PREFACE

Hydrogen Europe on PwC's Clean Hydrogen Lead Markets report

PwC's Clean Hydrogen Lead Markets report (the Report), commissioned by Hydrogen Europe, aims to find appropriate market-making measures to develop lead markets supporting Europe's competitiveness and clean industrial transition. Lead markets are a key pillar of the EU's **Clean Industrial Deal**, its industrial framework for competitiveness. The Report represents an impartial legal and economic analysis of market-making models readily available for policymakers, evaluating them from the standpoint of effectiveness, viability, and relevance for the hydrogen industry.

Lead markets aim to create reliable demand for low-carbon industrial products (namely for *low-carbon steel* and *fertiliser products*). Their purpose is to support market entry of these products and affect procurement preferences until they can compete with conventional products. Through establishing lead markets for CO_2-reduced steel and ammonia used in climate-friendly end-products, hydrogen demand will be incentivised indirectly as part of the industrial transformation. While lead markets are an important part in industrial policy, they are just one part of a successful hydrogen market ramp-up.

Models and approaches in the Report, supported by the hydrogen industry

The Report outlines a set of market-making regulatory measures to develop lead markets. In the context of clean steel, the Report focuses on primary steel production – through the hydrogen-based direct reduction of iron and electric arc furnace route.

- Measures such as "**Voluntary use of labels**" and "**Public procurement**" are significant, but in themselves not sufficient to provide an adequate push. The starting point for establishing effective lead markets must be a common, robust, and transparent definition of clean steel, through a product-based labelling and certification system. **Hydrogen Europe therefore emphasises the importance of a clean steel definition, based on a sliding-scale approach,** together with a primary steel performance metric,[1] without which steel producers would be incentivised to maximise scrap use, which is limited by growing scarcity of scrap and other technical issues. For a deep transformation of the steel industry, continued investment in hydrogen-based primary steelmaking is essential.
- "**Final product-based levy financed CfD**" and **"tax incentives"** may be supported by the industry, especially when it comes to predictable and reliable financing schemes on final products through compulsory EU-wide implementation. While they would require substantial public investment, the measures would create an immediate positive on the hydrogen and steel industries alike.
- A "**Sector-specific quota**" can have a significant impact, provided adequate enabling conditions are implemented EU-wide, including protection against global overcapacity, an effective CBAM, and competitive energy prices. If implemented correctly, clear, measurable

[1] The threshold currently applied within the study – a 70% reduction relative to the fossil fuel comparator of 94 g CO_2e/MJ – needs to be further linked to steelmaking requirements. As such, a robust, process- and product-based carbon intensity benchmark, such as the Low Emission Steel Standard (LESS), is preferred.

market and investment certainty can be built up, boosting investor confidence and mobilising private investment.

- A "**Supplier quota**", although important to consider, could be a misguided approach, as rightfully considered by the Report. There is a real risk that it would be bypassed or circumvented, essentially leading to carbon leakage and at the same time increasing steel prices without enabling optimisation along the value chain. The measure could jeopardise the European steel industry's competitiveness, limiting its ability to invest in decarbonisation through hydrogen.

In the context of clean fertilisers, the Report evaluates measures related to clean ammonia produced with clean hydrogen.

- A "**Food-based Levy Financed CfD Model"** could be an effective tool in ensuring offtaking of clean and low-carbon fertilisers as well as creating a market environment in which predictable and reliable financing can ramp up demand.
- A **"Bonus Model"** shows great potential in overcoming the price burden for low-carbon and renewable fertilisers but needs to be implemented in a way that recognises the complexities and particularities of the entire value chain. It should not put more administrative or operational burden on any player in the sector.
- A **"Supplier Quota"**, although an important element in the analysis of the market, would – like in the case of steel - be a misguided approach to take. Risks in implementing such a measure are both in creating an uneven playing field for imports, as well as putting unnecessary strain on a vulnerable European fertiliser industry.

Measures and approaches building on the Report

Further measures not reflected in the Report that benefit the wider discussion about lead markets are detailed below. These may not be expressly supported by Hydrogen Europe but have potential for the industry.

- "**Automotive credits**", whereby car manufacturers are provided with flexibility in reaching their fleet emission targets by integrating the production phase (i.e. the use of clean steel) of passenger cars and light duty vehicles, based on verifiable and certified emission reductions. This would provide manufacturers with a meaningful incentive to use low-emission steel. In this scheme, the calculation methods should remain simple, and measures should not trigger unwanted material substitution. This measure could be implemented in the upcoming passenger cars CO2 emission standards revision. Similarly, in the Corporate Fleets Regulation, extending the definition of "clean" both to the use phase and the production phase could be effective.
- "**ESPR**", wherein the Ecodesign framework sets requirements for intermediary products and product categories with substantial environmental impacts. By including low-emission materials like clean steel, the ESPR could define and label low-emission products, laying the foundation for lead markets across market segments.
- "**Clean and Low-carbon fertiliser certifications**", which is seen as an effective tool to implement in a range of EU legislation and policy, including the Fertilising Products Regulation, Eco-schemes, and more.

H_2 Lead Markets

Framework Study

November 2025

Disclaimer

Advisory Statement

This framework study was developed in collaboration between Hydrogen Europe aisbl (Hydrogen Europe) and PwC with input from individual members of Hydrogen Europe. The aim of the publication is to facilitate the discussion about the implementation of lead markets on the EU level; the described models and options are meant as a starting point only and require further analysis. Any views expressed in this framework study are solely that of the authors and do not necessarily reflect the opinions of PwC, Hydrogen Europe or its members.

PwC makes no representations as to the accuracy or any other aspect of information contained in this publication.

The information is provided on the understanding that the authors and publishers are not herein engaged in rendering legal, accounting, tax or other professional advice or services. As such, it should not be used as a substitute for consultation.

Content

Executive Summary

Key Takeaways

Executive summary

Current policy instruments, such as the EU ETS and CBAM, are not sufficient on its own to close the **cost gap between conventional and clean production pathways of primary steel and fertilizers**. This highlights the urgent need for new regulatory approaches. Policymakers could implement **lead markets to accelerate the adoption of clean hydrogen via clean primary steel and ammonia-based fertilizers**. This study outlines regulatory elements, potential timelines, and impacts, as well as mechanisms for facilitating the required uptake.

Clean steel

To support climate neutrality and industrial competitiveness, **establishing lead markets for clean hydrogen in the EU via the steel sector is crucial**. The analysis shows that ambitious quota-based regulatory models—either targeting primary steel supplier or end-product manufacturers—are the most effective mechanisms to drive large-scale adoption of clean hydrogen. These models can generate hydrogen demand while keeping end-product price increases minimal and acceptable to consumers. A **quota for end-product manufacturers** in connection with corresponding obligations for imported products and an exemption for exported products avoids a "carbon leakage effect". **Though voluntary labels and public procurement** can incentivize early adoption, they alone cannot create a significant market impact**.** They should be used as complementary measures, particularly for critical infrastructure and public sector projects. **Product-based levy financed CfD models** offer high theoretical effectiveness and efficiency, but the potential is currently limited by the EU's confined legal and fiscal authority. Their success would require expanded EU competencies or strong coordination among member states. To ensure investment stability and accelerate hydrogen adoption, policymakers should prioritize quota-based strategies with complementary incentives like labeling, public procurement, and targeted funding. Coordinated legislative efforts and stakeholder collaboration are vital for establishing Europe's leadership in climate-friendly technologies.

Clean ammonia-based fertilizer

The goal for the clean ammonia-based fertilizer market in the EU is to examine regulatory pathways to establish lead markets for clean hydrogen via the EU fertilizer sector, a key lever for decarbonizing ammonia-based fertilizer production and meeting EU climate targets. Achieving over 50% market share in clean fertilizers could fulfill 8% of EU's hydrogen production goals. The **supplier quota model** based on tradable certificates for fertilizer producers offers one transition option to clean hydrogen, while supporting infrastructure development and managing trade and political risks. However, the effectiveness of this model depends on the future development of clean ammonia imports, which could undermine the creation of a local hydrogen market. A **targeted bonus model** on the level of the agricultural producers can effectively stimulate hydrogen demand in agriculture if it is market-based and politically feasible, but it introduces administrative complexity and requires careful design to avoid excessive public spending. **The food-based levy financed CfD model** obligates food retailers to contribute to a fund supporting clean ammonia production, ensuring minimal end-product price increases and broad acceptability across the value chain. However, a sufficient legal and fiscal authority of the EU or a broad consensus of the Member States is required. **Voluntary models and public** procurement alone are insufficient to create a robust lead market but can serve as supplementary incentives.

1

Introduction

1.1

Background & objective

The study examines strategies to strengthen H2-demand via lead markets for CO2-reduced steel and ammonia-based fertilizer

Background & objectives of the study (1/2)

Industries to create lead markets

The sectors of **steel and ammonia-based fertilizer** fulfill the following to create H2 demand through lead markets for low-carbon industrial products:

- Clean hydrogen offers **potential for decarbonization** in these sectors
- Sectors have a **large share** of overall **GHG emissions** and thus decarbonization would yield substantial climate benefits
- **Technological readiness** of clean production processes based on hydrogen is given
- Relatively **low additional cost implication** of incorporating clean hydrogen into end products

In addition to these two markets refineries as well as industrial power generation are also options to create H_2 demand through lead markets

Goal of the study

The **Industrial Accelerator Act** (IAA*) aims at speeding up the decarbonization of energy-intensive industries by e.g. fostering markets for low-carbon industrial products – an approach to which this study contributes to in the following aspects:

- Identification of relevant **legislative frameworks** for the development of **lead markets**
- Exploration of **alternative regulatory approaches**
- Proposition of **adjustments** to existing legislations through a regulation-light regime
- **Unlocking** the **potential** of **clean hydrogen** in the short to medium term through clean lead markets

Key objectives

Outline key regulatory elements, possible **timeline** and **impacts** as well as **mechanisms** to establish predefined and time-bound uptake of clean steel and ammonia-based fertilizer

Development of a **lead markets agenda** in the EU, complementary to the RED III

Measure cost and impacts of new market design for climate-friendly products

* planned EU legislative act as part of the broader EU Clean Industrial Deal (scheduled for Q4/2025)

Current policy instruments have not proven sufficient to secure a comprehensive market ramp-up of clean hydrogen

Background & objectives of the study (2/2)

Clean hydrogen market design

Clean hydrogen enables decarbonization of energy-intensive industries and supports energy sovereignty and sustainable growth.

However, current policies are insufficient to support a comprehensive ramp-up of clean hydrogen.

- **Existing regulations**: have not proven sufficient for the ramp up of clean hydrogen markets
- **Fit for 55 package**: lays out a solid foundation, but further measures are necessary
- **Further policy plans**: are falling short in implementing measures, such as achieving REDIII and incentivizing clean hydrogen use necessary to meet the EU's carbon neutrality goals.

Challenges in the political landscape

Political actors have yet to translate ambition into concrete action and measures.

Initial efforts to address the challenges of developing clean hydrogen markets have been made.

- **EU Compass** and **Draghi report**: touch upon the creation of clean lead markets within a regulatory sandbox framework
- **IAA**: includes the idea to establish and protect European lead markets for low-carbon products from energy intensive industries with concrete measures

Lead markets in EU policy context

High-potential markets, where public policy can facilitate innovation uptake by shaping favorable conditions (e. g. through regulation, funding), are a starting point for tackling the hydrogen ramp up.

Lead markets are a sensible and cost-efficient intermediate step on the way to a hydrogen market that encompasses all sectors.

- **Goal**: “Foster demand for clean products [...] in EU
- public procurement”*
- **Cause**: clean lead markets must be implemented due to a “lack of stable and predictable market demand for clean tech products”*
- **Result**: demand-sided approach, distributing additional costs along the value chain to create a stable market and secure investments for industrial-scale deployment

* European Commission, 2025c

Initial efforts to address the challenges of developing clean hydrogen lead markets have been made in EU law

Summary of EU legislation and targets focused on hydrogen

(Thematic) Strategies

EU Hydrogen Strategy

- **Goals**: drive investment, scale production, boost demand, set standards, build infrastructure, and foster stakeholder cooperation
- **Measures**: 6 GW electrolyzer capacity for up to 1 Mt renewable hydrogen by 2024 and up to 40 GW for 10 Mt by 2030

Clean Industrial Deal

- **Goal**: accelerate decarbonization while boosting competitiveness in the energy-intensive industry and clean-tech sector
- **Among six pillars**: boosting demand for clean products and technologies (lead markets), including hydrogen

European Green Deal

- **Goal**: be first climate-neutral continent by 2050

Legislations / programs

Renewable Energy Directive III (RED III)

- **Goal**: RFNBOs* should account for at least 42% of all H_2 used in defined industries by 2030, and of 60% by 2035
- **Classification**: definition of RFNBO via delegated acts

Industrial Accelerator Act (IAA)

Under development

- **Goals**: faster approvals for energy access and decarbonization while maintaining high environmental standards, promotion of priority projects and industry clusters as well as creation of European lead markets for low-carbon products & protection from global competition

EU Hydrogen and Gas Decarbonization Package

- **Goal**: define rules for the H2 infrastructure and market design
- **Low carbon fuels**: July 2025 DA sets emission calculation rules for low-carbon fuels like hydrogen and requires at least a 70% reduction versus a fossil fuel comparator of 94 gCO_2/MJ.

Complementary strategies

Clean Deal Industrial Plan

- **Goal**: strengthen the competitiveness of Europe's net-zero industry and accelerate climate neutrality
- **Measure**: simplify approval and funding procedures so that at least 40 % of net-zero technologies are produced in Europe by 2030

European Action Plan for Steel and Metals 2025–2027 as well as European Chemicals Industry Action Plan

- **Goals:** Both action plans aim to strengthen the competitiveness, resilience, and sustainability of the respective industries in the EU. In addition, sustainability and resilience criteria will also be introduced.

RePowerEU Plan

- **Goals**: production and import of 10 million tons hydrogen each by 2030 and cover around 10% of EU energy demand by hydrogen in order to decarbonize energy-intensive industrial processes as well as the transport sector by 2050

* Renewable Fuels of Non-Biological Origin

Further regulatory measures, which have proven effective in other areas, may also contribute to the H_2 ramp-up through lead markets

Further policy options in use to foster hydrogen ramp up through lead markets

	Mandatory quotas & voluntary tenders	Product requirements	Certificates / labeling
Definition	• Quotas are mandatory production targets for using a certain share of environmentally friendly materials or fuels, with penalties for non-compliance • Individual producers may instead, on a voluntary basis, commit to targets in exchange for remuneration (e.g., contract for difference). Such agreements require a previous tender process	• Specific requirements that a product must meet to be placed on the market • Goal is to ensure certain characteristics, performance levels, or safety standards • Could include (physical) emission limits, which must be observed for each individual product	• Certificates confirm the use of clean materials/fuels during production and can be traded independently of the product • Labeling allows certificate owners to market their products with the low-carbon characteristics. Mass balance/book & claim systems allow mixing of eco- and conventional materials in the supply chain
Example	• **ReFuel EU Aviation:** quotas for fuel suppliers to provide sustainable aviation fuels at EU airports, airports to offer infrastructure as well as EU airlines to increase minimum share of SAF up to 70 % in 2050 • **Fuel EU Maritime:** targets to reduce emissions of energy used on ships in EU ports	• **Ecodesign Regulation:** framework for product requirements to cut carbon and environmental impact across lifecycle • **Construction Products Regulation:** unified EU standards for marketing and performance of construction products	• **Renewable Energy Directive (RED):** biofuels must cut emissions by a set margin and avoid feedstocks from high-biodiversity or high-carbon land and be verified through approved schemes ensuring traceability and compliance with EU standards • There are already specific regulations for certification of RFNBO and low carbon fuels in RED II and III
Implication H_2 lead markets	• A mandatory quota for the production, supply or use of clean steel or clean fertilizer is a possible way to implement lead markets. A quota requires either a physical mass balance or certificates for trading the low carbon characteristics. • Funding assumed, government can instead directly tender the production or use of clean steel /clean fertilizer	• Physical emission limits push producers to use clean hydrogen with partial use initially • Mandatory quotas have same effect, but can be implemented and administrated more efficiently, producers get more flexibility	• Certificates are necessary for any market design if (inefficient) physical quotas/emission limits shall be avoided • Certificate systems allow plant operators to opt for or against a clean production process based on individual considerations (tech/economics) • Voluntary labelling can be used instead of a quota

1.2

Framework

Clean property can be achieved by using any renewable or clean energy source

Definition

Definition of clean steel and clean fertilizer

- Primary steel made with any fuel derived from renewable or clean energy sources complies with the life-cycle GHG emissions savings requirement of 70 % relative to a fossil fuel comparator of 94 g CO2e/MJ[1]
- Ammonia-based fertilizer if the ammonia is made from the aforementioned energy sources

Use of the term clean hydrogen in the study

For the simplicity, the expression clean hydrogen is used as a generic term for the fuels utilized in the production of clean steel and clean fertilizer, in particular RFNBO and/or low carbon hydrogen

Illustration: Consequences for clean steel

Technology neutrality requires free choice of fuel…

Production of clean steel must be possible with any efficient low-carbon energy source, incl. **RFNBO, low carbon hydrogen and/or biofuel**. A mix of fuels is permissible

… but excluding the use of electricity to produce secondary steel …

Secondary steel is made from scrap iron in electric arc furnaces. There is no reason to additionally support the use of renewable electricity, which is already incentivised under EU and national laws. Primary and secondary steel can be distinguished based on the fuel used (hydrogen/gas/coke vs. electricity)

… and a clear focus on providing support for the hydrogen infrastructure

An alternative maximum CO2 value per ton of produce would allow producers to reduce emissions by other measures like gas-based steel production with CCS, weakening the ramp-up of the hydrogen infrastructure

Methodology to be modelled according Low Emission Steel Standard (LESS) …

Transparent, practical, and proven standard for a sustainable steel production

[1] Cf. Art. 29a RED III and Regulation (EU) 2021/2139, Annex I Section 3.10.

EU lead markets can drive clean hydrogen demand and production while ensuring investment stability for the existing project pipeline

Definition of clean lead markets

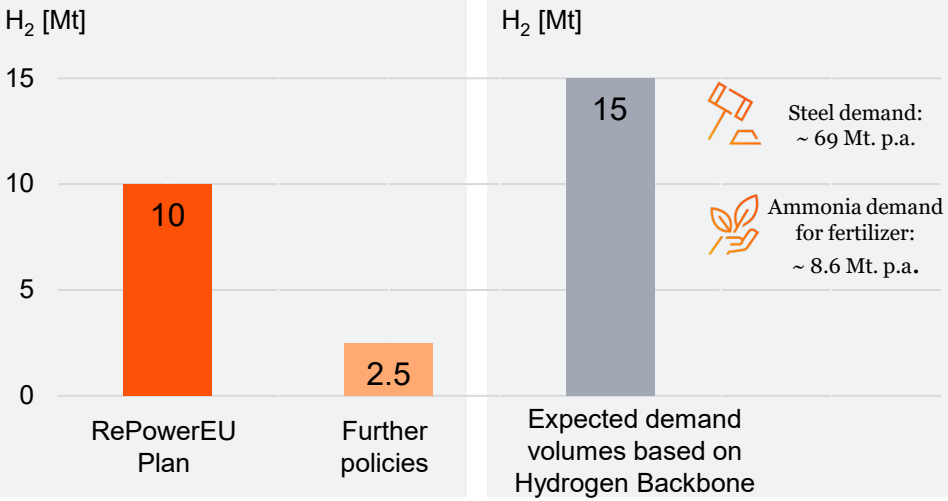
Estimated H_2 supply and demand in 2030 in the EU

Hydrogen supply

Predicted supply is derived from current EU regulations and policies, such as RePowerEU Plan, RED III etc. and their respective H2 production targets

Hydrogen demand

Estimates of hydrogen demand are based on industry demand assessments, such as the most recent analysis for the scaling of the EU hydrogen backbone



Lead market and H_2 impact

- A lead market should consider supply & demand
- The purpose is to create a **substantial demand for low-carbon products** based on clean hydrogen without dependency on long-term subsidies
- Lead markets are supporting **the scale-up of clean hydrogen** use until it becomes cost-competitive
- This study assumes that a **lead market should cover at least 20 % of EU's production** goals & industrial demand assessments

Aim for clean lead markets in this study

A LEAD MARKET IS ASSUMED TO INCENTIVISE **AT LEAST 20 % OR ~2 MT H_2** OF OVERALL EUROPEAN SUPPLY & DEMAND FOR CLEAN HYDROGEN

Sources: PwC Analysis; Hydrogen Europe (2025); European Hydrogen Backbone (2024); RePowerEU Plan

Based on various assessment criteria an objective evaluation of the shortlisted lead market models is ensured

Assessment methodology for shortlist

Approach for long- to shortlist

- Legal provisions, which are either already focusing on hydrogen or have proven effective for (other) markets, are sourced as possible **lead market frameworks**
- The market models focus on the concepts of **labelling**, mandatory **quotas** and **subsidies/tax credits**
- Based on the selection of lead market model, **longlists** are composed for both clean steel and ammonia-based fertilizer
- A **quick check** evaluates the models based on the criteria of effectivity, efficiency, carbon leakage prevention and lean implementation (for more details, see right)
- Only models, meeting these criteria, are part of the **shortlist** and will then be analyzed in more detail
- This approach ensures an o**bjective evaluation** to select the best lead market models

Assessment criteria description and rating

Criteria	Description
Effectivity	Assesses if a model effectively creates demand for clean steel/fertilizers (Establishment of lead markets)
Efficiency	Evaluates cost efficiency and compensation via market premiums or government- set payments for clean hydrogen in production
Carbon leakage prevention	Measures whether imports and exports can be controlled to avoid carbon leakage and loss of international competitiveness
Lean Implementation	Evaluates the degree of bureaucracy involved
Rating	High – medium – low – insufficient

Example for evaluation of lean implementation: level of government involvement

2

Clean steel

2.1

Status quo of steel in the EU

The steel industry is both in consumption and production a key pillar of the European economy

Status quo of the steel market in the EU

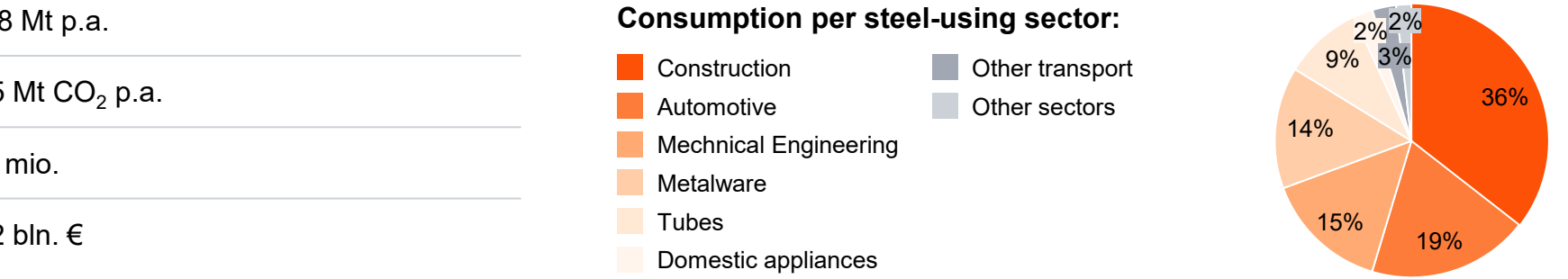
Primary steel production in the EU (2023)

Production sites:	27 (47 blast furnaces in total)
Main producer in the EU:	Germany
Crude steel production:	~ 69.8 Mt p.a.
CO_2 emissions:	~ 215 Mt CO_2 p.a.
Employees (total):	~ 2.6 mio.
Gross Value Added (total):	~ 152 bln. €

Steel consumption in the EU (2023)

Real steel consumption:	~ 138 Mt
Apparent steel consumption:	~ 125 Mt

Consumption per steel-using sector:



European steel imports and exports (2023)

Imports:	~ 26 Mt finished steel products
Exports:	~ 16.3 Mt finished steel products

◀ Asia, Other Europe/CIS/Turkey, Africa, South America, Oceania, North/Central America*

▶ Other Europe/CIS/Turkey, North/Central America, Africa, Asia, South America, Oceania*

Sources: Eurofer (2024), FfE (2020), WV Stahl (2024); *Countries in descending order

Clean hydrogen-based steelmaking achieves the highest emission reduction in decarbonizing primary steel production

Outlook of possible decarbonized production paths

Options to decarbonize steel production

- Currently, the **most common production route** is via coal-based blast furnace basic-oxygen furnace (BF-BOF), which causes high emissions
- From a technological perspective, **decarbonization** of steel production is possible through several options, such as decarbonization of the primary route via CCUS, retrofitting or/and using low-carbon biomass (e. g. biocoke) instead of coal
- The **most promising option** is however clean hydrogen-based direct reduced iron with an electric arc furnace (DRI-EAF-H2) due to the following aspects:

Uses **renewable electricity** and **clean hydrogen** as energy sources

Cuts **emissions** up to **95%** compared to BF-BOF route

In the short- to medium-term natural gas can be used to lower emissions, in the long run large amounts of **clean hydrogen** are required

Status quo DRI-EAF-H_2 projects

- Even though DRI-EAF-H_2 projects are the most popular for decarbonization, companies are **delaying** or **withdrawing** from final investment decisions
- One of the reasons is the slow market ramp-up of clean hydrogen and the additional costs burden
- The project status below indicates that only one-third of the current annual steel production capacity could be replaced by clean steel

Excerpt of the current H_2 project status quos in the EU*:

Announced:	7 projects	Power4Steel, Heracless
Finalized (research and testing):	4 projects	SuSteel
In construction:	5 projects	tkH2 Steel, HYBRIT, SALCOS, H-DRI Dunkirk, Hy4Smelt
Cancelled / postponed:	10 projects	Steel4Future, Gijón DRI and EAF

Sources: Choksey et al. (2025), Green Steel Tracker (2025), Hydrogen Insight; * iron and steelmaking only; Technologies: H-DRI, NG-DRI to H-DRI, NG-DRI to H-DRI + EAF, H-DRI + ESF

To ensure market sounded results, expert insights were collected from international key players across the entire steel value chain

Steel market insights (1/2)

Attributes of key players

Headquarters	Germany, Luxembourg
Revenue	7 – 62 bln. €
Headcount	14K – 125K
Subsidiary*	44 – 540+
Roles in value chain	Crude steel production, processing, trade, technologies

* subsidiaries with ≥ 50% ownership

Key findings

Quotas could enable a real **pull effect** from the market

Clean steel label is a requirement to enable offtake

Private procurement does not work without **public procurement**

Current regulations do not allow for **long-term planning**

End-product quotas drive demand while achieving market stability

Preferable to regulate the **raw materials** rather than end products

Overall / voices from key players

- Lead markets should enable long-term investments by bridging the gap until the ETS price is sufficiently high to make clean steel competitive
- Quotas and labels are viewed as the most favorable options

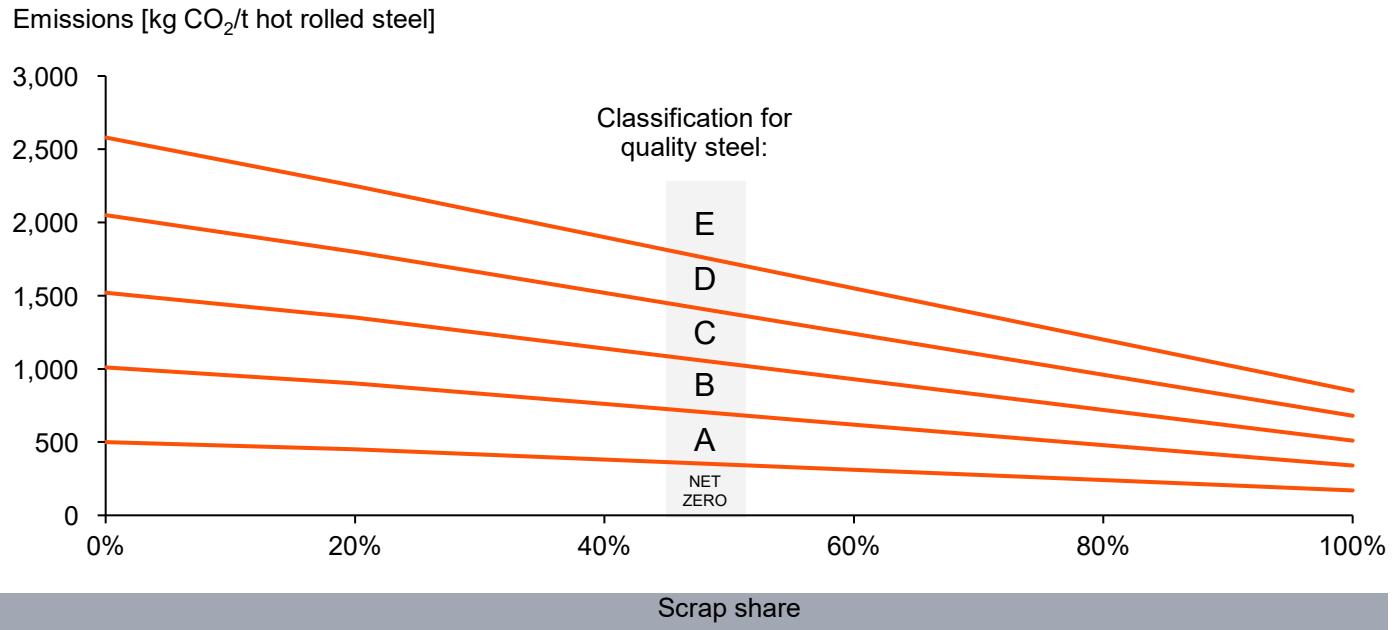
The industry has already put forward proposals for general certification standards of the primary and secondary steel sector

Steel market insights (2/2)

Low Emission Steel Standard (LESS) Framework

- **Definition**: standardized label for low-emission steel products, verifying the carbon footprint & supporting the transition to climate-neutral industrial production in Europe to foster lead markets for clean steel
- **Goal**: drive the steel industry's transition to near-zero emissions by providing a transparent standard that enables comparison, rewards decarbonization, and supports informed decisions for policymakers and customers
- **Independency**: verification of the LESS standard / certificates by an independent organization
- **CO_2 classification**: rating of steel products according to CO_2 emissions in clearly defined categories
- **Comparability & recycling**: All production routes are assessed uniformly, including fair consideration of scrap

LESS steel decarbonization scales for labeling



Proposed certifying process

1. Recording of emission data
2. Calculation of the Product Carbon Footprint
3. Classification into emission classes
4. Verification by independent third parties
5. Issuance of the LESS label

Sources: LESS (2025)

2.2

Possible clean steel volumes to meet EU climate targets

Meeting EU's emission reduction targets could increase hydrogen demand for clean steel production by up to 2.3 Mt until 2035

Possible clean primary steel volumes to meet EU climate targets

Key findings

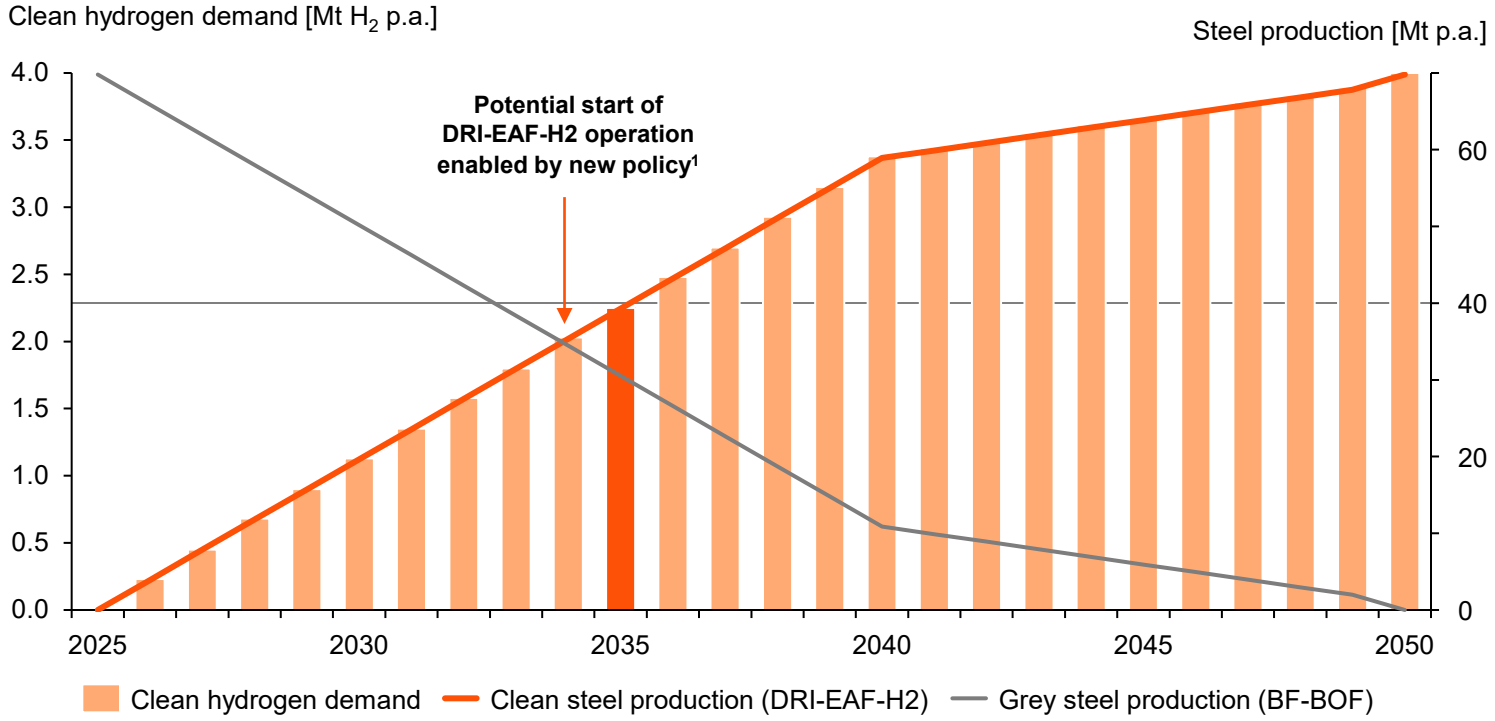
The EU aims to achieve a **90% reduction** in overall GHG emissions **by 2040**

To meet these targets directly, the steel sector must increase **primary clean steel** production to ~ **40 Mt** by 2035

This results in a potential increase of **hydrogen demand** for clean primary steel production by up to ~ **2.3 Mt by 2035**

The EU production of primary steel **is fundamentally suited** to **establish** a **lead market for clean hydrogen,** aligning with the definition in this study

Estimated clean hydrogen demand to decarbonize primary steel production



Sources: PwC analysis; Agora Industry et al. (2022), Agora Industry (2024); Eurofer (2024); Disclaimer: Assumes full replacement of BF-BOF with DRI-EAF-H2. Other pathways (e.g. blue/grey hydrogen, carbon capture, scrap) not considered.
[1]Provided that potential sites can receive a physical hydrogen supply via the hydrogen backbone.

Ideal steel lead markets are identified by a minimal price impact on end products, a willingness to pay and substantial steel demand

Price impact of clean hydrogen on consumer products

Key findings

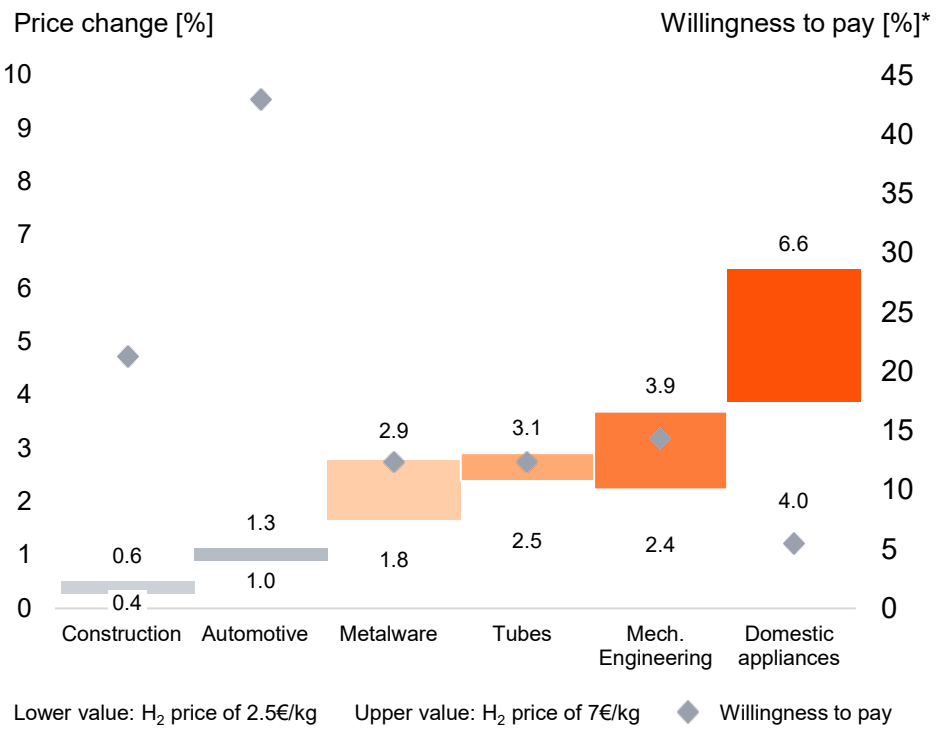
The price impact on end products is minimal, ranging between 0.4 – 6.6% (depending on H_2 prices)

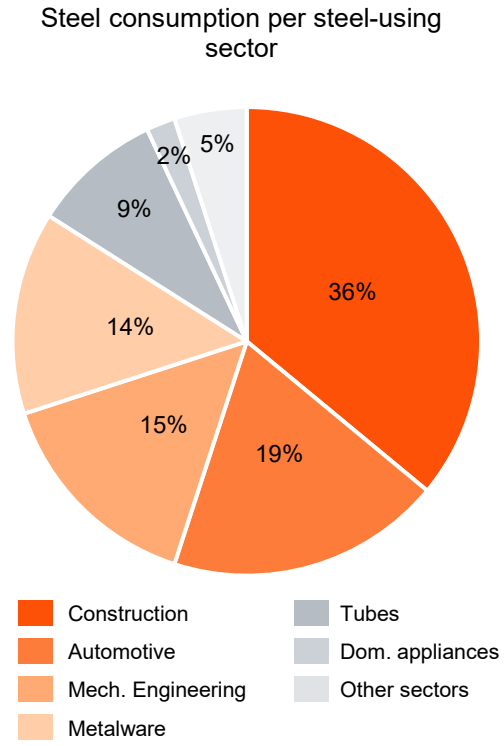
Lower additional costs are found for construction (e. g. family homes) and higher costs for domestic appliances (e. g. washing machine, refrigerator)

Willingness to pay a clean premium seems highest in the automotive industry due to the relatively small price impact of steel on the end product

The **automotive and construction sector** are **ideal** for **clean lead market** implementation covering approximately 55% of primary steel consumption

Effect of price change for end products, willingness to pay and market coverage





Sources: PwC analysis; Agora Industry (2022); Eurofer (2024), Sustainable Views (2024) based on BloombergNEF; * derived from signed low-emissions steel offtake agreements; share within the shown sectors

2.3

Eligible models and regulations

2.3.1

From long - to shortlist

Various market design options can accelerate a hydrogen market ramp-up for primary steel in different ways

Longlist models

Possible market design options

I. Voluntary use of labels

An official label for clean steel enables customers to support environmental targets on a voluntary basis. Manufacturers and builders may advertise the use of clean steel.

II. Public procurement

Public procurement involves public authorities acquiring goods, services, or works through regulated and transparent processes that increasingly include binding social and environmental criteria. Institutions of the EU/member states could be required to maintain a quota for clean steel in any procurement.

III. Supplier quota

A clean steel quota applied to the total primary steel supply is a fixed percentage that specifies how much of the total amount of primary steel produced must meet certain requirements, for example, regarding production based on clean hydrogen.

IV. Sector-specific quota

A sector-specific quota is a regulation tailored to the specific characteristics of a particular industry or to specific end products.

V. Product-based levy financed CfD

A revenue-based levy on various steel containing products (EU produced and imported) is collected and used in a dedicated fund. This fund provides hydrogen tenders and successful bidders receive the price difference between fossil fuels and clean hydrogen (product financed contract for difference).

VI. Tax incentives

Tax incentives are tax breaks or relief measures introduced by governments to promote the use of clean hydrogen. They can take the form of tax breaks, tax credits, accelerated depreciation, or reduced tax rates.

Supply-side models Demand-side models

As not all policy options provide the same benefits, five options are considered for further analysis

From long- to shortlist: quick assessment

#	Options	Effectivity	Efficiency	Carbon Leakage Prevention	Lean Implementation	Summary
I	**Voluntary labels**	medium	high	high	medium	medium
III	**Public procurement**	high	high	medium	high	high
III	**Supplier quota**	high	high	medium	high	high
IV	**Sector-/product- specific quota**	high	high	high	medium	high
V	**Product-based levy financed CfD**	high	medium	high	medium	high
VI	**Tax incentives**	insufficient	low	high	medium	insufficient

Current market regulations for decarbonization fail to meet climate targets and thereby jeopardize the desired hydrogen ramp-up

Deep dive: insufficient promotional effect of EU ETS and CBAM

Key findings

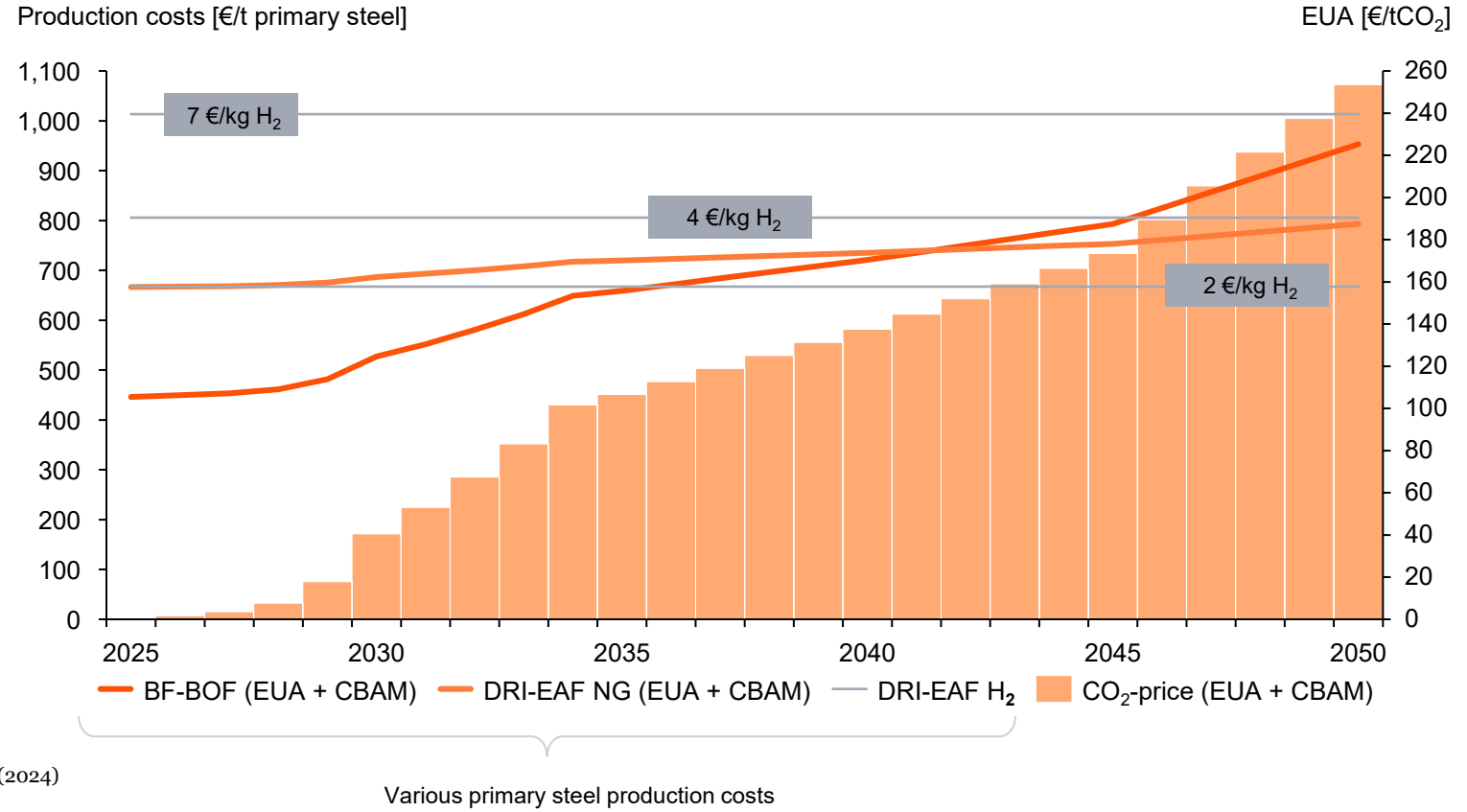
Current EU ETS projections estimate no **economic incentive** to produce clean primary steel before 2045. A global CO2 pricing scheme is required to ensure export competitiveness of EU steel producers.

Break-even points are dynamic and significantly **depend on hydrogen prices** (DRI-EAF H_2 route) and European Union Allowance (EUA) prices.

The **additional costs for producing clean primary steel** via the DRI-EAF H_2 route remain steep until 2040 according to current forecasts.

New policy instruments facilitating a clean hydrogen lead market are crucial to accelerate hydrogen production and must demonstrate market impact by 2040.

Estimated break-even production costs grey vs. clean primary steel over time



Sources: PwC analysis; Pahle et al. (2024), European Commission (2023), Agora Industry (2024)

Based on the quick assessment, five shortlisted regulatory options will be analyzed in more detail to foster H_2 steel lead markets

Shortlist

Most promising market design options

I. Voluntary use of labels

Suitable: Despite minor cost increases, a voluntary model for clean steel could be impactful. Companies may adopt it to cut Scope 3 emissions.

✓

II. Public procurement

Suitable: As a major steel consumer, the EU public sector could drive significant impact through quotas. Including critical infrastructure projects would enhance the model's effectiveness and set an example for private sector initiatives.

✓

III. Supplier quota

Suitable: A certificate-based quota system with penalties can effectively raise clean steel's share. It allows producers to coordinate mill conversions, concentrating efforts among fewer market participants.

✓

IV. Sector-specific quota

Suitable: Limiting quotas to specific consumer goods allows for consideration of economic resilience. Importers can help finance the system, and standardized obligations by product group can simplify implementation.

✓

V. Product-based levy financed CfD

Suitable: A revenue-based levy on various steel containing products sold in the EU (EU produced and imported) can finance a set of tenders to cover the price difference between gas and hydrogen (product financed contract for difference).

✓

VI. Tax incentives

Not suitable: A unified regulation across the EU is unlikely because the Union lacks legislative authority in this area, reducing the probability of consistent implementation among member states

X

Supply-side models Demand-side models

2.3.2

Outline of a model for a voluntary use of an EU-Label

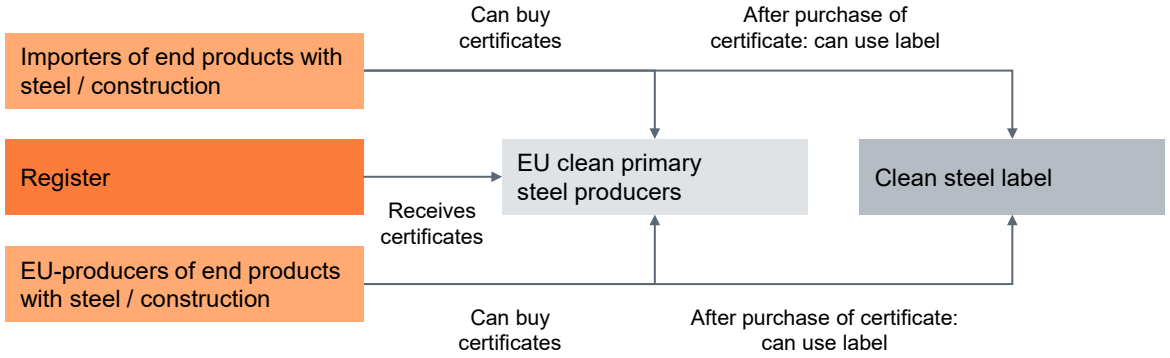
The voluntary use of an EU-label relies on the motivation of end-product manufacturers, or a clear consumer-sided market pull

Voluntary use of an EU-label: foundation

Model description

- Clean primary steel producers in the EU receive certificates from a central register after demonstrating clean steel production
- Manufacturers of end products can purchase certificates from clean primary steel producers
- With the purchased certificates, the manufacturers obtain the option to mark their end product with a clean steel label and deduct the corresponding steel related GHG reduction from the product carbon footprint
- Compliance is monitored by an EU or national register, and certificates must be presented when the product is placed on the market

Illustrative depiction



Regulatory comments

- **Existing approach:** EU could condition subsidies on the use of clean primary steel, building on its existing climate mainstreaming approach, which already allocates 30% of the 2021 – 2027 budget to climate-related measures
- **Structural reform:** general adaption is needed to make clean steel use mandatory across all EU funding programs, rather than defining climate actions individually per program
- **Additional incentives:** could include regulatory benefits – such as additional GHG credits for car or white good producers, reduced bureaucracy or emissions requirements – for voluntary clean steel use, subject to legal review

Challenges and opportunities

- **Unclear outcome:** as the clean label use is voluntary, there is no guaranteed ramp up in the lead market unless there is clear consumer demand
- **Uneven distribution across sectors:** For some sectors with limited marketing potential, it is less likely that there will be a significant demand for clean primary steel. It is uncertain whether the remaining sectors will be able to carry the ramp-up costs
- **Low political resistance to be expected:** participation is voluntary and there is no enforcement pressure, which fosters a generally more positive attitude toward the model
- Consumer-good manufacturers can **use labels in products where the willingness-to-pay is highest** and steer least cost decarbonization of product portfolio.

As a pioneer in clean steel and the second largest steel consumer the automotive industry would profit from an independent EU-label

Voluntary use of an EU-label: deep dive

Key findings

- The automotive industry is a forerunner for **voluntary** procurement of **clean steel**
- As the **second-largest consumer** of steel (19% of total demand) the automotive sector and thus a **significant share** of the European steel market could **profit** through the adoption of a voluntary EU label
- However, the **voluntary model** depends on the **ambitious level** of each company, making clean steel demand for producers **hard to predict**
- As there are already companies in steel processing industry aiming to **reduce their scope 2 & 3 emission** in their value chains, clean labels may support this voluntary movement

Examples - current voluntary clean steel initiatives and market outlook

	Automotive Industry	Energy sector
Explanation	• Various players are already sourcing some amounts of their steel with a reduced CO2 intensity • Steel produced with clean hydrogen plays a subordinate role • Currently there is no accepted standard for “clean” steel across the whole industry	
Example	**Mercedes Benz**	**Siemens Gamesa, Orsted, Vestas**
Decarb. goals	CO_2-neutral across all stages of the value chain and the entire life cycle by 2039	Net-zero CO_2 emissions by 2040
Status quo	50 kt clean steel annually and 200 kt by 2030 (from ~ 4% up to 16% of total steel use*)	One off purchase of 25 kt of steel with a CO_2 intensity of 0.7 tons per ton of steel
Approach	By 2030, only six major car manufacturers (≈ ⅓ of the market) have targets for sourcing clean steel – mostly only for around 15% of their steel requirements, with a maximum of 50%.	Few equipment manufacturers procure low-carbon steel to meet Scope 3 emissions reductions or mandatory greenhouse gas targets.

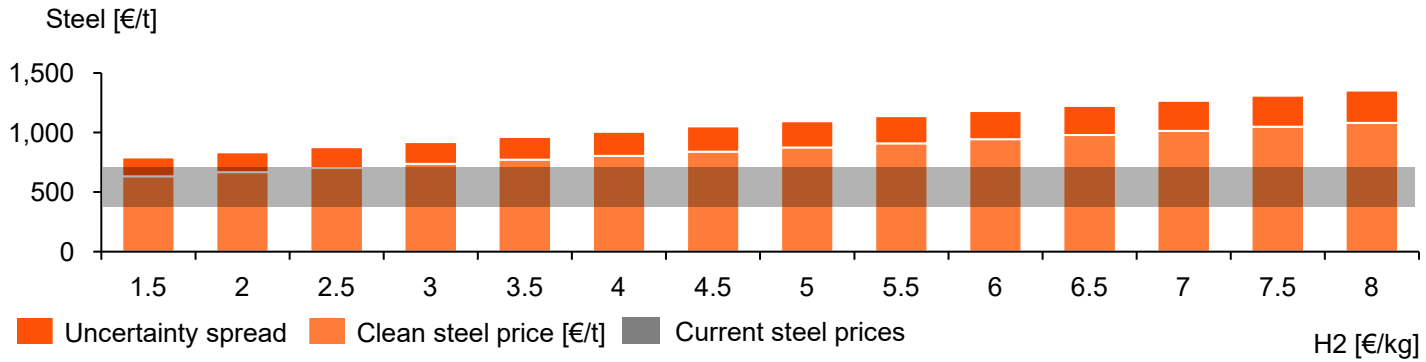
Despite scope 3 emission cuts in the voluntary model, it lacks in coverage and total impact due to its voluntary nature

Voluntary use of an EU-label: market impact

Key findings

- The voluntary model is unevenly established across the steel processing industries making primary clean steel demand for producers hard to predict
- A certification such as the Low Emission Steel Standard (LESS) can be used to incentivize the voluntary model
- Compared to conventional primary steel production, the use of clean hydrogen in the steel sector will only become economically attractive in the EU market when the price of hydrogen falls below approx. 2 €/kg*
- An incentive to use the model will only arise when H_2 prices are low, as the economic burden is still too high

Estimated primary steel prices in correlation to different H_2 prices



Sources: IEA (2023), Energy Technology Perspectives (2023), Devlin et al. (2023), stahlpreise.eu;
*Additional risk factors that may have a greater impact than those considered here include CAPEX, OPEX such as commodity prices, regulation, and internal carbon pricing.

Overall rating

Effectivity

Cons: Only public demand for steel can be covered (when not using large amounts of scrap)

Efficiency

Pros: Suppliers of public bodies can choose cheapest provider of certificates

Carbon leakage prevention

n.a.

Lean implementation

Cons: Every governmental supplier of covered goods involved and determination of (primary) steel content for each product necessary

Implementation models

- **Low Emission Steel Standard (LESS):** standardized label for low-emission steel, which verifies as well as certifies the carbon footprint of steel products through an independent organization and can therefore serve as a model for the regulatory design of voluntary use of an EU label

Rating: High Medium Low n.a

2.3.3

Outline of a public procurement model

In the framework of clean steel through public procurement, quotas and certificates can serve as leverage in the future

Public procurement model: foundation

Model description

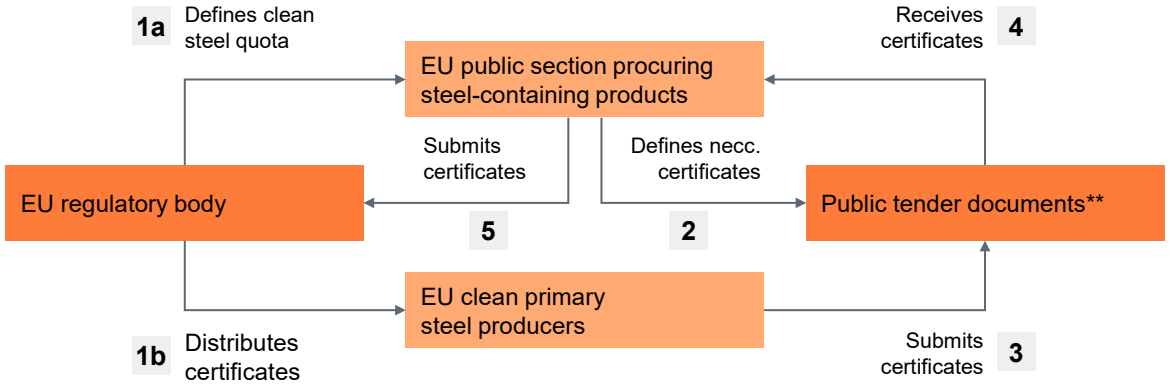
- Annual clean steel quota for the European public sector that procures steel-containing products (incl. buildings) is defined by a European regulatory body
- EU clean primary steel producers receive certificates from the same regulatory body after demonstrating clean primary steel production
- Certificates for clean steel would be required in public tender documents
- Quota for the public sector may increase annually, can be envisaged as a project-specific basis (e. g. large infrastructure projects, critical infrastructure) or as a flexible overarching national target
- The public sector has more procurement flexibility in critical infrastructure projects and could in the context of public tenders include the private sector building/ operating such infrastructure to use clean steel and hence increase offtake volumes, e.g. for power plants or pipeline and transmission infrastructure.

Regulatory comments

- **Subsidiarity risk:** public tender model may only be implemented voluntarily by Member States due to the principle of subsidiarity
- **Unclear legal basis:** uncertain whether rationale behind the CVD* can be ex- tended to justify mandatory clean primary steel procurement targets for Member States
- **Legal conflict:** targets for clean steel could be justified as necessary to stimulate the EU market. this justification may conflict with the principles of subsidiarity and proportionality, as Member States have discretion in how they meet their GHG targets
- **WTO rules:** public contracting authorities are generally not allowed to give preference to domestic products or suppliers

* Clean Vehicle Directive ** Third parties, such as construction companies, may be included in the transition of certificates

Illustrative depiction



Examples for challenges and opportunities

- **Taxpayer burden:** extra costs for clean primary steel are covered by the public sector, thus the European taxpayers
- **Unclear legal basis:** uncertain whether rationale behind the CVD* can be extended to justify mandatory clean steel procurement targets for member states

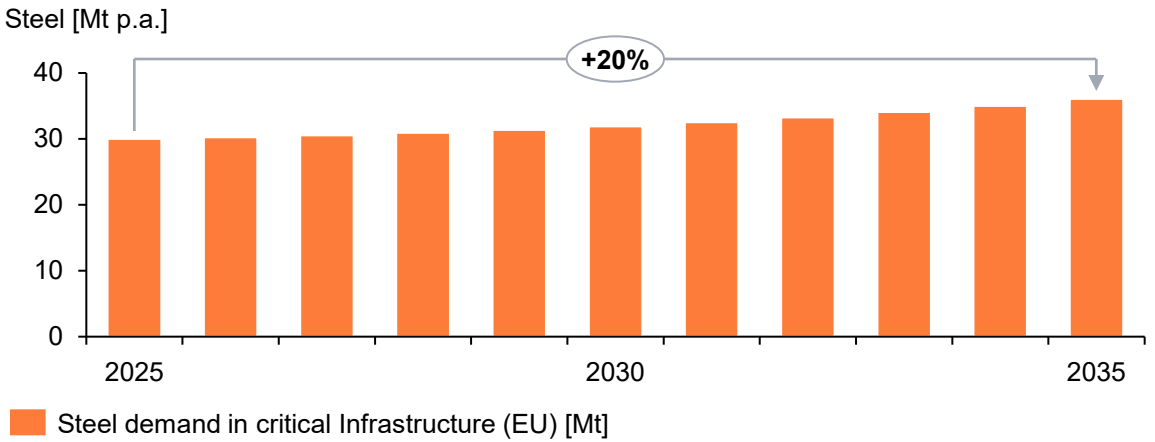
- **Demand creation via public sector:** guarantees baseline demand and supports market development due to public sector integration
- **Simplified compliance mechanism:** certificates are embedded in tender processes, reducing complexity for end-users and aligning procurement with climate goals

Some public institutions are already switching to lower-emission steel products to reduce emissions

Public procurement model: deep dive

Estimated Steel demand in critical infrastructure

- **Strategy:** EU is pursuing a strategy of resilience and autonomy, which aims to strengthen local primary steel production
- **Critical infrastructure:** the sector of critical infrastructure represents a significant part of the steel sector and uses steel for areas such as rails, gas, electricity, and hydrogen pipelines, bridges, harbors and airports
- **Support:** steel demand is supported by government investment programs and clean lead markets in which clean steel is given preference, e.g. public tenders
- **Increasing demand:** the need for construction and renovation of critical infrastructure, driven by politics & aging, is projected to increase by 20 % in 2035



CO_2-reduced rails for SNCF Réseau from Saarstahl Rails

General

- **Contract value:** > 1 bln. €
- **Term:** up to 6 years
- **Delivery volume:** 170,000 tons of CO_2-reduced rails per year, covering approximately 80% of SNCF Réseau's requirements

Technological and sustainable

- **Manufacturing method:** use of electric arc furnaces instead of blast furnaces, recycled steel from old rails ("Rails-for-Rails" cycle)
- **CO_2 savings:** 70% lower CO_2 emissions compared to the traditional blast furnace route translates to 200,000 tons of CO_2 emissions reductions per year, more than 1 million tons over the contract period

Economical and environmental

- **Jobs:** ~ 1,000 direct jobs secured at both sites
- **Award:** Saarstahl Rail received the Sustainability Championship Award from the Berlin Institute Supply Chain Management

Sources: SNCF (2024); Saarstahl (2025); ZDF (2025); European commission (2025), marketSTEEL.de; Bronk & Company; EUROFER Economic Outlook 2025; CAN Europe & E3G

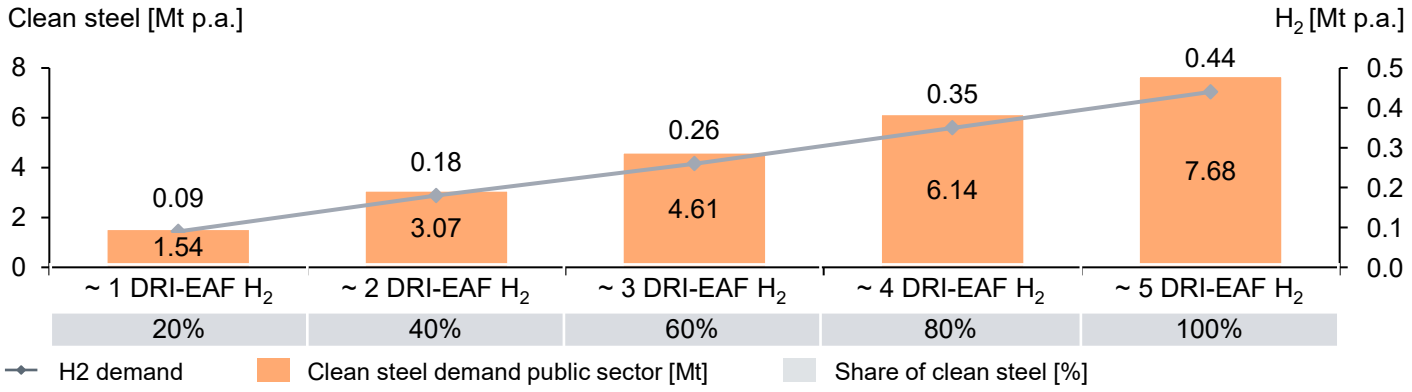
The success of the public procurement model depends largely on the extent of steel demand for public sector projects

Public procurement model: market impact

Key findings

- The public sector accounts for around 11% of EU steel demand, with a slightly higher share in the recycled steel market and likely to remain at 10 – 15% in the long term without incentive creation
- Through clean procurement and binding sustainability criteria, the government can specifically increase demand for low-carbon steel. However, this model is unlikely to generate more than 0.5 Mt of clean H_2 production.
- Assuming an immediate start of technical ramp-up and immediate conversion, adequate clean primary steel production cannot be expected before 2030

Estimated impact on market



* Calculated with a capacity of 1.5 Mt p.a. of the EAF

Overall rating

- **Effectivity**
  Pros: use can be required in projects funded by EU
- **Efficiency**
  Pros: Public sector can choose cheapest provider of clean steel certificates
- **Carbon leakage prevention**
  Pros: no burdening for EU products made with steel
  Cons: competition by clean steel made abroad
- **Lean implementation**
  Pros: certification can be carried out by private auditors

Implementation models

- **EU Regulation EcoDesign:** requires public authorities to give preference to sustainable products → may establish similar guidelines and criteria
- **Clean Vehicle Directive:** requires public authorities to procure a minimum proportion of low-emission vehicles with alternative drive systems

Rating: High Medium Low n.a

2.3.4

Outline of a supplier quota model

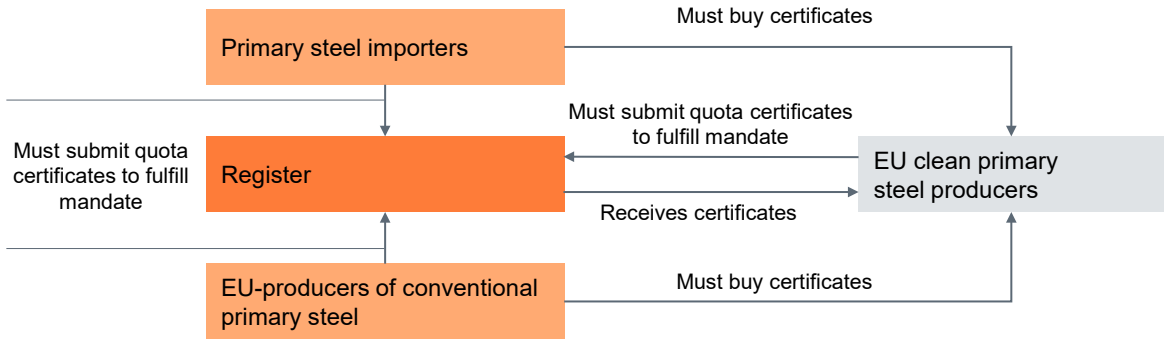
A quota for all primary EU steel suppliers is one possible option but needs to consider imports from non-EU states

Supplier quota model: foundation

Model description

- Primary steel suppliers (EU and importers) would have to demonstrate a certain quota of clean steel, achievable through their production or certificate acquisition.
- Certificates are issued exclusively to verified clean steel manufacturers within the EU, which can sell excess certificates to the market to offset additional production costs
- Implementation could take place in a framework with other regulatory measures, such as ETS / CBAM adjustments or competitive energy prices

Illustrative depiction



Regulatory comments

- **European focus:** only clean steel produced in the EU receives a compensation payment to foster the European hydrogen ramp-up
- **Idea of CBAM mechanism applies accordingly:** imports require quota certificates; no quota certificate requirement for steel exports (to prevent trade disadvantages)
- **Labelling certificates as an alternative for producers**: producers of clean steel have a choice to receive quota certificates (to be sold to other steel producers/importers) or labelling certificates (to be sold to manufacturers for marketing purposes, allowing them advertise the use of clean steel). Labelling certificates can also be applied to importers of clean steel, but cannot be used to fulfil quota
- **Compliant with WTO-rules:** clean steel receiving quota certificates must be sold as grey steel to avoid disadvantaging importers and prevent unfair price competition from subsidized EU production

Examples for challenges and opportunities

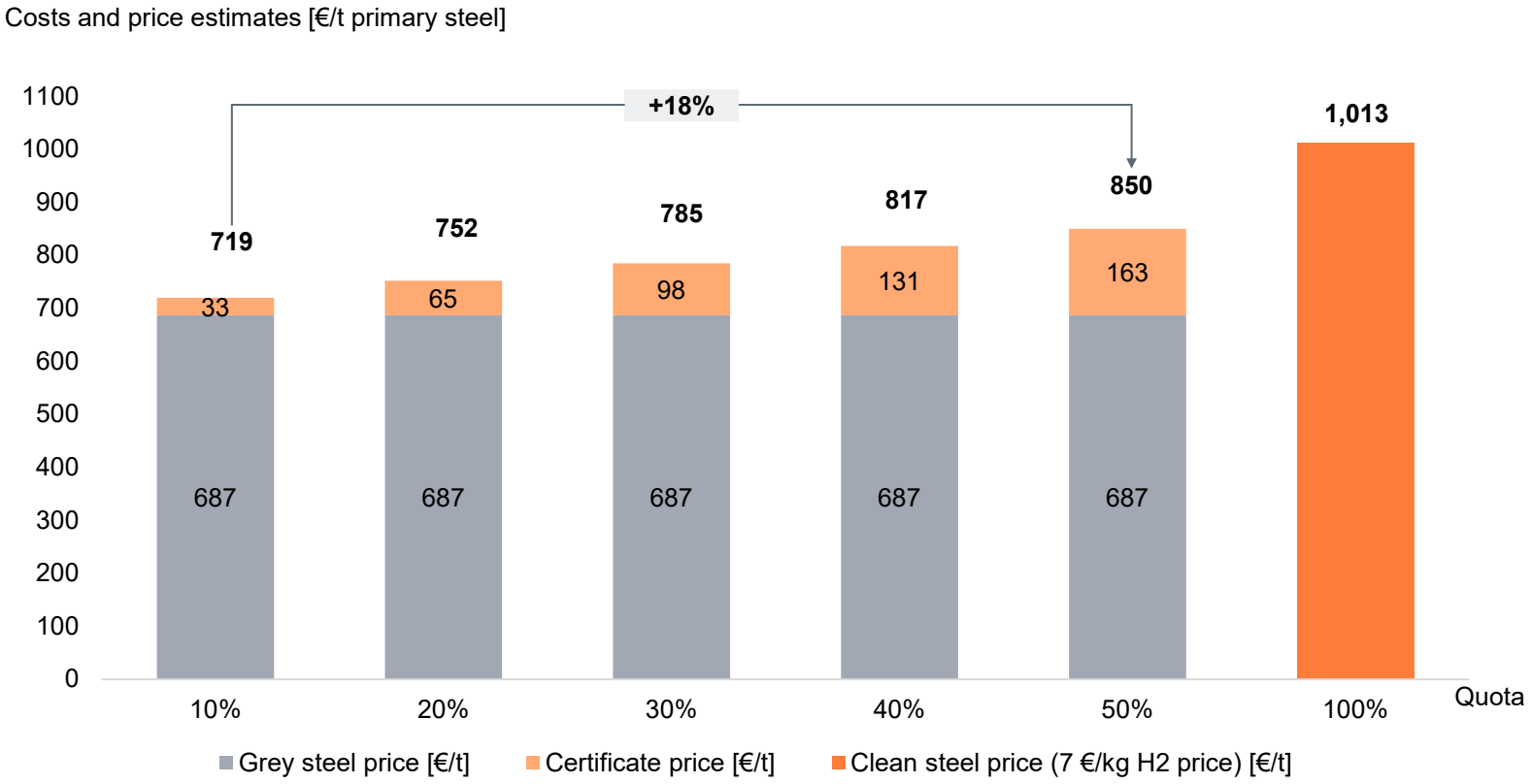
- **Possible bypassing:** by importing processed goods made with steel without certificate requirement. End-products are not subject to any quota obligation
- **Danger of deindustrialization:** quota obligations imposed on primary steel suppliers increases steel prices and thus end products downstream of the value chain, thus potentially weakening EU competitiveness against international suppliers

- **Inclusivity of primary steel imports:** integrates imported steel into the system, ensuring fair competition and broader market coverage

Certificate prices are based on the estimated clean steel price and share, closing the cost gap between grey and clean primary steel

Supplier quota model: deep dive

Exemplary static steel and certificate prices (2030)



Key findings

Certificate prices rise linearly with the proportion of clean steel, at a rate of 33 €/t per 10 % clean steel content

An increase in the proportion of clean steel from 10 % to 50 % results in a **price increase of 18 %** (719 €/t to 850 €/t)

Overall, pricing is **heavily dependent** on the **clean steel price** set and the associated **hydrogen price**. **clean steel producers** have the **power to make decisions** when it comes to certificate pricing.

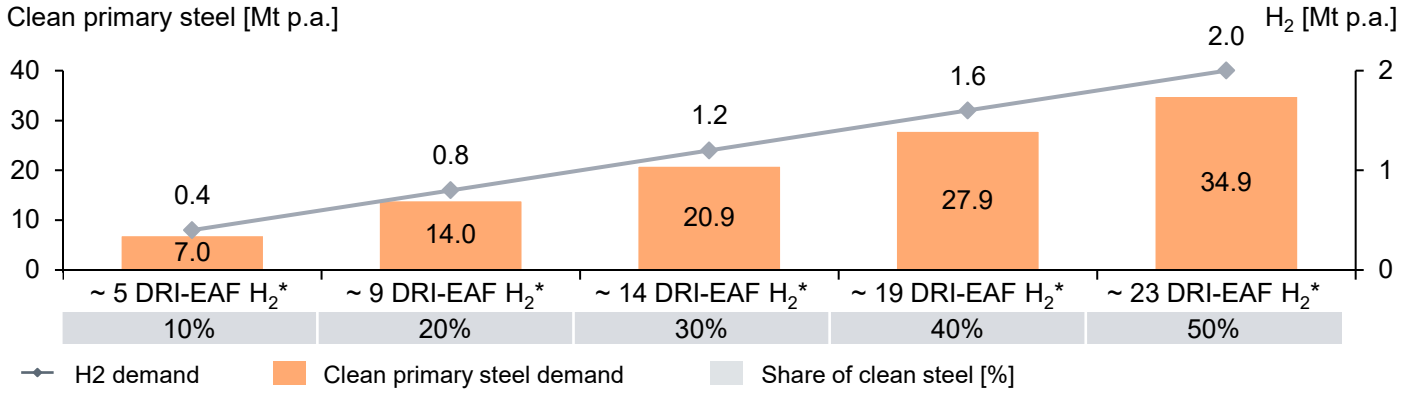
A quota on all steel suppliers in Europe would foster H_2 demand for a market ramp-up but needs to be chosen realistically

Supplier quota model: market impact

Key findings

- A supplier quota obligation for primary steel suppliers needs to be ambitious but has the potential to create meaningful H_2 demand.
- To facilitate a lead market of at least 2 Mt hydrogen demand, a minimum share of 50% clean primary steel production is required
- Implementing a 10% quota would result in a demand of merely 0.4 Mt of H2, which falls short of establishing a comprehensive lead market across the EU. With around four DRI-EAF H_2 plants, the hydrogen value chain would be localized.

Estimated impact on market



* Calculated with a capacity of 1.5 Mt p.a. of the EAF

Overall rating

Effectivity

Pros: Quota is subject to penalty, t.b.d. to exceed exp.cost gap

Efficiency

Pros: Market price of certificates based on supply and demand. No price regulation required.

Carbon leakage prevention

Pros: Controllability of steel imports/exports

Cons: Imports of goods made with steel cannot be burdened, exports cannot be relieved (e.g. in shipbuilding))

Lean implementation

Pros: Simple implementation at the level of manufacturers

Implementation models

- **ReFuel EU Aviation:** introduces quotas for fuel suppliers to provide sustainable aviation fuels at EU airports, requests airports to offer infrastructure as well as EU airlines to increase minimum share of SAF up to 70 % in 2050

Rating: High Medium Low n.a

2.3.5

Outline of a sector - or product-specific quota model

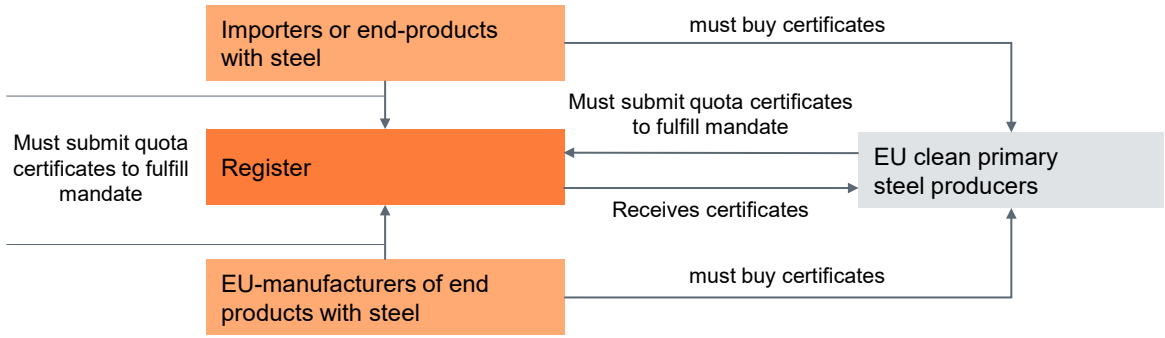
Similar to the supplier quota model, a sector- or product-specific quota model aims at affecting all regulated parties equally

Sector-/ product-specific quota model: foundation

Model description

- End products containing steel (e. g. cars, buildings or white goods) sold in the EU (EU made and imports) would purchase quota certificates for each end-product placed on the European market, regardless of steel quality
- Quota certificates are issued exclusively to steel from verified clean primary steel producers within the EU, which can sell excess certificates to the market to offset additional production costs
- End-product manufacturers are likely to pass these additional costs on to consumers via higher product prices

Illustrative depiction



Regulatory comments

- **Idea of CBAM mechanism shall be applied accordingly:** import requires certificates; no certificate requirement for exports (to prevent trade disadvantages)
- **Labelling certificates as an alternative for producers:** Producers of clean steel have a choice to receive quota certificates (to fulfil quota applicable for end product manufacturers and importers) or labelling certificates (to be sold to manufacturers for marketing purposes, allowing them advertise the use of clean steel). Labelling certificates can **also be applied for by importers of clean steel**, but cannot be used to fulfil quota requirement
- **Marketing as grey steel:** to comply with WTO rules, certified clean primary steel must be sold as grey steel to avoid disadvantaging importers and prevent unfair price competition from subsidized EU production

Examples for challenges and opportunities

- **Pricing:** market may face volatility if hydrogen-based primary steel production remains expensive, limiting certificate supply and driving up prices

- **Market incentive:** creates a demand-driven mechanism that rewards clean steel producers through certificate sales
- **Flexibility for end-product manufacturers** allows importers and EU producers to meet quotas via certificate purchases, without mandating direct sourcing
- **EU budget neutrality:** Project financing realized through quota market, with no EU funding required

ReFuelEU Aviation is an example for a regulation, which sets mandatory (blending) quotas

Sector-/ product-specific quota model: deep dive

Key findings

- **Types of SAF*:** Aviation biofuels made from biological sources (e. g. used cooking oil, agricultural residues, algae) and synthetic aviation fuels produced using renewable hydrogen and captured CO_2 via Power-to-Liquid (PtL) processes
- **Mandated quotas:** SAF demand is driven by EU blending mandates, ensuring a guaranteed market
- **Clean premiums:** SAF producers benefit from higher prices due to the environmental value of their fuels
- **Voluntary uptake:** Airlines may also adopt SAF voluntarily to meet ESG goals or consumer expectations.
- **Obligated parties:** Aviation fuel suppliers, EU airports, and aircraft operators are subject to compliance checks
- **Global sourcing**: SAF does not have to be produced within the EU, imports are permitted however meeting EU standards

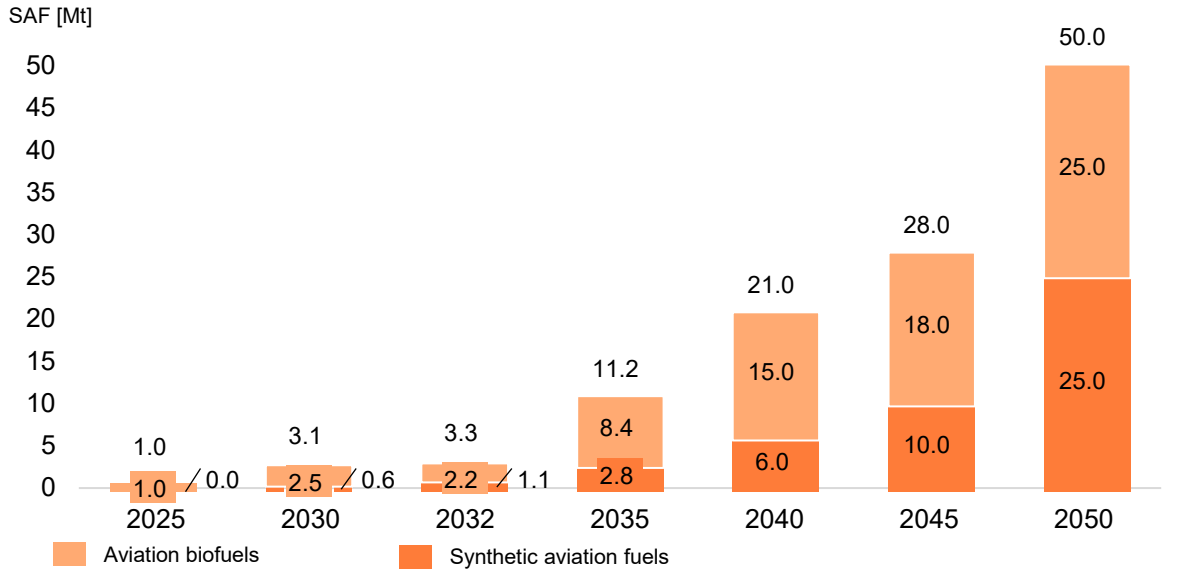
Estimated SAF volumes until 2050

Current synfuels & SAF production capacity in the EU:

< 0.5 GW

Required production capacity in the EU in 2035:

11+ GW



Year	2025	2030	2032	2035	2040	2045	2050
Share of SAF	2%	6%	6%	20%	34%	42%	70%
Min. share of H_2-SAF (e-SAF)	0%	1.2%	2%	5%	10%	15%	35%

Source: IEA (2024), NOW GmbH (2023) * Sustainable Aviation Fuel

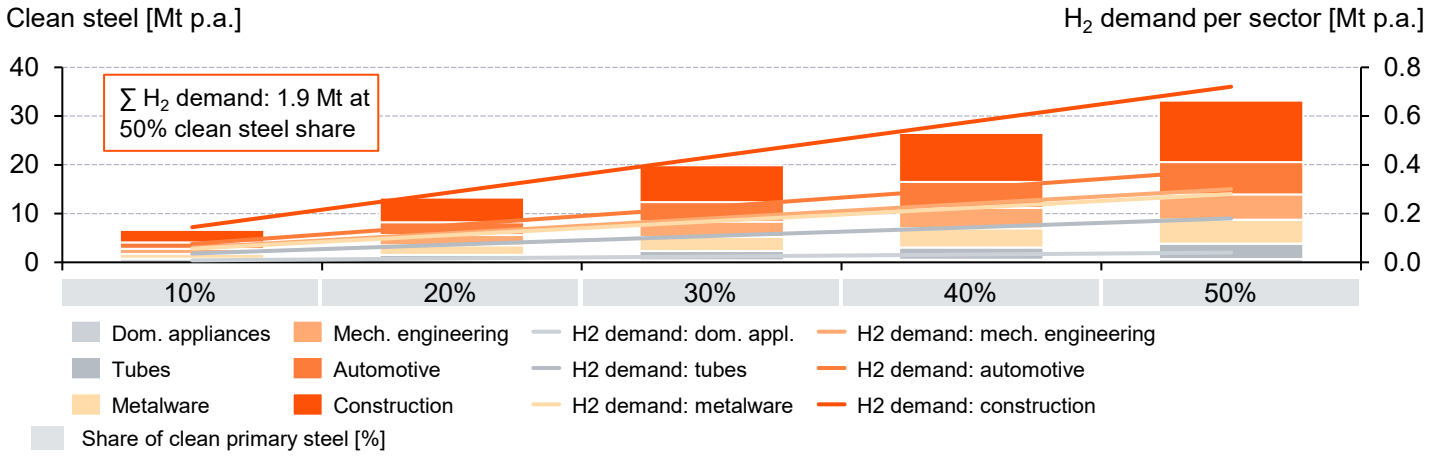
A targeted quota can address specific market segments and serves as a flexible mechanism to manage decarbonization

Sector-/ product-specific quota model: market impact

Key findings

- Fixed quotas on end products across processing industries can mirror the same market impact of supplier quotas, but they encompass the full value chain and include also imported goods.
- Products that are exported e.g. from the automotive and mechanical engineering sector, may be excluded from the quota system to ensure international competitiveness
- Therefore, quotas can be customized for each sector to take their characteristics into account while creating a level playing field with meaningful incentives for decarbonization

Estimated impact on market



Overall rating

- **Effectivity**
  Pros: Quota is subject to penalty, sector flexibility
- **Efficiency**
  Pros: Market price of certificates based on supply and demand. No price regulation required
- **No carbon leakage/maintain competitiveness**
  Pros: Imports of goods made with steel can be equally burdened and exports can be relieved from certificate obligation
- **Lean implementation**
  Cons: Every manufacturer/ importer/exporter of covered goods will be involved

Implementation models

- **ReFuel EU Aviation:** introduces quotas for fuel suppliers to provide sustainable aviation fuels at EU airports, requests airports to offer infrastructure as well as EU airlines to increase minimum share of SAF up to 70 % in 2050

Rating: High Medium Low n.a

2.3.6

Outline of a Product-based levy financed Contract for Difference model

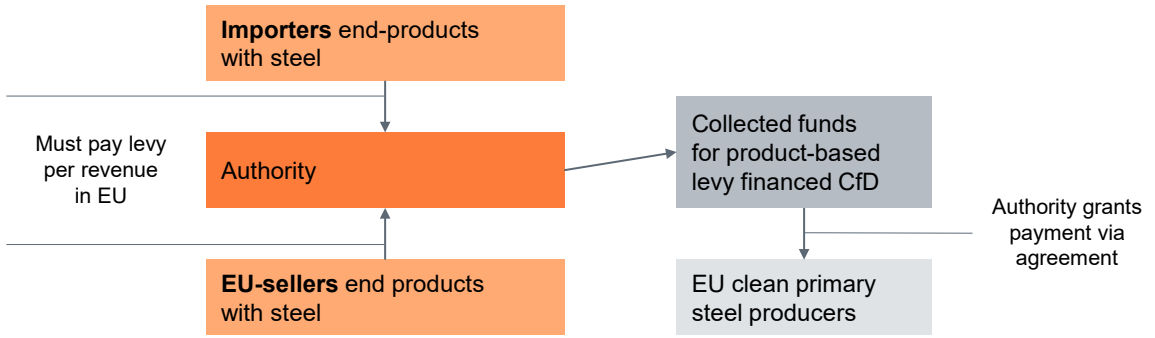
Even though a CfD financed via a product-based levy shows high effectivity and efficiency, its realistic success is unclear

Product-based levy financed CfDs model with a tender: foundation

Model description

- End-products containing steel (e. g. cars) sold in the EU would pay a levy based on product revenue within the EU, regardless of steel quality
- Levies contribute to a fund that supports European clean primary steel producers
- Clean primary steel producers can apply for a grant payment covering the additional costs compared with the conventional production and bidders offering the lowest subsidy demand per ton of steel are awarded the grants
- Successful bidders enter into agreement with authority, accepting an obligation to produce clean primary steel in the awarded amount (CfD). Bidders face penalties for underperformance
- End-product manufacturers can sell the products to their customers as usual and are likely to pass these additional costs on to consumers via higher final prices

Illustrative depiction



Regulatory comments

- **Idea of CBAM mechanism shall be applied accordingly:** import requires levy payment; no levy requirement for exports (to prevent trade disadvantages)
- **Labelling certificates as an alternative for producers:** Producers of clean steel have the option to receive labelling certificates (to be sold to manufacturers for marketing purposes, allowing them advertise the use of clean steel) if they do not win the bid for a CfD. Labelling certificates can also be applied for by importers of clean steel
- **WTO requirements:** clean primary steel subsidized under a CfD must be sold on the market as grey steel to avoid a conflict with WTO requirements, which state that products from outside the EU must not be treated less favorable than produced in the EU. However, limiting the tender to EU steel producers is possible

Examples for challenges and opportunities

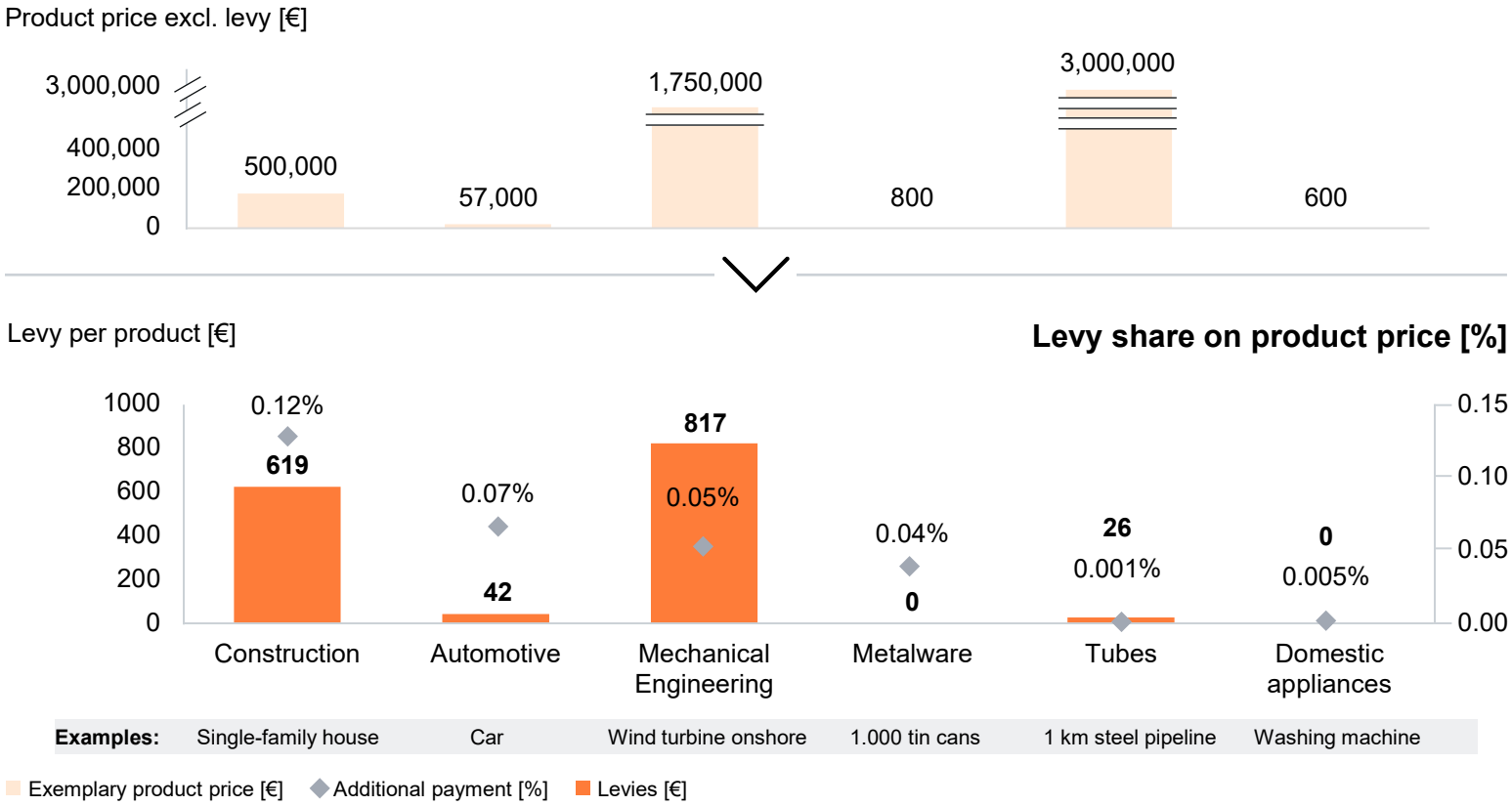
- **High level of control:** Based on the Contracts for Difference (CfD) climate protection agreements, the EU can specify in advance exactly how much clean steel shall be produced
- **Limited EU competence:** EU currently lacks the legal authority to collect additional funds, which may hinder effective implementation. Voluntary participation of all member states is uncertain, the EU's own budgets are limited

- **Level playing field:** both importers and EU sellers contribute equally, reducing the risk of trade distortion and ensuring WTO compatibility
- **EU budget neutrality:** Funding originates from product seller and no EU funding is required

The overall product price would be only marginally affected by a levy on the use of clean primary steel

Product-based levy financed CfD model: deep dive on product prices and levies

Exemplary price and levy calculation for the steel intensive sectors



Explanation

The **levies** on steel-intensive sectors are **very low** in percentage terms when measured against the surcharge on the end-costumer price

The percentage surcharges vary between **0.001%** in the tube sector and **0.12%** in the construction sector

Compared to the total product prices, this results in **low additional costs** for clean steel, which are passed on to the end-customer

In summary, the willingness to pay for clean steel should be hardly affected

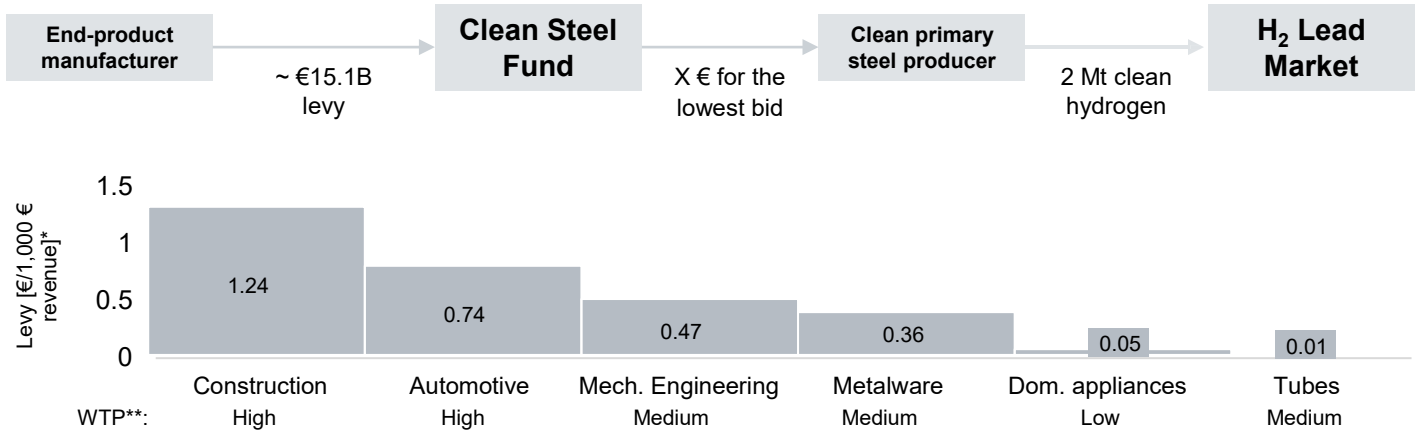
A fund paid by end-product manufacturers can have significant impact on the clean steel offtake due to the low price impact

Product-based levy financed CfDs model: market impact

Key findings

- To fulfill the criteria of **2 Mt hydrogen demand** to creating a lead market, a share of at least **50% clean primary steel** is required, resulting in a cost gap of about **15.1 bln. € p.a.** (H_2 price of 7 €/kg)
- **End-product manufacturer pay** into a fund **according to their steel related revenue in the EU**
- As a result, the **construction (**+ 1.24 %) and **automotive** (+ 0.74 %) sectors bear the **highest levy** per €1,000 revenue, yet they also demonstrated a **higher willingness-to-pay**
- However, availability of public long-term funding as an alternative to a levy is uncertain

Estimated impact on market



Sources: PwC analysis, Eurofer (2024), Sustainable Views (2024) based on BloombergNEF, Statista, Cognitive Market Research (2025); *50% clean steel; **willingness to pay (WTP)

Overall rating

- **Effectivity**
  Pros: High target adherence, EU can determine amount to be tendered, contractual penalty applies
- **Efficiency**
  Pros: Providers with lowest price are chosen
- **No carbon leakage/maintain competitiveness**
  Pros: Imports of goods made with steel can be equally Burdened as EU made products
- **Lean implementation**
  Pros: Simple implementation of levy on end products

Implementation models

- **Contracts for Difference (CfD):** state could cover additional costs incurred by companies when switching to climate-friendly production processes and companies apply for funding, sign an agreement with the state as well as receive compensation payments for a fixed period as long as climate-friendly production remains more expensive

Rating: High Medium Low n.a

2.4

Summary

Sector quotas are politically realistic and effective – other models are simpler but less effective

Summary

1 To establish a lead market for clean hydrogen, targeting the primary steel sector and related downstream industries is vital. Achieving a primary **clean steel market share of over 50% would generate substantial demand incentives**, aligning potentially with 20% of the EU's hydrogen production goals.

2 Demand-side regulatory models have been analyzed to create a lead market. **Supplier quota obligations for primary steel suppliers have potential for establishing a lead market** for clean hydrogen but **need to ensure a level playing field with non-EU primary steel suppliers**. Additional incentives could increase uptake, e.g. additional CO2 credits for early adopters, use of clean steel in vehicles etc.

3 The **sector-specific quota and product-based levy financed CfD models impose obligations at the end-producer level**, spanning the entire value chain. Neither consumer goods prices nor the willingness to pay will likely be significantly impacted by clean steel usage. Indicative estimates **suggest that end-product price increases would remain well below the inflation rate (<2%)** and are widely deemed acceptable.

4 The models for **voluntary use of EU labels and public procurement guidelines** (covering 11% of the steel market) do not independently lead to the establishment of a significant lead market in the short and medium term. The regulatory implementational effort is low and these models, along with the inclusion of critical infrastructure in procurement guidelines, **should be seen as supplementary incentive mechanisms.**

5 Even though the **product-based levy financed CfD model shows high effectivity and efficiency**, its realistic **success is unclear due to limited authority of the EU**. However, primary steel and hydrogen volumes are significant and some companies could achieve strong scope 3 emission reductions.

A new EU regulation would be suitable for implementation

Possible implementation framework and options

Potential implementation timeline

Timeline

- Proposal by EU Commission
- Feedback period
- Trilogue Negotiations by European Parliament (EP) and EU Council
- Adoption by European Parliament
- Adoption and Ratification by EU Council

Exemplary legislative process

Exemplary legislative process for Refuel EU Aviation (regulation (EU) 2023/24):

1. July 14, 2021: The European Commission presented the proposal for the RefuelEU Aviation regulation as part of the "Fit for 55" package.
2. December 2021 to July 2022: Consultations and feedback on the Commission's proposal (discussions in European Parliament, positioning of Council and European Parliament)
3. April 25, 2023: Parliament and Council reach a provisional agreement in trilogue
4. September 13, 2023: The European Parliament approves the outcome of the negotiations
5. October 9, 2023 (adoption by the Council); October 18, 2023 (signing); October 31, 2023 (publication in the Official Journal of the EU)

> 2 years

Implementation models and potential impact

Implementation models	Potential impact of 50% clean primary steel share
Voluntary model	Not predictable
Public procurement model	~ 0.3 Mt H_2 demand
supplier quota model	~ 2 Mt H_2 demand
Sector- and product specific model	~ 1.9 Mt H_2 demand
Product-based levy financed CfD model	~ 2 Mt H_2 demand

3

Clean ammonia-based fertilizer

3.1

Status quo of ammonia-based fertilizer market in the EU

Ammonium production in the EU is insufficient to meet demand and shows high emission levels

Status quo of the ammonia-based fertilizer market in the EU (1/2)

Ammonia-based fertilizer production in the EU (2023)

N-fertilizer production sites:	36
Main producer in the EU:	Germany, Netherlands
Ammonia production: **N-fertilizer production:**	~ 10.7 Mt p.a. ~ 27.6 Mt p.a.
CO_2 emissions ammonia industry:	~ 17 Mt CO_2 p.a.*
Employees (total fertilizer):	76,000
GVA (total fertilizer) :	1.6 bln. €

Ammonia-based fertilizer consumption in the EU (2023)

Real n-fertilizer consumption:	~ 8.3 Mt
Apparent ammonia consumption: **Apparent n-fertilizer consumption**:	~ 12.7 Mt** ~ 31.5 Mt

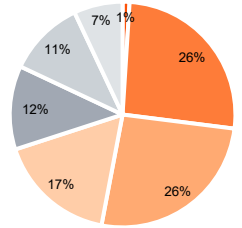
Ammonia consumption:

~ 20% industrial applications (e.g. plastics)

~ 80% fertilizer

- Wheat
- Coarse grains
- Fruits & vegetables
- Grassland
- Oilseeds
- Fodder crops
- Maize for biogas

Nitrogen-fertilizer use by crop:



Ammonia is the basis for all nitrogen fertilizer and is itself based on hydrogen. The term “n-fertilizer” used in this study always includes ammonia and thus, hydrogen.

Import / Export of n-fertilizer (2023)

Imports:	**~ 9.3 Mt**	◀ Egypt, Russia, Algeria, USA, Trinidad & Tobago, Turkey, Oman, Norway, Canada
Exports:	**~ 5.4 Mt**	▶ USA, Norway, Turkey, Canada, Marocco

Sources: Eurofer (2024), FfE (2020), WV Stahl (2024); *Countries in descending order
Sources: Hydrogen Europe, Fertilizers Europe (2024), Eurostat, ReportLinker (2023), Alsulaiman, A. & Chyon, K. (2025), PwC Analysis; *Calculated with an emission intensity of 2,0 t CO2 per t ammonia1 ** production + imports – exports

There are various efforts to minimize emissions in ammonia production, including the increased use of clean hydrogen

Status quo of the ammonia-based fertilizer market in the EU (2/2)

Options to decarbonize ammonia-based fertilizer production

- The **most common production route** for ammonia is currently via Haber-Bosch process using hydrogen derived from natural gas as feedstock, causing high emissions
- **Decarbonization** of fertilizer production is possible through several options, such as clean hydrogen, CCUS, biomass feedstock, etc.
- The **most promising option**, however, is clean ammonia production from using clean hydrogen due to the following aspects:

Uses **renewable electricity** and **clean hydrogen** as energy sources

Cuts process **emissions** to almost **zero**

In the short- to medium-term blue ammonia, i. e. using CCUS, can be used to lower emissions; in the long run, large amounts of **clean hydrogen** are required

Status quo H_2 projects

- Currently, H_2-electrolysis projects are the most popular for ammonia decarbonization
- However, companies are **delaying** or **withdrawing** from final investment decisions due to various reasons
- Main reasons for low numbers of projects are **high production costs**, combined with **policy gaps** and **weak demand signals**

Excerpt of the current H_2 project status quos in the EU*:

Concepts:	14 projects	HydrGEN, Høst - Esbjerg green ammonia plant
Feasibility study:	23 projects	Iberdrola - Palos de la Frontera, Green Wolverine
Operational:	2 projects	Iberdrola - Puertollano I, REDDAP

Sources: PwC analysis, IEA (2024), United Nations Industrial Development Organization (n.d.) * ammonia production only; Technologies: SOEC, other electrolysis, PEM, ALK

To ensure market sounded results, expert insights were collected from international key players in the fertilizer industry

Ammonia-based fertilizer market insights

Attributes of key players

Headquarters	United States, United Kingdom, Poland, Germany, France
Revenue	9 – 88 bln. €
Headcount	20K – 100K+
Subsidiary*	60 – 600+
Roles in value chain	NH_3 producers, fertilizer manufacturers, EPC/O&M for electrolyzer etc.

* subsidiaries with ≥ 50% ownership

Key findings

Planning security is important → duration of regulatory periods is particularly important, considering **long terms**

Without a **CFD mechanism**, ramp-up will be difficult.

CBAM does not bridge the **cost gap** to clean ammonia and does not provide the intended **market security**

Regulations have good targets but do not function without **penalties**

If accepting that OpEx will generally be higher due to reduced cost efficiency → inevitably reach **quotas**

Labelling systems by an independent organization, which takes care of the **revenue redistribution**, sounds promising

Overall / common understandings

- Investment hesitation can be traced back to missing long-term planning security as well as the lack of market security
- Quotas considering international imports and in combination with penalties were commonly perceived as one of the preferred market options

3.2

Possible volumes of ammonia-based fertilizer to meet EU climate targets

Adopting a fertilizer production based on clean H_2 could be the basis of lead markets and boost a hydrogen economy

Possible volumes of clean ammonia production to meet EU climate targets

Key findings

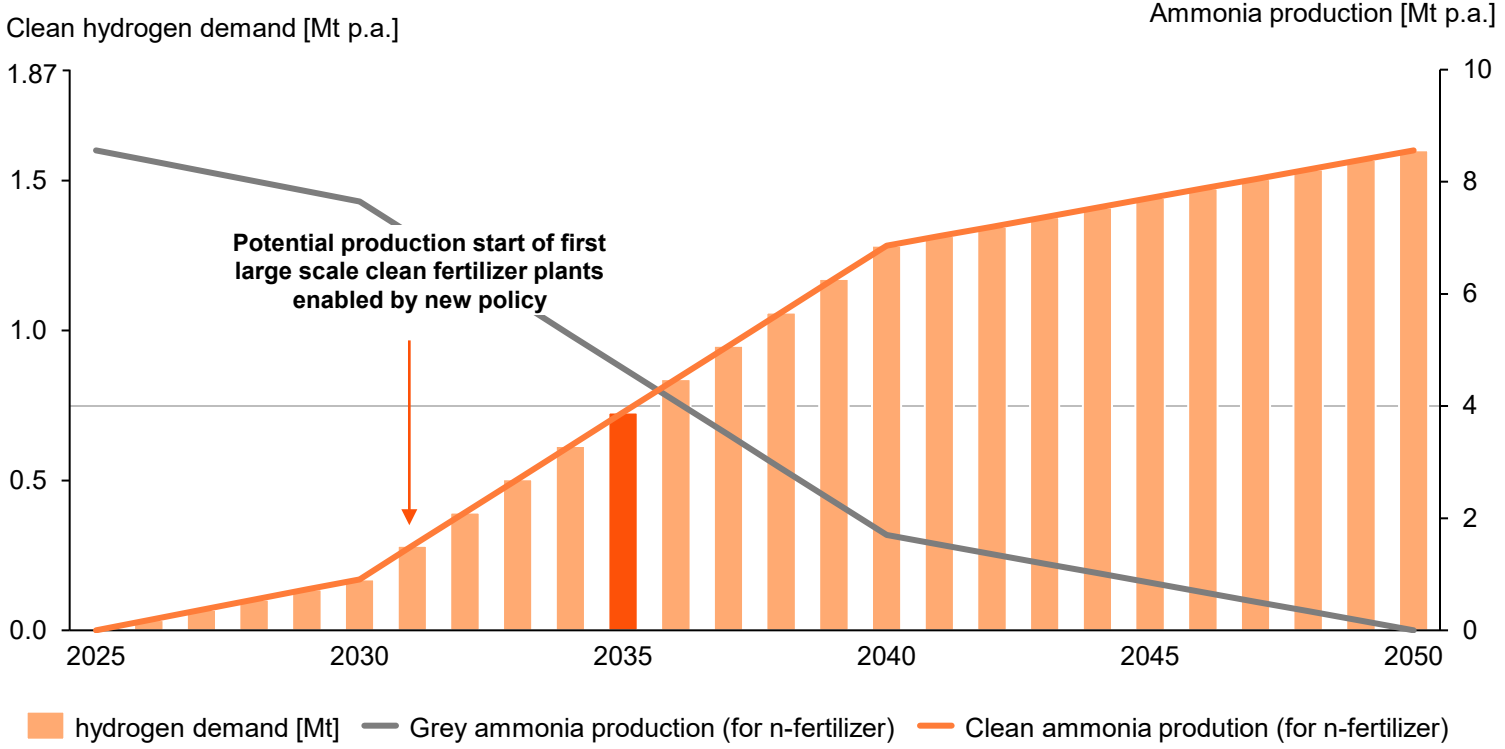
The EU aims to achieve a **90% reduction** in overall GHG emissions **by 2040**

To meet these targets directly, the fertilizer sector must increase **clean ammonia-based fertilizer** production to **~ 4 Mt by 2035**

This would result in a potential increase of **clean hydrogen** demand for clean ammonia production of **~ 0.7 Mt by 2035**

The EU ammonia-based fertilizer sector **alone cannot form a lead market and needs to be paired** with steel (or another industry) to meet the threshold defined above

Estimated clean hydrogen demand to decarbonize ammonia-based fertilizer production*



*Assumption: 80% of total ammonia production in the EU is used for n-fertilizers. Only emissions of ammonia production are taken into account. H_2 demand per NH_3: 0.187 kg; Emissions intensity grey: 2 $tCO_2/t\ NH_3$

The clean fertilizer price sensitivity is apparent in the agricultural value chain, while the end customer price impact remains marginal

Price sensitivity analysis

Background

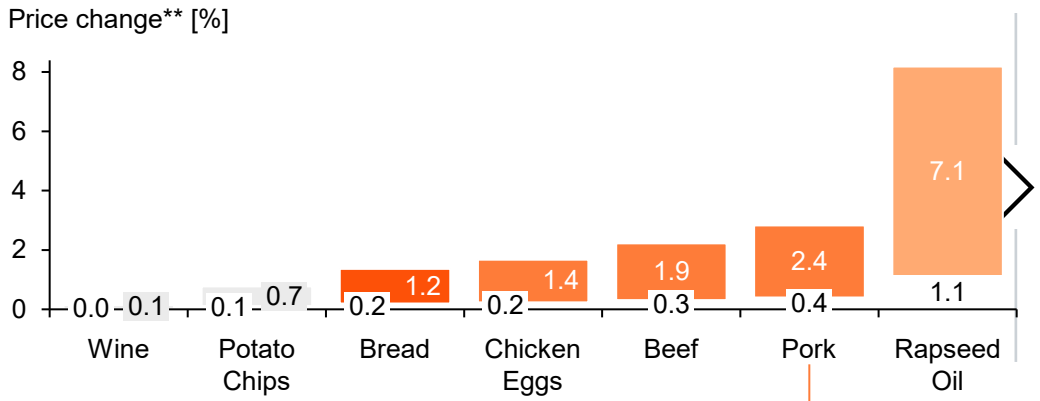
Rising costs for clean fertilizer strongly affect crop prices - especially for low-cost maize silage (7- 40 %), which is widely used as animal fodder

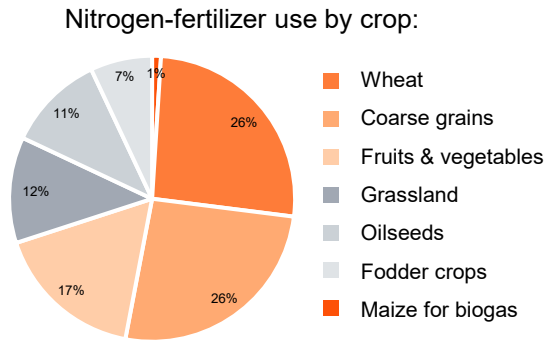
Since fertilizer is only a partial cost factor, the **final** product **price difference** is **marginal** (dependent on the product and H_2 prices)

For **example**, although fodder crop prices are rising, the additional cost for pork meat remain relatively low

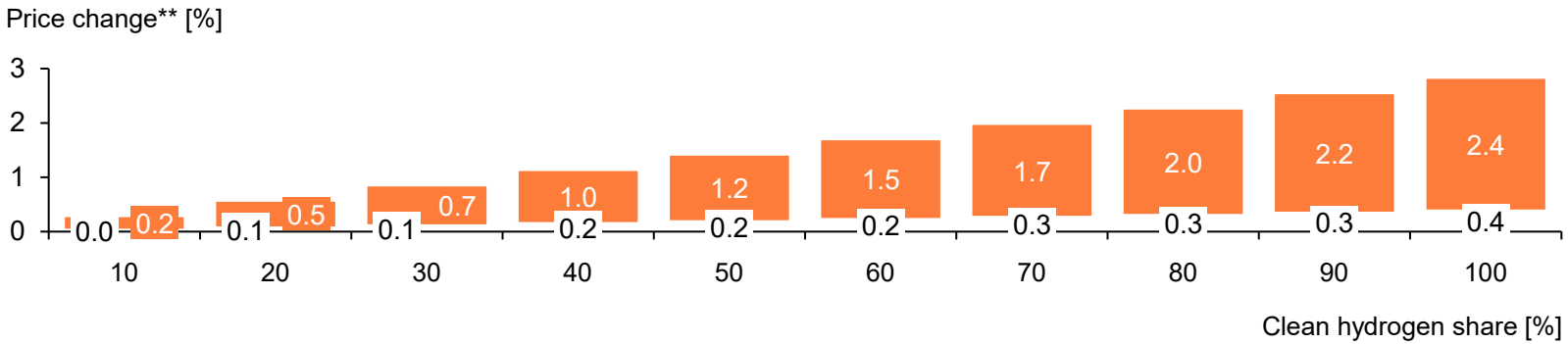
Even if 100% clean fertilizer will be used, **consumer retail prices would be hardly affected**

Effect of price change by clean fertilizer for end products*





Deep dive: quota impact on pork meat



* Calculated based on a price gap for conventional and clean fertilizer of around 200-1,000 €/t (based on a hydrogen price of 2.5 – 7.5 €/kg), ** Lower bar: H2 price of 2.5 €/kg, Upper bar: H2 price of 7.5 €/kg

3.3

Eligible models and regulations

3.3.1

From long - to shortlist

In theory, various market design options can be used to foster the use of ammonia-based fertilizer

Longlist models

Possible market design options

I. Quota for fertilizer supplier

Each EU and non-EU supplier of fertilizer must meet the quota, either to be fulfilled by physical production or buying certificates from the market. Producers of clean fertilizer receive certificates when using clean ammonia.

II. Bonus model

Agricultural producers receive a bonus to their subsidies if they can demonstrate that they purchased and used clean fertilizer.

III. Food-based levy financed CfD

Retailers pay a food revenue-based levy into a dedicated fund, which offers tenders to producers of clean fertilizer. Successful bidders receive a Contract for Difference (CfD) to cover the price difference of grey vs. clean fertilizer.

IV. Public procurement

A quota could be applied to the public sector when purchasing fertilizer. As an alternative, public procurement rules could be used to require a quota for agricultural products grown with clean fertilizer.

V. Voluntary model

The private sector can buy clean fertilizer on a voluntary basis. Producers of agricultural products using clean fertilizer will be granted the right to use a clean fertilizer label.

VI. Eco schemes

Clean fertilizers may become mandatory under EU eco-schemes, which support climate-friendly farming practices and could soon include clean fertilizer use as an eligible activity under the 2023–2027 Common Agricultural Policy.

VII. Joint procurement

Drawing on the experience of Producer Organizations (POs) under the Common Agricultural Policy, joint procurement initiatives and targeted incentives such as reduced VAT for POs could stimulate bulk offtake of clean fertilizers.

Supply-side models Demand-side models

As not all policy options provide the same benefits, three options are considered for further analysis

From long- to shortlist: quick assessment

#	Options	Effectivity	Efficiency	Carbon Leakage Prevention	Lean Implementation	Summary
I	**Quota for fertilizer supplier**	high	high	medium	high	medium
III	**Bonus model**	medium	medium	n/a	medium	medium
III	**Food-based levy financed CfD**	high	high	high	high	high
IV	**Public procurement**	**insufficient**	high	high	high	insufficient
V	**Voluntary model**	**insufficient**	medium	high	high	insufficient
VI	**Eco schemes**	**insufficient**	medium	high	medium	insufficient
VII	**Joint procurement**	**insufficient**	high	medium	medium	insufficient

Current policy instruments fail to meet climate targets and thereby jeopardizing the necessary clean hydrogen ramp-up for fertilizer

Deep dive: insufficient promotional effect of EU ETS and CBAM

Key findings

Current policy instruments, i.e. EU ETS, are **insufficient** to meet sector-specific EU climate targets

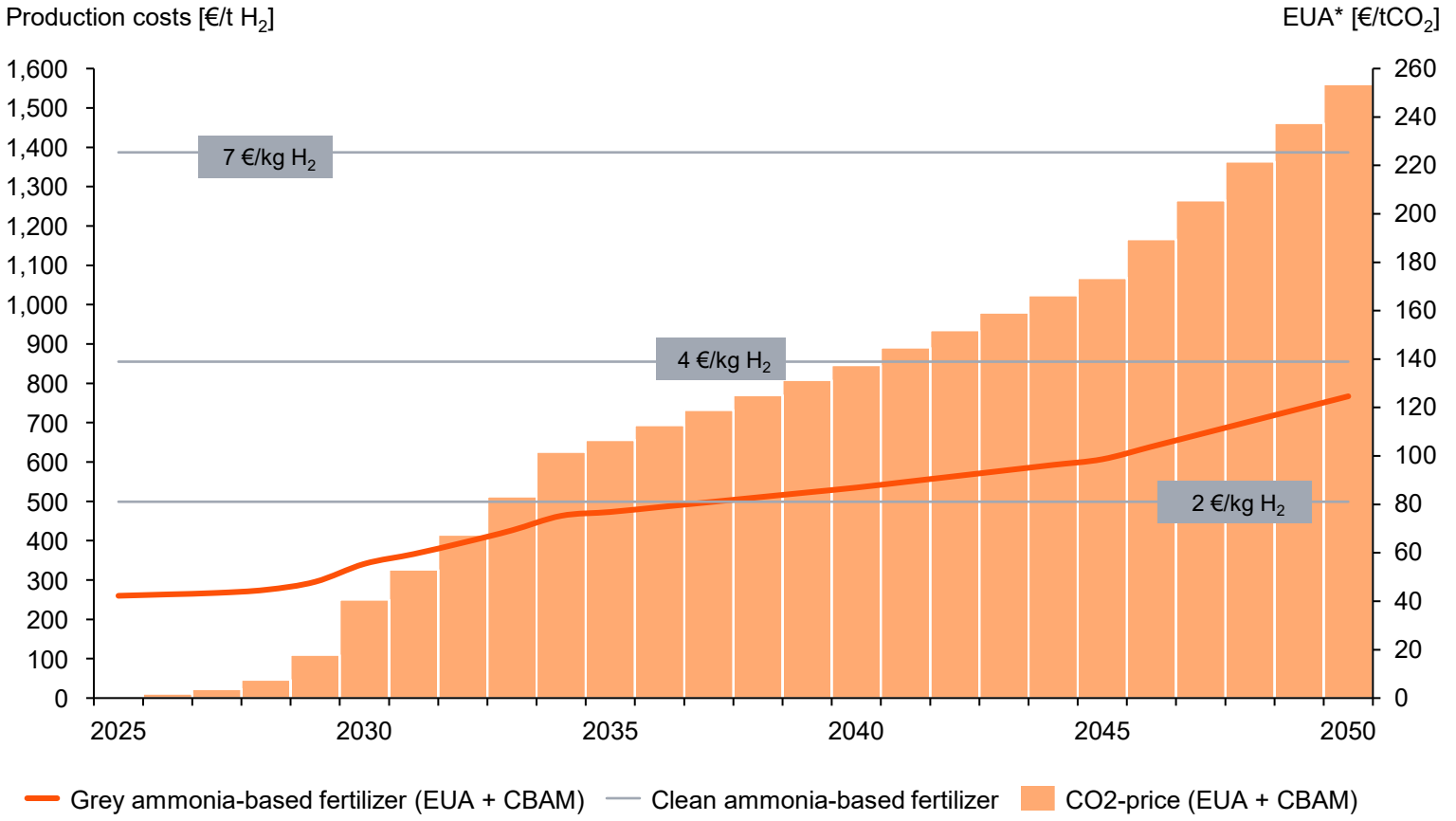
Clean fertilizer production becomes **economically viable** vs. grey fertilizer only **after 2050** under conservative clean hydrogen price assumptions

To close the gap EUA prices must rise to at least 563 €/tCO_2

New policy instruments are critical to accelerate the urgently needed scale-up of hydrogen production and utilization

Sources: PwC analysis, Hydrogen Europe, Pahle et.al (2024); *EU Allowances

Estimated break-even production costs grey vs clean ammonia-based fertilizer over time



Based on the quick assessment, three shortlisted regulatory options will be analyzed in more detail for clean ammonia

Longlist models

Possible market design options

I. Quota for fertilizer supplier

The entire fertilizer sector is covered by the quota system, with penalties ensuring compliance Successful examples of such systems, like ReFuelEU Aviation, demonstrate their effectiveness.

✓

II. Bonus model

A bonus for the use of non-fossil fertilizer as part of the general subsidy scheme for the agricultural sector seems more practical than a mandatory quota system for all farmers.

✓

III. Food-based levy financed CfD

Contract for Difference (CfD) providing for the long-term production of non-fossil fertilizer are an effective way to promote the use of green ammonia

✓

IV. Public procurement

Demand for fertilizer mainly in the private sector, no relevant demand by the public sector

A labelling system for agricultural products grown with non-fossil fertilizer only for use in the public sector appears disproportionate

X

V. Voluntary model

Insufficient demand in addition to existing labels for organic food. The EU Organic Farming Regulation stipulates that synthetic chemical fertilizers are prohibited in organic farming.

X

VI. Eco schemes

As Eco-schemes are voluntary and farmers are allowed to choose among several different sustainable practices, no significant demand can be ensured

X

VII. Joint procurement

Joint procurement does not solve the underlying problem that agricultural producers have not sufficient incentive to use the more expensive non-fossil fertilizer, even if VAT incentives are provided. A certificate system makes bulk procurement unnecessary.

X

Supply-side models Demand-side models

3.3.2

Outline of a supplier quota model

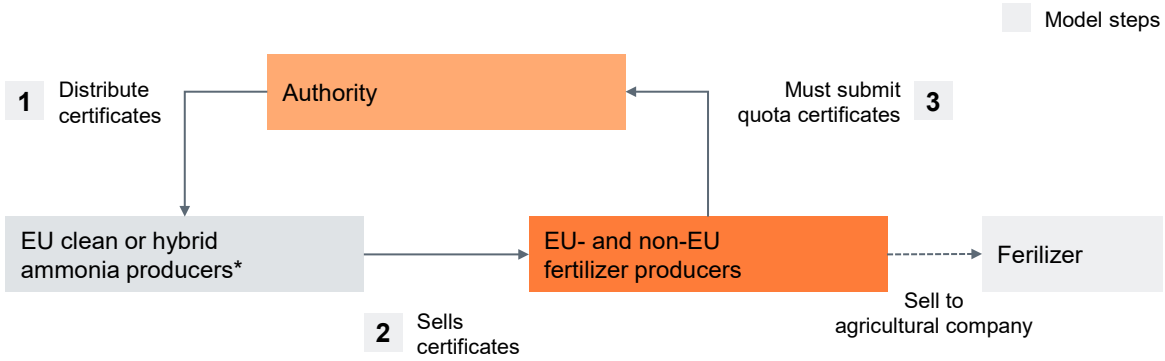
A quota on the supplier is one possible option but needs to carefully consider the international nature of the ammonia market

Supplier quota model: foundations

Model description

- Ammonia-based fertilizer supplier receive certificates based on the share of clean hydrogen used in the production process, allowing both hybrid and fully clean plants to participate
- Share of clean hydrogen to be increases over time to ensure that the short-term fertilizer cost increase is limited
- European as well as non-European fertilizer suppliers must submit a set number of quota certificates for cancellation to meet their clean ammonia quotas
- Non-European fertilizer suppliers must fulfill the same clean ammonia quotas based on their ammonia revenues generated in the EU
- Penalties to be applied to EU and non-EU suppliers in case quotas are not met

Illustrative depiction



Regulatory comments

- **European focus questionable:** If the EU decides to import clean ammonia on a large scale from non-EU countries, it would contribute to the quota certificate allocation

Examples for challenges and opportunities

- **Failed Lead Market for the use of hydrogen:** clean ammonia is foreseen as an energy carrier for hydrogen imports. The direct import of clean ammonia produced abroad could obstruct the formation of a clean hydrogen lead market under the quota model.
- **Technology neutrality and competitive fairness:** both EU and non-EU fertilizer producers must purchase certificates supporting international competitiveness and ensuring WTO compliance

* Amount of received certificates depends on the share of clean hydrogen used for ammonia production

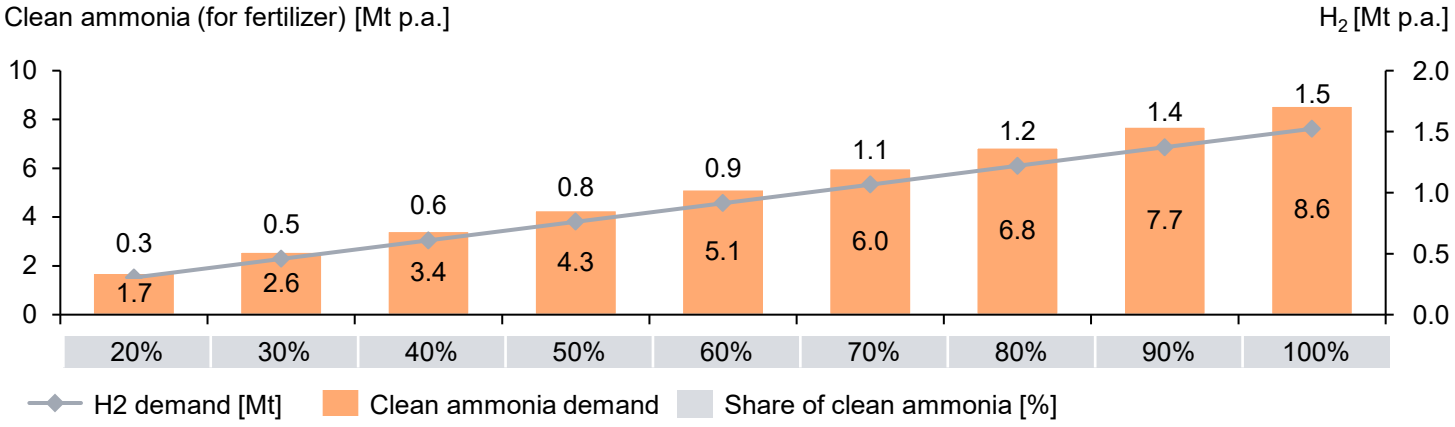
Monetary benefits of certificates can enable an optimal transition based on lowest conversion costs

Supplier quota model: market impact

Key findings

- The certificate mechanism **allows optimal allocation of transition efforts** based on the lowest cost of adapting clean H2 and enables ammonia production sites with favorable preconditions to invest early on
- To ensure a relevant impact on clean ammonia and subsequently clean hydrogen a **market share of 50% should be targeted**
- To ensure **hydrogen availability** through local production or imports, swift action is required

Estimated impact on market



Overall rating

Effectivity

Pros: Quota is subject to penalty

Efficiency

Pros: Fertilizer manufacturers choose the cheapest supplier of clean ammonia or produce it themselves

Controllability of import and export effects

Pros: Import of fossil fertilizers requires certificates; no certificate requirement for exports

Cons: Agricultural imports using conventional fertilizers cannot be taxed, and exports using clean fertilizers cannot be exempted from taxation

Lean implementation

Pros: Implementation at the level of fertilizer producers is comparatively simple (limited number of market participants)

Implementation models

- **ReFuel EU Aviation:** quotas for fuel suppliers to provide sustainable aviation fuels at EU airports, requests airports to offer infrastructure as well as EU airlines to increase minimum share of SAF up to 70 % in 2050

Rating: High Medium Low n.a

3.3.3

Outline of bonus model

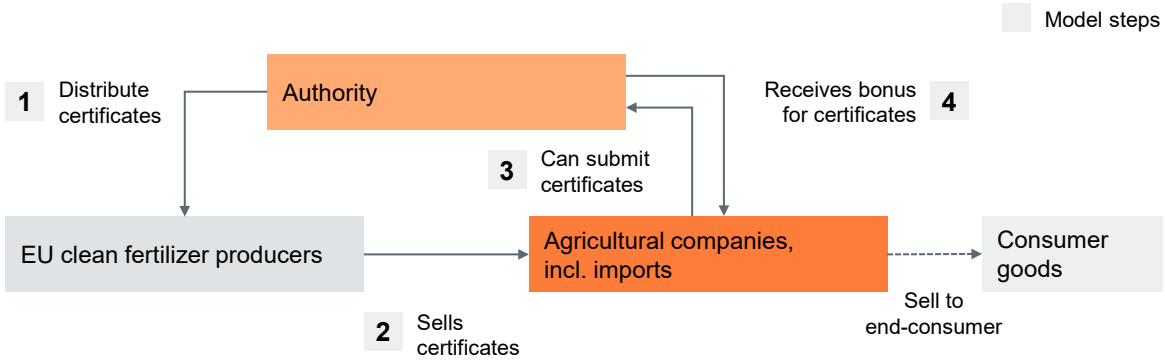
The bonus model can create a hydrogen market pull but is complex in its implementation and creates few upsides

Bonus model: foundation

Model description

- Producers of clean fertilizer receive certificates from the government after demonstrating their ammonia-based fertilizer production
- Agricultural enterprises can buy certificates from fertilizer producers for purchasing clean fertilizer
- Agricultural enterprises can redeem the certificates for government bonus payments and are likely to include the additional costs in their end-product

Illustrative depiction



Regulatory comments

- **Regulatory trade-off:** even though WTO GATT rules do not apply for the agricultural sector, the bonus model must be compliant with WTO Agreement on Agriculture

Examples for challenges and opportunities

- **Additional costs:** bonus must reflect additional costs for clean fertilizer plus a margin as an incentive, otherwise agricultural enterprises are likely to buy conventional fertilizer only
- **Taxpayer burden:** too generous bonus will place a burden on public finances and thus, total governmental spending must be limited, e. g. by capping the maximum number of certificates to be redeemed per hectare of land
- **Efficient use of funds:** bonus is only granted when clean fertilizer is actually used, ensuring targeted and effective support

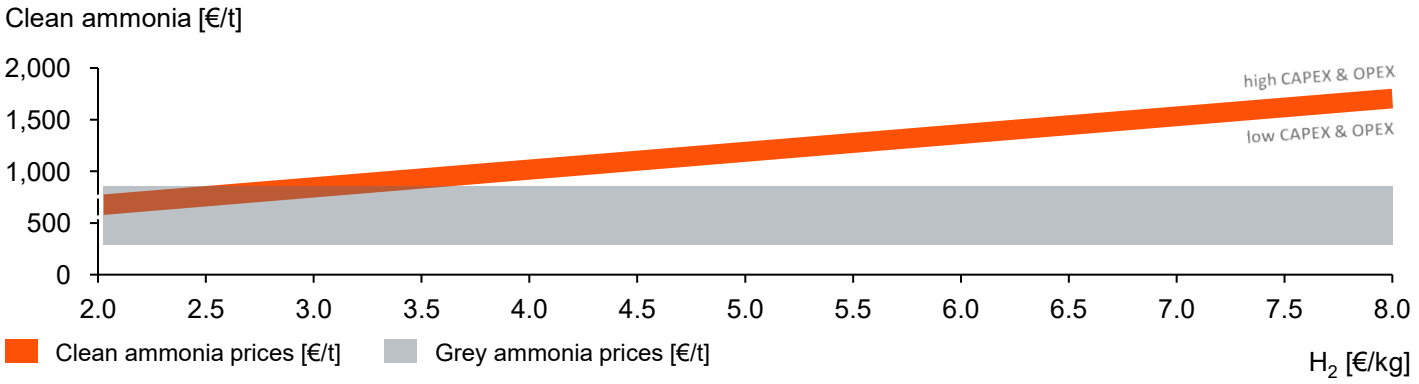
Due to strong price differences between grey and clean ammonia, bonuses must be substantial to have a real incentive effect

Bonus model: market impact

Key findings

- Considering current H_2 prices of **6 to 8 €/kg** the possible bonus payment for using clean fertilizer from clean ammonia needs to be between **550 and 1.200 €/t**
- With **hydrogen prices below 2.5 €/kg,** creating incentives for the use of clean fertilizers **through bonus payments is no longer necessary,** or **only to a small extent,** according to current estimates

Price comparison grey ammonia to clean ammonia



Sources: PwC analysis, Dechema (2022), Hydrogen Europe (2023), Fraunhofer PtX-Atlas (2022), IW Köln (2023)

Overall rating

Effectivity

Cons: Risk: target quota is not reached if bonus is too low

Efficiency

Pros: Agricultural enterprises can buy clean fertilizer from market

Cons: Bonus must be determined by the government Agri-cultural enterprises must be incentivized with an extra margin

Controllability of import and export effects

n.a.

Lean implementation

Cons: Additional subsidy mechanism for a high number of agricultural enterprises

Implementation models

Regulation (EU) No 1307/2013 regulates direct payments to agricultural holdings under the European Union's Common Agricultural Policy (CAP). Regulation (EU) No 1305/2013 regulates the promotion of rural development in the European Union through the European Agricultural Fund for Rural Development (EAFRD). The directives do not contain any explicit individual provisions or limit values that directly relate to CO_2 reduction. However, measures could be implied here that link payments to the use of ammonia- based fertilisers.

Rating: High Medium Low n.a

3.3.4

Outline of food-based levy financed CfD model

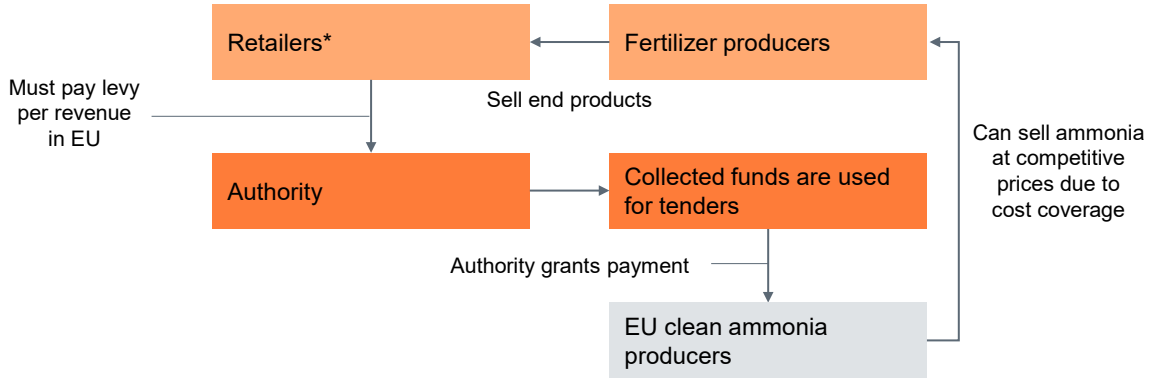
Retailers pay a levy that enables EU clean ammonia producers to receive compensation and offer this product at competitive prices

Food-based levy financed CfD model: foundation

Model description

- Retailers would pay a levy per revenue within the EU based on food product revenue, regardless of ammonia share in fertilizer
- Revenue contributes to a fund that supports European clean ammonia producers
- Clean ammonia producers can apply for a grant payment covering the additional costs compared with the conventional production and the bidders asking for the lowest subsidy payment is awarded the grant
- Successful bidders enter into agreement with authority, accepting an obligation to produce clean ammonia in the awarded amount (Contract for Difference - CfD)
- Successful bidders would have to pay penalties for underperformance
- Fertilizer producers can sell all types fertilizer to its customers as usual and the higher clean fertilizer costs are covered by consumers via slightly higher food prices from retailers

Illustrative depiction



Regulatory comments

- **Idea of CBAM mechanism shall be applied accordingly:** import requires levy payment; no levy requirement for exports (to prevent trade disadvantages)
- **WTO-requirements:** clean ammonia subsidized under a CfD must be sold on the market as grey ammonia to avoid a conflict with WTO requirements, which state that products from outside the EU must not be treated less favorable than produced in the EU. However, EU-only subsidies are possible

Examples for challenges and opportunities

- **Limited EU competence:** EU currently lacks the legal authority to collect additional funds, which may hinder effective implementation. Voluntary participation of all member states is uncertain, the Union's own budgets are limited
- **Limited certainty for ramp-up:** If long-term funding for the mechanism is not secured, market participants may be reluctant to invest in clean ammonia
- **Level playing field:** both importers and EU sellers contribute equally, reducing the risk of trade distortion and ensuring WTO compatibility
- **EU budget neutrality:** Funding originates from product sellers and no EU funding required

* Levy must be paid independent of share of origin of sold products (EU-produce and imports)

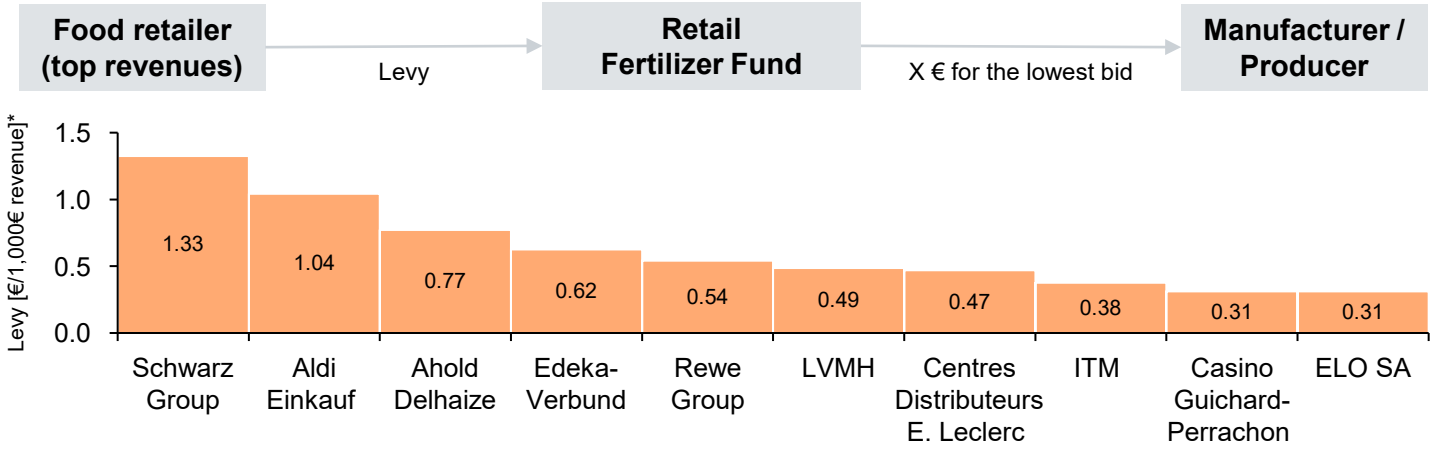
The impact of clean fertilizers on food prices is minimal, while providing food retailers with an efficient scope 3 reduction option

A mandatory fund sponsored by food retailers provides financial certainty

Overview

- Using **50 % clean hydrogen*** in ammonia-based fertilizer production can result in additional costs of clean ammonia production of up to **4.22 bln. €** (assumed H2 price of 7 €/kg) and a clean hydrogen demand of 0.78 Mt
- Food retailers pay into a fund according to their market share by buying certificates
- As a result, the Schwarz Group (1.33) and Aldi (1.04) bear the highest levy per 1,000 € revenue, yet end-consumers faced significantly higher inflation rates in recent years (>10% in 2023, 3.3% in 2025)
- Availability of public long-term funding as an alternative to a levy is uncertain

Mechanism as an example



Sources: PwC analysis, Statista (2023), EU; * Neither a 50 % nor even a 100 % share of clean hydrogen is sufficient to establish a lead market as defined in this study

Rating

Effectivity

Pros: Contractual obligation to produce clean fertilizer

Efficiency

Pros: Markt mechanism (tender)

Controllability of import and export effects

n.a. Retailers pay a levy regardless of EU produced or imported food

Implementation

Pros: Tender process is only necessary for producers of clean fertilizer

Cons: Levy must be collected from all retailers

Implementation models

- **German Contracts for Difference:** state covers additional costs incurred by companies when switching to climate-friendly production processes and companies apply for funding, sign an agreement with the state as well as receive compensation payments for a fixed period as long as climate-friendly production remains more expensive

3.4

Summary

Fertilizer is an international commodity and a lead market policy needs to ensure that EU producers yield benefits from the clean transition

Summary

1 To establish a lead market for clean hydrogen, targeting the fertilizer sector and related downstream industries, offers relevant offtake potential. Achieving a primary **clean fertilizer share of over 50% would generate sector specific demand incentives**, aligning potentially with 8% of the EU's hydrogen production goals.

2 The **supplier quota model implements tradable certificates** to enable the transition to clean hydrogen in fertilizer production. The mechanism can ensure infrastructure development but trade and political risks need to be considered. Future **clean ammonia imports into the EU** must be monitored, as they **could undermine the creation of a local lead market** for clean hydrogen via clean fertilizer production.

3 A targeted **bonus model** can **effectively boost hydrogen demand** in agriculture — if it is **market-based, politically feasible**, and keeps complexity and costs under control.

4 The **food-based levy financed CfD model imposes obligations at the end-producer level**, spanning the entire value chain. Neither end-product prices nor the willingness to pay will likely be significantly impacted by the share of clean fertilizer usage. Indicative estimates suggest that **price increases for food products will remain well below the EU's food inflation rate** (<3.3% projected for 2025) and are generally acceptable.

A new EU regulation would be suitable for implementation

Outline of food-based levy financed CfD model (example)

Implementation timeline for EU legal acts

Timeline

- Proposal by EU Commission
- Feedback period
- Trilogue Negotiations by European Parliament (EP) and EU Council
- Adoption by European Parliament
- Adoption and Ratification by EU Council

Exemplary legislative process

EU legal acts include regulations, directives, decisions, recommendations, and opinions.

- A regulation that is adopted is immediately applicable.
- A directive must still be implemented by the member states.
- Recommendations and opinions are not binding.

If the **food-based levy financed CfD model** is to be implemented legally, it would probably be necessary to adopt a directive, as the respective food-based levy conditions would have to be implemented by the member states. In addition, a recommendation from the EU Commission might be required.

Example: Timeline for the legislative process for the Nitrates Directive (91/676/EEC):

- Commission proposal: September 9, 1988
- adoption by the Council: December 12, 1991 → Duration of the process > 3 years
- Implementation period for the member states: two years.

In total > 5 years

Implementation models and potential impact

Implementation models	Potential impact
Supplier quota model	~ 0.8 Mt H_2 demand
Bonus model	Not predictable
Food-based levy financed CfD model	~ 0.8 Mt H_2 demand

4

Conclusion and Outlook

Lead markets are an effective way to increase demand and provide investment certainty for clean steel and ammonia-based fertilizer plants

"This is why **lead markets** must be at the heart of our action"

2025 State of the Union Address by President von der Leyen

Clean Steel

Steel producer and end product manufacturer consultation to identify most promising model/ model combination to create lead markets

Potential to achieve **20%** **of the EU's hydrogen production goals**

Clean ammonia-based fertilizer

Fertilizer supplier and retail company consultation to identify most promising model/model combination to create lead markets

Potential to achieve **8%** **of the EU's hydrogen production goals**

Thank you

pwc.com

Authors

Matthias Stephan
Director / Lawyer
matthias.stephan@pwc.com
+49 1511 7509839

Jürgen Peterseim
Director
juergen.peterseim@pwc.com
+49 160 92426858

Marco Garbers
Senior Manager / Lawyer
marco.garbers@pwc.com
+49 171 3529187

Sebastian Föllner
Manager
sebastian.foellner@pwc.com
+49 1517 2874889

pwc.com

Contacts

Jorgo Chatzimarkakis
Chief Executive Officer
ceo@hydrogeneurope.eu

Laurent Donceel
Director
l.donceel@hydrogeneurope.eu

Stanislas Demeestere
Officer
s.demeestere@hydrogeneurope.eu

Annex

Abbreviations

BF-BOF	Blast furnace basic oxygen furnace
CBAM	Carbon Border Adjustment Mechanism
CCFD	Carbon Contracts for Difference
CCUS	Carbon capture utilization and storage
CID	Clean Industrial Deal
CVD	Clean Vehicle Directive
DRI-EAF	Direct reduction of iron ore and electric arc furnace
DRI-EAF H2	Direct reduction of iron ore and electric arc furnace with hydrogen
DRI-EAF NG	Direct reduction of iron ore and electric arc furnace with natural gas
EII	Energy-intensive industries
ESG	Environmental, Social, Governance goals
ESPR	Ecodesign Regulation
EU	European Union
EU ETS	European Union Emission Trading System
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GVA	Gross Value Added
IAA	Industrial Accelerator Act
LESS	Low Emission Steel Standard
Mt	Megaton (Million metric tones)
PO	Producer Organizations
PtL	Power-to-Liquid
RED	Renewable Energy Directive
RFBNO	Renewable fuels of non-biological origin
SAF	Sustainable Aviation Fuel
TSO	Transmission System Operator
VAT	Value Added Tax
WTO	World Trading Organisation
WTP	Willingness to pay

Sources

Agora Industry (2024). Creating markets for climate-friendly basic materials. Potentials and policy options. Available at: https://www.agora-industry.org/fileadmin/Projekte/2023/2023-29_IND_Lead_Markets/A-IND_330_Lead_Markets_WEB.pdf.

Agora Industry, FutureCamp, Wuppertal Institute and Ecologic Institute (2022). Transforming industry through carbon contracts: Analysis of the German steel sector. Available at: https://www.agora-industry.org/fileadmin/Projekte/2021/2021_10_DE_KIT/A-EW_268_KIT_Background_Study_Steel_EN_WEB.pdf

Agora Industry, Wuppertal Institute and Lund University (2024). Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking. Available at: https://www.agora-industry.org/fileadmin/Projekte/2021/2021-06_IND_INT_GlobalSteel/A-IND_324_Low-Carbon-Technologies_WEB.pdf

Alsulaiman, A. & Chyong, K. 2025. The Economics of Decarbonising Europe's Ammonia Industry: Policy, Pathways, and Trade-offs in a Hard-to-Abate Sector. OIES paper ET43.The Oxford Institute for energy studies. Available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/03/ET-43-The-Economics-of-Decarbonising-Europes-Ammonia-Industry.pdf

Bronk & Company (2024). Chancen und Risiken: Stahlbedarfsprognose 2030, 2022, Available at: https://bronk-company.com/de/2024/06/stahlbedarfsprognose-2030/

CAN Europe & E3G

Choksey, Ysanne; Lehne, Johanna; Ruiz Bautista, Carlota; Hovenier, Julia; Lot, Behnam; Jankowiak, Boris; López, Sara; Strîmbovschi, Sabina; Parodi, Julian; Hauschke, Fynn; Krishna, Jai; Nigro, Riccardo; Schaible, Christian; Tricarico, Emilie; von Berlepsch, Tilman; Gross, Hannah; Brunstein, Aurelie; Rocamora, Cynthia; Ashley, Caroline; Waagsaether, Katinka Lund; Pidgeon, Alice; Alford, Chris. (2025). The State of the European Steel Transition. Available at: https://eeb.org/wp-content/uploads/2025/03/State-of-Steel-Report.pdf

Cognitive Market Research (2025). Seamless Steel Tube Market Report 2025 (Global Edition). Available at: https://www.cognitivemarketresearch.com/seamless-steel-tube-market-report.

Dechema (2022). Perspective Europe 2030 Technology options for CO2- emission reduction of hydrogen feedstock in ammonia production . DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V (2022). Available at: https://dechema.de/dechema_media/Downloads/Positionspapiere/Studie%20Ammoniak.pdf

Deloitte Netherlands (2025). Mobilizing consumer demand for green hydrogen-based products: Potential role of demand-side policies to stimulate decarbonisation of European heavy industry. Available at: https://www.energie-nederland.nl/wp-content/uploads/2025/02/2025-Deloitte-Mobilizing-Consumer-Demand.pdf.

Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC and Decision (EU) 2015/1814, establishing a system for greenhouse gas emission allowance trading and a market stability reserve for the Union greenhouse gas emission trading system. Official Journal of the European Union, L 130, 16 May 2023, pp. 134–202. Available at: https://eur-lex.europa.eu/eli/dir/2023/959/oj/eng

Sources

Devlin et al. (2023). Global green hydrogen-based steel opportunities surrounding high quality renewable energy and iron ore deposits, Alexandra Devlin, Jannik Kossen, Haulwen Goldie-Jones & Aidong Yang, 2023, https://doi.org/10.1038/s41467-023-38123-2

Draghi, M. (2024). The future of European competitiveness: A competitiveness strategy for Europe (Part A) & In-depth analysis and recommendations (Part B). European Commission. doi:10.2872/9356120.

Energy Technology Perspectives (2023)., IW Köln (2023)

Eurofer (2025). Economic Outlook 2025: Economic and steel outlook 2025 2026 – Q2 Report Data upto, including Q4 2024, 2025. Available at: https://www.eurofer.eu/assets/publications/economic-market- outlook/economic-and-steel-market-outlook-2025-2026-second-quarter/EUROFER-Economic-Report-Q2-2025.pdf.

Eurofer (2024). European Steel in Figures. Available at: https://www.eurofer.eu/assets/publications/brochures-booklets-and-factsheets/european-steel-in-figures-2024/European-Steel-In-Figures-2024-v2.pdf

European commission (2025). EU-Kommission legt Aktionsplan für die Stahl- und Metallindustrie vor, 2025, EU Comission – German Delegation, Available at: https://germany.representation.ec.europa.eu/news/eu- kommission-legt-aktionsplan-fur-die-stahl-und-metallindustrie-vor-2025-03-19_de

European Commission (2021). "Fit for 55": delivering the EU's 2030 Climate Target on the way to climate neutrality. COM/2021/550 final. Brussels.

European Commission (2025a). A Competitiveness Compass for the EU (COM(2025) 30 final). Brussels. Available at: https://commission.europa.eu/document/download/10017eb1-4722-4333-add2- e0ed18105a34_en?filename=Communication_1.pdf.

European Commission (2025b). Industrial Decarbonisation Accelerator Act. Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14505-Industrial-Decarbonisation-Accelerator-Act-speeding-up-decarbonisation_en.

European Commission (2025c). The Clean Industrial Deal: A joint roadmap for competitiveness and decarbonisation (C(2025) 7600 final). Brussels. Available at: https://eur-lex.europa.eu/legal- content/EN/TXT/?uri=CELEX%3A52025DC0085.

European Hydrogen Backbone (2024). EHB Implementation Roadmap: Public support on catalyst for hydrogen infrastructure. Available at: https://ehb.eu/files/downloads/EHB-2024-Implementation-Roadmap-Part-2.pdf

Sources

Forschungsgesellschaft für Energiewirtschaft (2020). European Steel with Hydrogen: Ffe Discussion Paper 2020-04. Available at: https://www.ffe.de/wp-content/uploads/2020/12/20201211_European-steel-with-hydrogen-in-2050_Format_Discussion-Paper_final.pdf

Hydrogen Europe (2023). Clean Ammonia in the future energy system. Available at: https://hydrogeneurope.eu/wp-content/uploads/2023/03/2023.03_H2Europe_Clean_Ammonia_Report_DIGITAL_FINAL.pdf

Fraunhofer IEE (2022). PtX-Atlas. Available at: https://maps.iee.fraunhofer.de/ptx-atlas/

Hydrogen Europe (2024)a. Ammonia-based chemicals trade briefing (internal document).

Hydrogen Europe (2024)b. Clean Hydrogen Monitor 2024. Available at: https://hydrogeneurope.eu/wp-content/uploads/2024/11/Clean_Hydrogen_Monitor_11-2024_V2_DIGITAL_draft3-1.pdf

Hydrogen Europe (2025). The case of Green Lead Markets: ensuring competitiveness, energy security and decarbonization. Hydrogen Europe Position paper. Available at: https://hydrogeneurope.eu/wp-content/uploads/2025/06/2025.06_GreenLeadMarketspaper_H2Europe-1.pdf.

IEA (2023). Energy Technology Perspectives 2023. Paris. Available at: https://www.iea.org/reports/energy-technology-perspectives-2023.

IEA (2024). Hydrogen Production and Infrastructure Projects Database. Paris. Available at: https://www.iea.org/data-and-statistics/data-product/hydrogen-production-and-infrastructure-projects-database.

LeadIT (2024). Clean Steel Tracker. Available at: https://www.industrytransition.org/green-steel-tracker/

LESS (2025). Rulebook for the classification system of the Low Emission Steel Standard (LESS) Version 1.1 (2025). Available at: https://lowemissionsteelstandard.org/downloads

marketSTEEL.de (2025). EU-Stahlaktionsplan und Investitionspaket der Bundesregierung, 2025, Dagmar Dieterle-Witte. Available at: https://www.marketsteel.de/meinungen-details/eu-stahlaktionsplan-und-investitionspaket-der-bundesregierung.html.

Sources

NOW GmbH. (2023). NOW-Factsheet: ReFuelEU Aviation Regulation. Available at: https://www.now-gmbh.de/wp-content/uploads/2023/11/NOW-Factsheet_ReFuelEU-Aviation-Regulation.pdf.

Pahle, M., Quemin, S., Osorio, S., Günther, C., & Pietzcker, R. (2024). The Emerging Endgame: The EU ETS on the Road Towards Climate Neutrality. http://dx.doi.org/10.2139/ssrn.4373443.

ReportLinker (2023). European Fertilizers Gross Value Added Per Employee FTE by Country. Available at: https://www.reportlinker.com/dataset/63eee9fba898bdd1db48c7b37a2b8a53150dcd8b#:~:text=The%20analysis%20of%20the%20European%20Fertilizers%20Gross,Portugal%20show%20lower%20values%2C%20indicating%20potential%20productivity.

Saarstahl (2025). Saarstahl Rail schließt langjährigen Liefervertrag mit SNCF Réseau für klimafreundliche Schienen ab: Großauftrag sichert regionale Arbeitsplätze in der Stahlindustrie und im Bahnsektor, 2025. Available at: https://www.saarstahl.com/aktuelles/pressemitteilungen/saarstahl-rail-schliesst-langjahrigen-liefervertrag-mit-sncf-reseau-fur-klimafreundliche-schienen-ab-grossauftrag-sichert-regionale-arbeitsplatze- in-der-stahlindustrie-und-im-bahnsektor/?id=18242.

SNCF (2024). Low-carbon rails: the circular economy in action at SNCF Réseau, 2024. Available at: https://www.groupe-sncf.com/en/commitments/sustainable-development/eco-friendly-rails.

Statista (2023). Leading food and beverage retailers of Europe in 2021, based on revenue. Availkable at: https://www.statista.com/statistics/666886/leading-food-retailers-of-europe-based-on-sales/#:~:text=Leading%20food%20and%20beverage%20retailers%20of%20Europe%202021%2C%20based%20on%20revenue&text=In%202021%2C%20the%20German%20based,the%20request%20of%20the%20co mpany.

stahlpreise.eu (2025). Stahlmarkt ruhig: Warmband verharrt auf konstantem Niveau. Available at: https://www.stahlpreise.eu/

Strategic Perspectives (2025). Lead markets: driving net-zero industries made in Europe. Brussels. Available at: https://strategicperspectives.eu/wp-content/uploads/2025/03/Lead-markets.pdf.

Sustainable Views (2024). Explainer: the ‘green premium’ for industrial products. Available at: https://www.sustainableviews.com/explainer-the-green-premium-for-industrial-products-e5553e64/#:~:text=Growing%20demand?,17%20and%2019%20agreements%2C%20respectively.

United Nations Industrial Development Organization (n.d.). Green Ammonia for Low Carbon Fertilizer: A targeted solutions for utilising hydrogen from renewable sources to decarbonise fertiliser production in developing countries. Available at: https://www.unido.org/solutions/green-ammonia-low-carbon-fertilizer.

ZDF (2025): Saarstahls Schienen-Deal: ein Erfolgsmodell?. Available at: https://www.zdfheute.de/wirtschaft/unternehmen/gruener-stahl-industrie-krise-saarstahl-frankreich-100.html