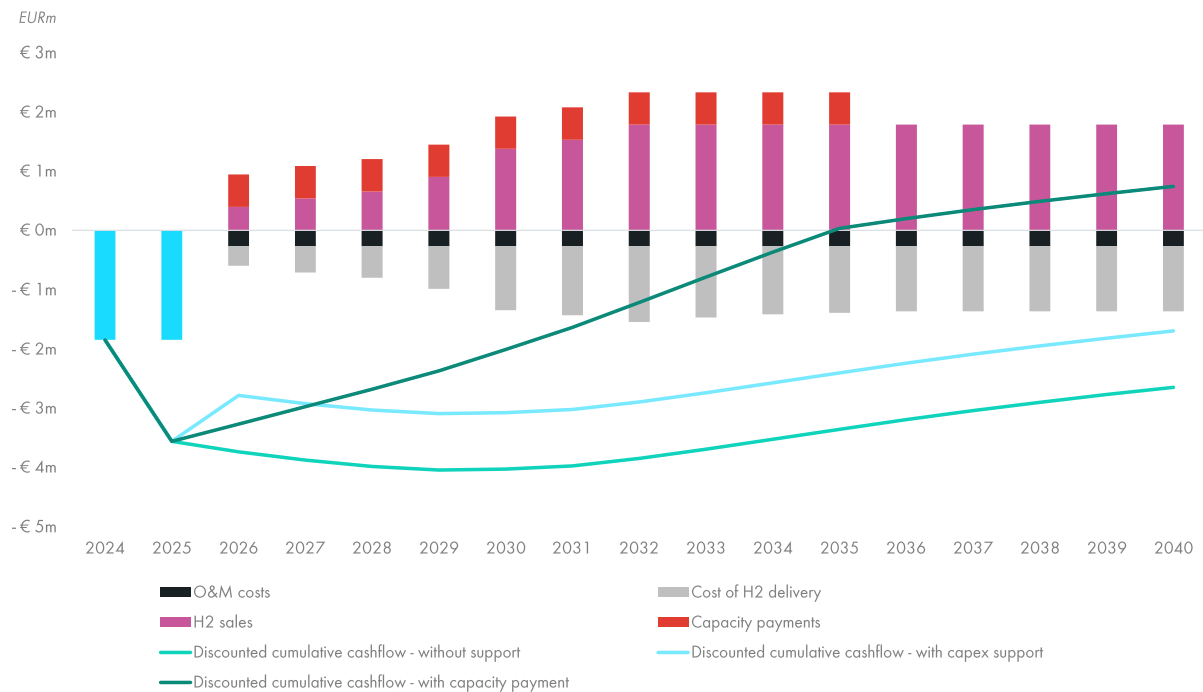
- › **Offer a fixed rent**, based on the capacity of the stations, disbursed over 8-10 years under the condition of continued high performance of the stations. The quality and reliability of the HRS network would be evaluated on the basis of precise criteria (level of availability, price of hydrogen, accessibility, payment options, etc.)
- › Grant Member states greater **control over the quality and reliability** of the HRS network by using capacity payment mechanisms instead of CAPEX-based support (which does not give much **visibility on the operational characteristics** of the network deployed). This is key to ensuring successful uptake in utilisation.
- › Ensure a **territorial coverage**: the state (in consultation with fleet operators) would focus the effort on developing a **viable planned network** of HRS where demand for hydrogen fuel is expected to materialise;
- › Implement a **competitive selection process** to ensure best value for money. The state would award a payment that is sufficient to ensure bankability of the stations, but competition will ensure that the state does not pay more than necessary. In addition, a competitive process will facilitate state aid approval.
- › **Foster the development of clusters** with the objective to have a plurality of operators and to optimise hydrogen logistics costs (which can be a substantial part of the fuel cost).
- › Use models/initiatives that have been **tested and approved by state aid authorities**, to ensure a rapid and effective implementation of AFIR.

The "Capacity Payment" mechanism provides an answer to all challenges listed in the previous section. Of course, several articulations could be envisaged to **design and implement** the capacity payment. For instance, the capacity mechanism could be adjusted based on the exact utilisation on the network. A **profit sharing mechanism** could also be implemented (e.g., above a certain level of utilisation, the profits would be shared with governments).

Such a mechanism exists and has notably been set up in Germany **to support fast charging infrastructure for BEVs**, which faces similar challenges as hydrogen infrastructure. This new mechanism has been approved by the EU state aid authorities<sup>14</sup>.

The benefits of the capacity payment mechanism with regards to HRS business case over the CAPEX support typically given for HRS today is clearly shown in the chart below.

**Figure 5:** Financial forecast for a 1 tonne/day HRS, started construction in 2024, with either no support, a 30% CAPEX grant in the first year of operation, or a €0.55m/tonne/day capacity payment for the first ten years of operation

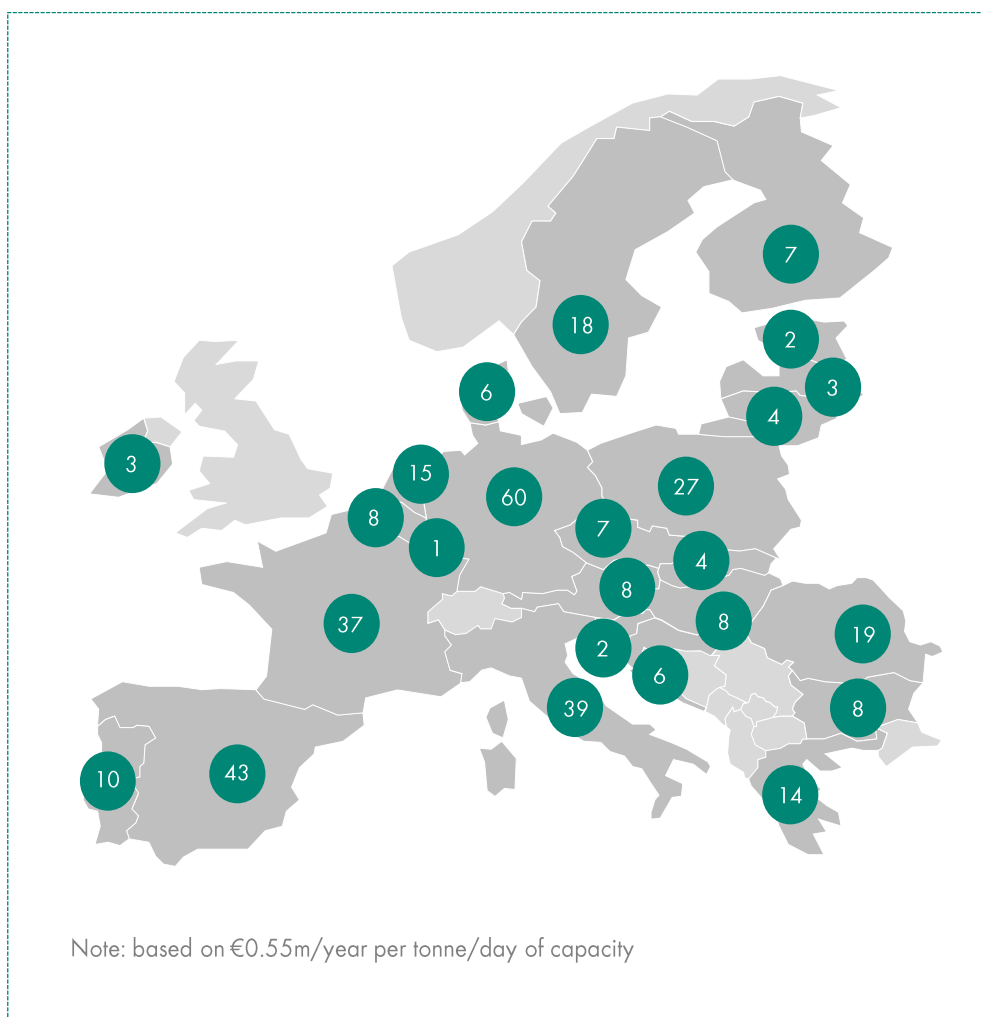


<sup>14</sup> [European Commission](#)

## HOW MUCH WOULD IT COST?

The total funding required to deliver the AFIR network across Europe using the capacity mechanism is expected to be €1.8billion (discounted value)<sup>15</sup>. While a substantial amount, it should be noted that this allows **all 27 European Member States to meet the requirement of AFIR** for hydrogen refuelling. This will also enable the deployment of hydrogen vehicles and therefore contribute to meeting the Heavy-Duty CO2 Standards. Implementing AFIR represents a necessary condition for decarbonizing road transport in Europe, but certainly not a sufficient one.

**Figure 6:** estimated annual capacity payment needed per country to fulfil AFIR (€m per year, undiscounted value), based on Hydrogen Europe deployment estimates



Vehicle OEMs and suppliers in Europe estimate that **billions of Euros have already been invested in the development of hydrogen vehicles**. This is substantially more than the funding required to enable the development of a full AFIR-compliant HRS network, which is necessary to realise the benefits of the investments already made by OEMs.

<sup>15</sup> The analysis considered the following rollout for the AFIR HRS network: 50 HRS deployed in 2026, 100 in 2027, 150 in 2028, 150 in 2029 and 200 in 2030.



In addition to **unlocking billions of Euros of investment** across the hydrogen vehicle, production, and refuelling supply chains during the 2020s, the commercialisation of the first hydrogen refuelling network **will enable further investment from 2030 into hundreds of times more stations** which will not require financial support.

In terms of budgetary impact, the implementation of a capacity payment would be **equivalent to one wave of IPCEI**. The financial effort remains important but would lead to **significant spillover effects, strengthening Europe's industrial leadership** in hydrogen distribution technologies.

## COMPLEMENTARY SCHEMES TO THE CAPACITY PAYMENT LIKELY TO REDUCE THE BUDGETARY IMPACT FOR MEMBER STATES

While we believe that the capacity payment as described in the previous section constitutes the most suitable support mechanism, we acknowledge that Member States may want to explore complementary or alternative mechanisms which have different impact on their budget and on users. The table below gives an overview of these mechanisms, their impact, and their relation to the proposed capacity payment.

MEASURES	SUPPORT PAID BY	FOCUS OF THE AID	EFFECT & RELATION WITH CAPACITY PAYMENT
Capacity payment	State	HRS	
Longer concession (territorial exclusivity)	Users of HRS	HRS	<ul style="list-style-type: none"> <li>• Create first mover advantage</li> <li>• Increase long term profitability</li> <li>• Reduce capacity payment</li> </ul>
Renewable Energy Directive	Users of fossil fuels	Cost of hydrogen	<ul style="list-style-type: none"> <li>• Reduce cost of hydrogen</li> <li>• Reduce capacity payment</li> </ul>
Mandate on fleet operators	Users of fleets	Vehicles	<ul style="list-style-type: none"> <li>• Reduce underutilisation</li> <li>• Reduce capacity payment</li> </ul>
Subsidy on vehicles	State	Vehicles	<ul style="list-style-type: none"> <li>• Reduce underutilisation</li> <li>• Reduce capacity payment</li> </ul>
Mandate on motorway operators	Users of motorway	HRS	<ul style="list-style-type: none"> <li>• Eliminate first mover disadvantage</li> <li>• Alternative to capacity payment</li> </ul>
Mandate on fuel retailers	Users of fossil fuels	HRS	<ul style="list-style-type: none"> <li>• Eliminate first mover disadvantage</li> <li>• Alternative to capacity payment</li> </ul>

### ***(Sub)concession models***

In Europe, several countries have implemented motorway management concessions. These motorways have service/rest areas with petrol refuelling stations. Concessionaires are often chosen for very long period (several decades). This is both a tool and a legal constraint to be taken into account and could be an opportunity: the inclusion of HRS deployment targets on these concessioned motorways could potentially **reduce the level of public funding needed to achieve a viable business case**. Indeed, HRS operators would benefit from:

- › **Exclusivity**, which would result in increased utilisation compared with other HRS in the medium term.
- › **First mover advantage**: as excellent early testbeds for commercial hydrogen refuelling networks, HRS operators on concessioned motorways will benefit from learnings on the technology and market for hydrogen fuel which can be leveraged as the sector expands.
- › **Higher margin**: HRS operators located on concessioned areas are usually able to charge a small premium to end users, therefore improving the business case. Increased utilisation and higher margins in the medium term could offset some of the short-term losses associated with the lack of vehicles and reduce the level of subsidies required.

The result would be an improvement in the short-term business case and, consequently, a **lower level of capacity payment** needed to achieve the same return target.

### ***Mandate on fleets***

One of the main obstacles to the introduction of ZEVs (battery or hydrogen-powered) is that their cost is higher than that of diesel, at least for the first few years while costs fall. As the transport sector is extremely competitive, it is difficult, if not impossible, for a carrier to bear this additional cost if its competitors do not also bear it, as it would immediately lose its competitiveness. Instead of having a first mover advantage, there is a first mover disadvantage.

On the other hand, if all carriers are subject to the same obligations, this removes the first mover disadvantage. These mechanisms would therefore provide HRS operators with better visibility on demand and strengthen their medium-term business models. This **increased certainty could therefore reduce the support needed** through the capacity payment mechanism.

In California, the California Air Resources Board (CARB) recently approved a new rule requiring fleets operating in California to deploy an increasing percentage of ZEVs starting in 2024 (**100% of new sales for medium- and heavy-duty vehicles** will have to be zero-emission by 2036). In France, the government has already announced conversion targets for public fleets in **urban areas with more than 250,000 inhabitants**. For instance, from January 2025 onward, 50% of new buses deployed will have to be either battery or hydrogen vehicles.

At a larger scale, the European Commission could propose a policy initiative to **favour the purchase of clean vehicles** by corporate fleets before the end of this year (2023). Introducing such measures would encourage the adoption of ZEVs in the short term and eliminate political uncertainty. However, these mandates on fleets would not entirely remove the short-term underutilisation challenges, as **vehicles are not yet available in large volumes**.

## **RED Transposition**

The Renewable Energy Directive (RED III) creates an obligation for fuel suppliers to integrate a share of renewable energy. This obligation notably includes that by 2030, 5.5% of the energy used for transport should be comprised of advanced biofuels and/or renewable hydrogen, with a minimum portion of 1% renewable hydrogen. This represents up to one million tons of renewable hydrogen according to Hydrogen Europe<sup>16</sup>.

Member States now have to transpose the Directive into their national legislation and ensure that:

1. their transposition gives a high value to renewable hydrogen and
2. it will be done in a way that supports the HRS operators.

Some countries have already made progress on this, notably Germany with its system of “GHG quotas”<sup>17</sup> and France with the TIRUERT (incentive tax for the usage of renewable energy in transport)<sup>18</sup>. Under these schemes, fuel suppliers will have to sell an **increasing percentage of renewable fuels** every year. Fuel retailers who fail to meet the legal target will have to pay penalties unless they acquire certificates from qualified third parties. The value of the certificate could therefore be used to reduce the costs of hydrogen at the pump and reduce the total cost of ownership (TCO) for hydrogen vehicles. When transposing the RED, Member States should ensure that it is done such as to support the development of hydrogen mobility<sup>19</sup>.

These schemes are **likely to improve the economics** of HRS in the medium-term by providing an **additional source of income**, through the sale of certificates (if the transpositions are aligned with the German and French models). HRS operators would have therefore the possibility to **include certificates in their business models**. This represents a way for Member States to support the deployment in a complementary way, without impact on their budget, and to reduce the level of funding needed through the capacity payment.

However, there are still uncertainties regarding the implementation of these schemes and the short-term impact on HRS business models. If RED transpositions will certainly improve the economics of HRS in the medium-term, **they will not be sufficient to remove short-term bottlenecks** and unlock HRS deployments, notably because they do not address underutilisation challenges.

## **Direct subsidies to vehicles**

Direct subsidies to vehicles would **foster the uptake of hydrogen vehicles** and provide better visibility to OEMs. The objective is not only to bring hydrogen vehicles to the market, but also to make sure that prices will be sufficiently attractive for end-users. In this context, **direct acquisition grants** to encourage end-users could be an interesting option to increase the

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<sup>16</sup> [Hydrogen Europe](#)

<sup>17</sup> The Work program of the European Commission mentions such initiative for the second half of 2023.

<sup>18</sup> See [documentation](#) from the French Government. The French Government is currently considering a revision of the TIRUERT mechanism to integrate the RED III requirements. Detailed proposals have been made by [France Hydrogène](#) to ensure the TIRUERT better supports the deployment of HRS.

<sup>19</sup> Member States could also consider the possibility to reward the use of low carbon hydrogen in addition to renewable hydrogen.



competitiveness of hydrogen vehicles in the short-term. This would secure a **short-term TCO reduction** for hydrogen vehicles and support end-users in their transition to zero-emission mobility. Of course, there are a myriad of different options that could be explored to foster the uptake of hydrogen vehicles (e.g. tax rebates for hydrogen vehicles, zero-emission areas, etc.).

Direct subsidies to vehicles will **not compensate for the low utilisation in the short-term**, as a ramp-up in manufacturing capacity will still be required. However, if designed correctly, they will ensure that hydrogen vehicles are attractive to end-users. OEMs will therefore be more confident in the roll-out of the market and could accelerate their production capacity, ensuring a stronger ramp-up in the medium-term.

## EXTRA-BUDGETARY TOOLS COULD BE USED AS AN ALTERNATIVE TO CAPACITY PAYMENTS IN SOME COUNTRIES

In some countries, governments could decide **not to proceed** with the capacity payment, as it will involve a budgetary effort (even if complementary options described in the previous section have the potential to significantly reduce the level of commitment needed). If the Member State is not able to take on the risk or support the costs of hydrogen refuelling infrastructure, obligations for this infrastructure are required.

Consequently, two main alternatives to the capacity payment have been analysed, which have the potential to **overcome the short-term bottlenecks** identified in the previous sections. They would guarantee the deployment of a comprehensive HRS network ahead of the vehicles, reduce HRS CAPEX and development costs by leveraging scale effects, and therefore improve the competitiveness of hydrogen at the pump for end-users.

### ***Mandate on motorways***

Several Member States have established concessioned motorways. If Member States were to create a mandate on motorways, all **concessionaires would be obliged** to deploy HRS (directly or indirectly) along the main corridors. If designed correctly, this would ensure the deployment of a comprehensive network of refuelling stations in the short-term (ahead of the vehicles), **in line with AFIR requirements**.

On concessioned motorways, vehicles often have to pay for the right to use the infrastructure. Across the EU, billions of transactions are carried out on toll-roads every year. To account for the short-term low utilisation, concessionaires may decide to **slightly increase the toll price**. This would cover the short-term losses and ensure the network can be deployed ahead of the vehicles without jeopardising the network business case. Consequently, this toll increase would represent a **'virtual' capacity payment**<sup>20</sup>. Of course, the toll increase should be designed to be sustainable for end-users.

This scenario would **not be suitable for the entire HRS network**, as some countries do not have motorways under concession. Nevertheless, it represents an alternative that could be of interest in certain Member States. A simplified analysis shows that an 11-cent increase per toll transaction for trucks would be equivalent (in terms of budget generated) to the total budget required to finance the capacity payment presented above<sup>21</sup>.

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<sup>20</sup> The calculation in terms of toll increase only aims to give an order of magnitude and other compensation mechanisms could also be designed to encourage HRS deployments on motorways.

<sup>21</sup> According to [ASFA](#), 200 million toll transactions were recorded for trucks in France (2022). Taking into account the total number of trucks deployed in France (615k according to [ACEA](#) data), this gives a ratio of 325 toll transactions per year and per truck. This ratio was then extrapolated to the rest of Europe to obtain an estimate of the total number of toll transactions for trucks. Multiplying 325 by 6.4 million trucks ([ACEA](#) data), we reach about 2.1 billion toll transactions at EU level.

## **Mandate on fuel retailers**

Member States could decide to introduce a mandate on fuel retailers, setting deployment **obligations** depending on the number of petrol refuelling stations deployed on the territory (e.g. for every 100 to 200 petrol refuelling stations in operation, 1 HRS must be deployed). This could guarantee the deployment of the network in the short-term, ahead of the vehicles.

In principle, existing fuel retailers could be interested in installing HRS alongside their petrol and diesel stations, thereby ensuring the **continuity and gradual decarbonisation of their business**. However, the operation of HRS during the deployment phase is not profitable due to underutilisation. A fuel retailer could offset the loss it makes on its HRS by a slight increase in its petrol/diesel selling price<sup>22</sup>. This is only viable if all fuel retailers are subject to the same obligation as fuel sales are extremely competitive and it is difficult for a fuel retailer to bear this additional cost if its competitors do not also bear it.

There are more than 110,000 petrol/diesel stations in Europe and AFIR is calling for the installation of c.660 HRS, which would represent about 1 HRS for every 150 petrol/diesel stations. A mandate to install 1 HRS for every 150 petrol/diesel stations would only have a **minimal impact on the cost of petrol and diesel**. There is a precedent for this type of scheme (e.g., to support the development of biofuels).

At the European level, significant quantities of fossil fuels are used for transport applications. In 2020, final consumption of motor gasoline and diesel for transport represented more than **254 billion litres**<sup>23</sup> in the EU, of which approximately 55 billion litres were consumed by heavy-duty vehicles. Thus, a 0.4-cent euro per litre increase in fuel prices for heavy-duty vehicles would be equivalent (in terms of budget generated) to the total budget required to finance the capacity payment presented in the previous sections.

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<sup>22</sup> The calculation in terms of diesel/petrol price increase is intended to provide an order of magnitude. Other compensation mechanisms could also be imagined to encourage HRS deployments by fuel retailers.

<sup>23</sup> [European Transport in Figures, 2022](#)

## INCREASING COORDINATION AMONG PUBLIC AND PRIVATE STAKEHOLDERS IS ESSENTIAL TO INCREASE VISIBILITY AND FOSTER THE HRS ROLLOUT

As highlighted, public support mechanisms will be critical to support the rapid implementation of AFIR. The previous sections have pointed out dedicated schemes that could be used to tackle short-term bottlenecks. Of course, a **myriad of articulations, adaptations, combinations** could be envisaged to design the optimal scheme.

In any case, **greater coordination** between public and private hydrogen stakeholders will be essential to guarantee better **visibility**, and therefore reduce the level of financial risk throughout the entire value chain. Member States and the EC will only implement new support mechanisms if they are convinced that OEMs and infrastructure providers will contribute significantly to the short-term effort. Indeed, subsidies from Member States are limited, and it is critical to maximise their impact by **combining them with joint commitments** from key hydrogen players, in order to set up integrated and de-risked business models. The **stronger the commitments from all stakeholders**, the faster and more effectively the sector can get to scale. These commitments could include:

- › **HRS providers:** committing to provide stations with sufficiently high capacity and in the correct locations to meet AFIR requirements, with an acceptable hydrogen price and high reliability.
- › **OEMs:** committing to provide certain number of vehicles through time, providing estimated geographic splits of vehicle sales or commitments to hydrogen prepurchase for customers.
- › **Fleet operators:** committing to purchasing vehicles and providing information on likely geographic distribution, or commitments to hydrogen prepurchase.

The above list intends to give ideas and should not be considered as exhaustive. In any case, we should not focus on **unilateral efforts**, but rather promote mutual commitments to support the rapid deployment of hydrogen mobility. The aim is not to create additional complexity, but rather to ensure each stakeholder benefits from long-term visibility and optimal market conditions. Several levels of commitment could be envisaged to **foster coordination**:

- › **Geographical level:** hydrogen stakeholders could reassure their commitment to deploy infrastructure and vehicles at EU, national, and even local levels.
- › **Collective dimension:** hydrogen stakeholders could decide to take individual, bilateral, or collective commitments to foster the deployment of hydrogen mobility. This could include, notably, the number of vehicles/HRS deployed in a dedicated geographical area, and compliance with quality and reliability standards.
- › **Binding level:** hydrogen stakeholders could decide to release publicly key components of their short-term strategy (e.g. deployment target in a given country), but they could also formalise agreements with other stakeholders (e.g. through MOUs).

The possibility and modalities of such commitments should be discussed in detail in a **coordinated process with Member States**. Above sections aim to provide a summary of the main tools that could be used by Member States and the European Commission to foster AFIR implementation, but they represent above all a starting point for further collective discussions. The inclusion of private

stakeholders in the discussions would strongly benefit the initiative by enabling further knowledge sharing (field experience, bottlenecks identified, technical background, etc.). This is why the setup of a **dedicated working group with public and private stakeholders** would greatly facilitate the discussions and the implementation phase of AFIR.

## CONCLUSION

If a **coordinated strategy for the deployment of HRS** across the EU is implemented without delay, CO<sub>2</sub> standards set by the European Commission for hydrogen vehicles can be met by the 2030 target. As outlined in this report, **the immediate and planned deployment of HRS with strategic locations by 2027 is critical** to meeting the 2030 timeframe. Coalitions must be ready to participate to ensure coordinated roll-out of HRS.

AFIR requirements for deployment of HRS at 200km intervals along TEN-T corridors **can be fulfilled in one step** if an immediate and planned approach is taken. This would enable the commercial scale up of hydrogen vehicle deployment from 2026 and **allow future HRS to be built without government support**. However, this must be implemented without delay, else a slow and unplanned deployment of HRS will prevent coverage targets and emissions standards being met on the required timelines and incur additional expense for government and industry alike.

This report details how the financing of a **planned network** in which HRS operators are bound to performance standards and hydrogen price requirements is essential to the successful implementation of AFIR on short timescales. The support mechanism which was best placed to **minimise the issue of short-term underutilisation and financial loss** was the use of a **capacity payment mechanism** with support from additional elements. It is estimated that a capacity payment of €0.55m/year per tonne/day of capacity would be sufficient to stimulate investment in the sector. This results in a total subsidy requirement of €1.8 billion (discounted value) over 10 years to implement AFIR across all EU Member States.

There are further opportunities to implement policy which can **reduce the budget for capacity payments**, including (sub)concession models, mandates on fleets, or RED transposition. These complementary mechanisms will allow Member States to reduce the financial input required to deliver AFIR on time and in one step. For some countries, **extra-budgetary tools may be appropriate as an alternative** to capacity payment mechanisms, such as mandates on motorways or fuel retailers.

The **coordination** of EU Member States **across geographical and policy frameworks** is essential to enable the rapid rollout of HRS and hydrogen vehicles. Joint commitments between HRS providers, OEMs, and fleet operators can facilitate faster and effective scaling. Although significant effort will be required for the rollout of a reliable HRS network and the associated ramp-up of hydrogen vehicles, **delivery can be achieved given financial support and collective commitment**. This will unlock the billions of euros invested in the development of hydrogen mobility technologies across the supply chain, and enable Europe to maintain its position as a global leader in zero carbon transport.

The creation of a **dedicated working group at EU level**, bringing together key industry players (vehicle manufacturers, infrastructure providers, fleet operators), financiers, and voluntary Member States would enable active coordination of the AFIR implementation phase and effectively support a quick and dense roll-out of HRS well ahead 2030.



## SUPPLEMENTARY INFORMATION

**Table 2:** Selected assumptions of utilisation, price, and cost for 8 tonne/day HRS during lifetime

8 tonne/day station (start-up in 2030, commissioning in 2032)																
Year	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Utilisation <sup>1</sup>	50%	60%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
H <sub>2</sub> Price <sup>2</sup>	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €
H <sub>2</sub> Cost <sup>3</sup>	5.00 €	4.70 €	4.50 €	4.40 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €

<sup>1</sup>High utilisation scenario based on 2030 deployment scenario

<sup>2</sup>2030 hydrogen prices based on internal calculations and data sets from ERM

<sup>3</sup>2030 cost assumptions based on internal calculations and data sets from ERM

**Table 3:** Selected assumptions of utilisation, price, and cost for 1 tonne/day HRS during lifetime

1 tonne/day station (start-up in 2024, commissioning in 2026)															
Year	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Utilisation <sup>1</sup>	10%	15%	20%	30%	50%	60%	70%	70%	70%	70%	70%	70%	70%	70%	70%
H <sub>2</sub> Price <sup>2</sup>	10.80 €	9.82 €	8.98 €	8.21 €	7.53 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €	7.00 €
H <sub>2</sub> Cost <sup>3</sup>	9.00 €	8.10 €	7.29 €	6.56 €	5.90 €	5.31 €	5.00 €	4.70 €	4.50 €	4.40 €	4.30 €	4.30 €	4.30 €	4.30 €	4.30 €

<sup>1</sup>Base case utilisation with 2024 deployment timelines<sup>2</sup>Based on internal calculations and data sets from ERM<sup>3</sup>Based on internal calculations and data sets from ERM**Table 4:** Assumptions applicable to general HRS deployment scenarios

Assumptions		
Discount rate		8%
Years to plan & build HRS		2 years
Lifetime		15 years
Fixed OPEX <sup>1</sup>	1 tonne/day	0.27 m€/year
	8 tonne/day	0.5 m€/year

<sup>1</sup> Based on internal calculations and data sets from ERM