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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Project Development Assistance for Regions

Policy support for hydrogen

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Hydrogen is expected to play a significant role in Europe's future energy system but supportive policies will be required to overcome initial market barriers

Context

- Across Europe there is a growing consensus that hydrogen will play a **significant role in decarbonising energy systems** and achieving the EU target of net-zero emissions by 2050.
- **Hydrogen can be produced in large quantities from low or zero-carbon energy sources** and used as a feedstock, a fuel or a means of storing / carrying energy. It has many possible applications across industry, transport, power and building sectors and provides a viable alternative for many hard-to-decarbonize applications for which there are no other zero-emission options that meet the needs of end users.
- However, to date, hydrogen represents only a small fraction of the global and EU energy mix and is **largely produced from fossil fuels**, notably from natural gas or coal, resulting in the release of **70 to 100 million tonnes of CO_2 annually in the EU**[1].
- The 2020 European Hydrogen Strategy states that the first step is to **'decarbonize existing hydrogen production'** and then to expand the role of hydrogen to '**become an intrinsic part of an integrated energy system'**[1].
- To achieve this, renewable and low-carbon hydrogen production costs need to **reach cost parity with fossil-based hydrogen**, and the product (fuel, feedstock, energy carrier etc.) needs to be cost competitive with incumbent options (e.g. diesel/petrol, natural gas).
- Today, this is not achievable, with **low carbon hydrogen expected to be ~33% more expensive** on a per kilogram basis, and **renewable hydrogen between ~167–267% more expensive**[1].
- **Funding support/incentives and a strong regulatory framework will therefore be required** to overcome initial market failures and to encourage a transition to low or zero emission hydrogen production set out in the EU strategy and required to satisfy EU climate targets.

1.EU Hydrogen Strategy (2020) https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

This document provides a succinct overview of the legislative support in place today and areas where member states can increase the role of hydrogen

Purpose of document

- Although there is growing appetite across Europe to expand hydrogen in the energy mix, the **current policy landscape in the EU does not directly support hydrogen** and public investments into production and end uses have been piecemeal.
- This document aims to **outline the legislative environment today** and the role hydrogen can play in this framework.
- It also reviews ambitious **national policies in place, or under discussion, which provide support for hydrogen** production or consumption. This highlights possible areas of expansion for hydrogen policy across member states.
- The document also outlines some of the **key options for intervention** in the hydrogen sector going forward based on policy research and pilot activities.

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Low-carbon or renewable hydrogen benefits indirectly from existing legislative tools

- To date, there are **limited legislative tools dedicated to incentivising the uptake of hydrogen** on a commercial basis. The majority of applicable tools relate to increasing the role of renewable energy in the energy mix and decreasing emissions from the most carbon-intensive industries.
- The table below provides a high-level summary of the EU legislation in place today across key sectors and in areas which hydrogen can access benefits.

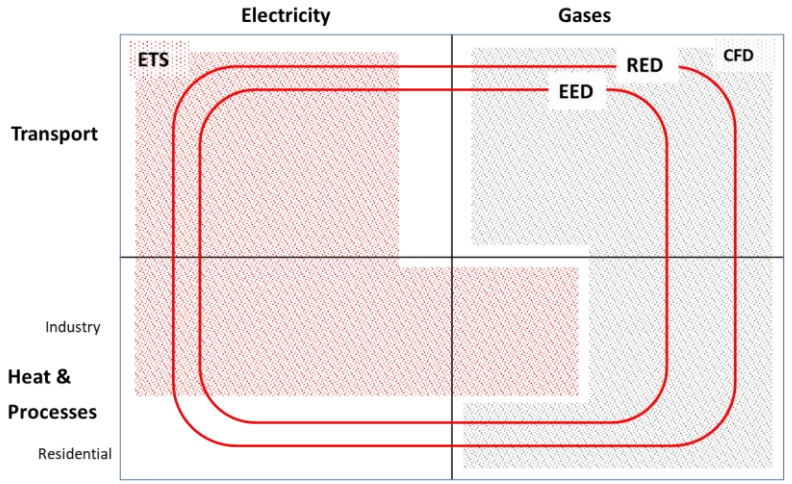
Sector	Requirement	Legislative Tools	Hydrogen's role
Transport	CO_2 reduction PM/NOx/SOx reduction Integration of RES	Renewable Energy Directive II (RED II) CO_2 emission standards for LDVs/LCVs CO_2 emission standards for HDVs Clean Vehicle Directive Alternative Fuel Infrastructure Directive	Renewable/low carbon hydrogen as a fuel
Industry	Decarbonisation	EU Emission Trading Scheme	Renewable/low carbon hydrogen as a feedstock switch
Gas/Heating	Decarbonisation (to remain a player) Integration of RES	Renewable Energy Directive II (RED II) Upcoming Gas regulation	Renewable/low carbon hydrogen as a feedstock switch
Power	Storage/ancillary services Integration of RES	Renewable Energy Directive II (RED II) Electricity Market Design	Rapid response electrolysers and sectoral integration

* Not an exhaustive list

Lack of a dedicated legislative framework for hydrogen creates gaps in support which hinder the full scale-up potential of hydrogen being realised

The current legislative framework provides a foundation of support for hydrogen but is limited in its impact on the sector as:

- **Support is hard to access for hydrogen** – hydrogen is rarely directly referenced as being eligible for subsidy and multiple sustainability certificates/guarantees of origins are required to ensure compliance with legislation. This makes the process hard to navigate, especially considering the lack of standardisation across the sector with regards to the lifecycle emissions of different hydrogen production pathways.
- **Incentives don't provide the critical volume of investment required to drive commercial uptake** – support is not generous enough to substantially increase production volumes of hydrogen and drive down the cost of production (and its use) to levels competitive with fossil-fuels.
- **Many gaps exist** – hydrogen is not covered in all sectors and there is a distinct lack of legislative tools relating to industry.
- **Focus on capital and consumption incentives –** incentives are focussed on supporting the cost premium of equipment (e.g. electrolyser, carbon capture and storage (CCS)), rather than on-going operational premiums. Additionally, end users are targeted rather than driving the market to transition as a result of production incentives.



Scope of European Directives across sectors[1]

- **ETS**: Energy Trading Scheme
- **CFD**: Contracts for Difference
- **RED**: Renewable Energy Directive
- **EED:** Energy Efficiency Directive

1. Hydrogen Europe (2019) Hydrogen in the EU Energy Policy (with edits from Element Energy). Source: https://ec.europa.eu/energy/sites/ener/files/documents/1_hydrogeneurope_chatzimarkakis.pdf

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Policy support can be divided into production and consumption incentives

Policy landscape for hydrogen

- The current policy support for hydrogen can largely be divided into two forms of incentives:

Point of production incentives

- Defined as subsidies towards the capital (e.g. electrolyser, CCS) or operational (e.g. electricity and water) costs of hydrogen production.
- Designed to encourage the construction of any assets which can produce hydrogen.
- Current policy focus is on subsidising the capital cost of hydrogen production assets, with less attention given to the operational costs of the assets (which have a larger effect on the overall business case).

Point of consumption incentives

- Subsidy on hydrogen once it has been delivered to the end user.
- Can be capital subsidies for the conversion of plants/equipment to accept hydrogen or a direct hydrogen subsidy to improve hydrogen's business case for the end user.
- Aim to drive the market for hydrogen consumption by creating a palatable business case for both producers and consumers of hydrogen, relative to their business as usual.

- To date, there are **limited examples of both incentive types** for hydrogen.
- Production policy incentives have been **small-scale and largely focussed on facilitating R&D and deployment** projects. Initial investments have been driven by EU funding facilities or programmes such as Horizon2020 and the CEF Blending Facility. For more details see Appendix (slide 34).
- A number of consumption incentives have been initiated in member states as a result of EU directives to reduce emissions. For example, in the UK there is the **Domestic and Non-Domestic Heat Incentive[1&2]** and the **Climate Change Levy Agreement[3]**. However, there are limited examples of member states applying this to hydrogen.

1. Domestic Renewable Heat Incentive (2021): https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi
2. Non-Domestic Renewable Heat Incentive (2021): https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi
3. Climate Change Agreements (2021): https://www.gov.uk/guidance/climate-change-agreements--2

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Production incentives have been limited in recent years to capital subsidies but there is a move towards subsidising operational premiums

Status of production incentives

- Production incentives on the EU scale have largely focussed on **facilitating R&D and deployment projects**.
- Due to the nature of projects, funding has historically been channelled to research programmes or **supporting the capital cost** of equipment.
- Projects have been on a relatively small scale and focussed in Western Europe where national and regional governments have provided supplementary funding.
- Projects have led to important first-of-a-kind deployments and cost reductions in hydrogen production equipment, infrastructure and fuel cell vehicles. However, no project has been able to achieve a viable whole life business case. This is because:
  - **Capital support is not sufficient** to cover the full premium of the new technologies which means commercial players still face a cost to transition.
  - **Higher operational costs** for low or zero carbon hydrogen production are not accounted for. Lack of funding for this makes a long-term business case unsustainable for producers and consumers.
  - **Regulatory barriers in place** make it difficult to access low production costs (e.g. grid levies increase the price of electricity available to electrolysers and do not yet recognise the value of grid services (e.g. balancing) that the equipment can provide) or taxes on energy consumption prevent competitiveness (e.g. Climate Change Levies vary across member states).
- Member states are beginning to recognise these barriers and have started to investigate more policies providing capital and operational support for hydrogen projects.

Work is underway across member states to define supportive policies for hydrogen

Examples of production policy (not exhaustive)

Intervention Strategy	Country	Description	Value	Status (early 2021)
Capital support for hydrogen production	UK	*UK Low Carbon Hydrogen Fund* - The fund will support the deployment of low carbon hydrogen production capacity and encourage private sector investment.	£90m (~€105m).	Under consultation.
Operational support for hydrogen production	The Netherlands	*Sustainable Energy Transition subsidy (SDE++)* – Subsidy programme to support a transition to low carbon energy sources. Document names hydrogen (from electrolysis) as eligible for subsidy support for the 'operating shortfall' of the technology[1].	€5bn with a subsidy intensity of up to €300/tonne CO_2 avoided for up to 15 years.	First phase of call closed in Dec 20.
Contracts for Difference	Germany	*Carbon Contracts for Difference (CCFD)* – government fixes the price of carbon for a defined period and will subsidise any negative difference between the fixed and market rate.	To be confirmed.	Tenders expected to be launched in late 2021.
Tax exemptions for hydrogen production	The Netherlands	*Tax exemption* - Investments which result in the replacement of fossil fuels by hydrogen (produced via electrolysis) are deductible from the profit before being taxed up to 45.5%.	No set budget.	On-going.

- Critical to the wider adoption of hydrogen support is a **certification scheme** for hydrogen which can validate the origins of its production and its eligibility as a low-carbon or renewable fuel, feedstock or energy storage mechanism. A clear EU standard on hydrogen is also needed to allow a functioning trade market within, and between, member states.
- Work on standardisation is being undertaken as part of the **Certifhy** project and the European Committee for Electrotechnical Standardization is developing standards on Guarantees of Origin.

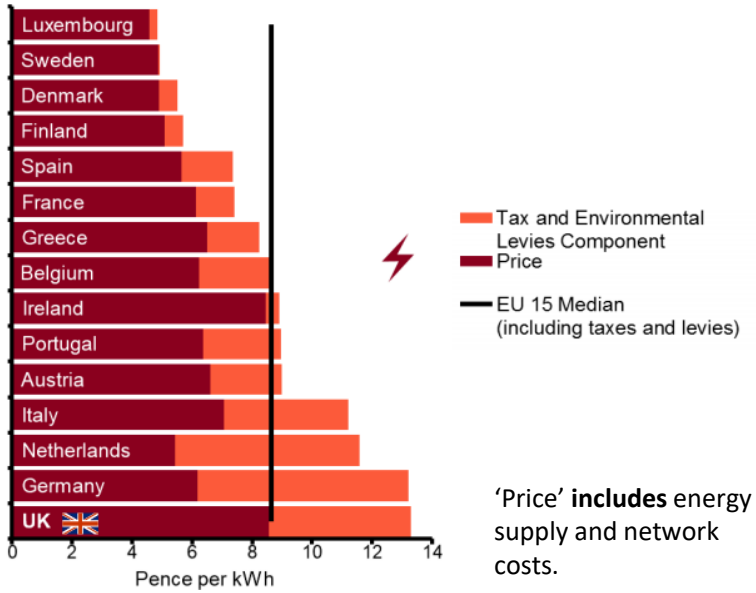
1. Netherlands Enterprise Industry (2020): https://english.rvo.nl/subsidies-programmes/sde/features-sde **2. Netherlands Enterprise Industry (2020)** Stimulation of Sustainable Energy Production and Climate Transition: https://english.rvo.nl/sites/default/files/2020/11/Brochure%20SDE%20plus%20plus%202020.pdf **3. European Commission (2020)**: https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2410

Supporting electricity costs of hydrogen production via electrolysis is also gaining traction across member states

The current state of the market for an electrolyser operator

- When producing hydrogen by electrolysis, access to low cost renewable electricity is vital as **electricity costs make up a large proportion of the final hydrogen production price**.
- Although renewable electricity prices have fallen in recent years, the impact of this on hydrogen price has been limited due to:
  - **Certain Member States mandating metered connection to the grid** – many EU countries mandate that large renewable energy installations (e.g. wind turbines, solar panels) must be connected to the national grid/transmission operator. This means that electrolyser operators are exposed to grid and connection charges which increase the price of electricity.
  - **High grid fees** – grid electricity is exposed to large network fees, grid fees and taxes. The dark brown bars in the graph to the right show the average grid electricity price for industrial consumers (including energy supply and network cost components) across EU15 countries between January and June 2020 before taxies and levies.

Industrial electricity prices via the grid across EU 15 countries



'Price' **includes** energy supply and network costs.

Source: BEIS Quarterly Energy Prices 2020 Quarter 3[1]

Prices are for medium industrial consumers and are declared in GBP. Medium consumers are defined as having an annual consumption of 2,000 - 19,999 MWh per annum.

1. BEIS (2021) Quarterly Energy Prices 2020 Quarter 3 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956490/QEP_Q3_2020_Revision.pdf

Member states are beginning to implement exemptions to electricity market regulations to allow lower cost electricity to be accessed by electrolysers

Examples of production policies in the electricity market (not exhaustive)

Intervention Strategy	Country of implementation	Description	Status
Removal of 'renewables levy' for green hydrogen production	Germany	Producers using renewable energy to generate green hydrogen do not have to pay the renewables levy on the electricity they use. This is expected to amount to a saving of 6.5 cents per kWh in 2021[1].	On-going
Reduction of electricity consumption taxes	Norway	Hydrogen produced via electrolysis is exempt from electricity consumption taxes[2].	On-going
Subsidies for VRE* curtailment and grid balancing	UK	The UK National Grid provides demand response subsidies for electrolysers which could help reduce the electricity cost component of the hydrogen.	On-going
Regulations to allow direct connection of RES supplies to electrolysers	UK, France and others	Market regulations in some countries (e.g. UK, France) allow a direct connection between RES and electrolysers to access low-cost electricity (without grid fees). In Member States where this is not possible, assessments are on-going to change market regulations to allow more flexibility.	On-going

- The value of direct connections is being **recognised by the commercial market** with a number of companies developing directly coupled systems to access low cost electricity and produce renewable hydrogen (e.g. Lhyfe, France; Gigastack, UK). This strategy helps avoid grid charges, provides the renewable energy operator revenues by selling to the grid and requires little funding/intervention from member states.

1. Clean Energy Wire (2020): https://www.cleanenergywire.org/news/germany-paves-way-electrolyser-ramp-scrapping-renewables-fee-hydrogen-production 2. Dolci et al (2019) https://doi.org/10.1016/j.ijhydene.2019.03.045 * VRE: Variable Renewable Energy

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European directives are key drivers of consumption-based incentives but policy makers need to identify and prioritise hydrogen in their national frameworks

Status of consumption incentives

- **European directives and funding are key drivers for the introduction of consumption incentives** across member states, also known as 'demand side' policies. They largely relate to targets set in EU Climate strategies to reduce CO_2 emissions in line with the Paris Agreement.
- In some cases, directives have set targets for hydrogen. For example, in the case of the Alternative Fuels Infrastructure Directive (AFID), Member States have been tasked to deploy hydrogen refuelling stations at 300km intervals on the TEN-T network to develop fuel cell mobility applications. However, this is not yet a mandatory target and thus its impact remains limited. Of the actions that were taken to address this, European Commission funding was required to initiate projects (e.g. H2Nodes, MEHRLIN etc.).
- In most cases, **European directives remain 'solution' agnostic to allow Member States flexibility** on how to implement the targets and distribute funds to the sectors and parties that need them the most.
- Although hydrogen can be integrated into many directives aimed at reducing emissions or transitioning to a green economy, **Member States have to identify and prioritise hydrogen as a solution** for low or zero-carbon feedstock, fuel and/or energy storage. This will require the **introduction of specific policies to support hydrogen** and supportive regulatory systems to allow its large-scale production and use.
- The recent **recast of the Renewable Energy Directive II (RED II) provides a key opportunity for hydrogen to become more engrained in national sustainability targets**. The following slides provide a brief overview of RED II, outlining the key targets and areas where national policy could be devised to support hydrogen.

The recast of the Renewable Energy Directive in 2018 provides a key opportunity for member states to support hydrogen as a transport fuel

Overview of RED II

- The Renewable Energy Directive was originally introduced in 2009 with a 2020 target for 20% of final energy consumption to be from renewable resources, with a sub target of 10% for transport fuels.
- RED II is a 'recast' version with 2030 targets of **32% of final energy consumption** and **14% of transport fuels*** to be from renewable resources.
- The Directive defines a **series of sustainability and GHG emission criteria** that transport 'fuel' must comply with to count towards the overall 14% target and to be eligible for financial support from member states. Some of the key targets and eligibility criteria are outlined below:

RED II 2030 targets for transport fuels

- Member states must require fuel suppliers to supply a **minimum of 14% of transport fuels** from renewable energy sources.
- Contribution of biofuels from food and feed crop feedstocks towards this target to be **capped at 7%, or 1% above a member state's fuel mix in 2020.** If a country's cap is below 7%, they can reduce their overall target from 14% by the same amount.
- **Advanced biofuels and biogas** should be at least 0.2% in 2022, 1% in 2025 and 3.5% in 2030 of final energy consumption in the transport sector.

Transport fuels to be included

- **Biofuels produced from food and feed crops -** 7% cap.
- **Biofuels produced from high indirect land use change risk feedstocks** – capped at 2020 levels and reducing to zero by 2030.
- **Renewable electricity** – min 70% renewable content.
- **Renewable liquid and gaseous transport fuels of non-biological origin** – derived from renewable resources other than biomass (hydrogen included) – min 70% GHG reduction compared to fossil fuels.
- **'Advanced Biofuels'** – made from a list of waste biomass feedstocks. These can be double counted towards meeting RED II targets.

* Road and rail fuels

Three hydrogen production routes are expected to be eligible within RED II but its role in contributing to targets will depend on member states

Hydrogen in RED II

- Hydrogen can be eligible under the current sustainability criteria, but its role will vary across member states as there is freedom within RED II for countries to decide which fuels to support and how to finance them:

"Member States may exempt, or distinguish between, different fuel suppliers and different energy carriers when setting the obligation on the fuel suppliers" – p.44[1]

- Detailed rules and guidance on the eligible production methods (and use of hydrogen) still need to be published (expected mid-2021). National interpretations by member states will be vital in determining the role of hydrogen in future energy systems.
- Based on the current definitions in RED II, three hydrogen production routes could be used to support targets and be deemed eligible for funding support*:

Gas based routes

- Reformation of biomethane would meet the 70% GHG reduction threshold, but may not meet the 'additionality' criteria, as the biomethane could be used directly in a CNG vehicle instead.
- "Advanced" biofuel status depends on the source of the biogas.
- Gas grid can be used to mass balance biogas as the source for the reformer.

Electrolyser routes

- Electrolyser directly connected to a renewable generator.
- **With clarification**, two further electrolysis routes could be possible:
  - Grid-connected electrolyser located to reduce grid congestion from renewables.
  - Grid-connected electrolyser with a special type of PPA ensuring temporal and geographical correlation between production and consumption.

Biomass gasification

- Gasification of conventional biomass could count towards RED II targets, while gasification of waste-based biomass could be considered for "advanced" status.

*Full rules yet to be announced 1. EUR-Lex (2018): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

Hydrogen produced via electrolysis will be expected to meet strict sustainability criteria in order to be named an 'advanced biofuel' under RED II

Renewable hydrogen produced by electrolysis in RED II

- Hydrogen produced via electrolysis using renewable electricity could be considered as an equivalent to 'advanced biofuels' in certain sections of RED II.

"Member States may exempt fuel suppliers supplying fuel in the form of electricity or renewable liquid and gaseous transport fuels of non-biological origin from the requirement to comply with the minimum share of advanced biofuels.. " – p.44[1]

- However, the hydrogen produced will have to meet strict sustainability criteria (in addition to a 70% GHG reduction threshold). Key criteria include:
  - **Additionality** – renewable electricity used to produce hydrogen should be "adding to the renewable deployment or to the financing of renewable energy" (p.15). This also means ensuring that the renewable generating capacity used "comes into operation after, or at the same time as, the installation producing [the hydrogen]" (p.47) [1]
  - **PPAs with renewable generators** – there must be a "temporal and geographical correlation"(p.14) [1] between the electricity generated and that used in the electrolyser.
  - **Congestion** – hydrogen produced by a grid-connected electrolyser only counts as fully renewable when the "electricity generation and the fuel production plants are located on the same side in respect of the congestion" (p.14) [1]

1. EUR-Lex (2018): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

Although many consumption incentives exist to introduce renewable fuels and feedstocks, very limited examples are available for hydrogen

Examples of consumption policy

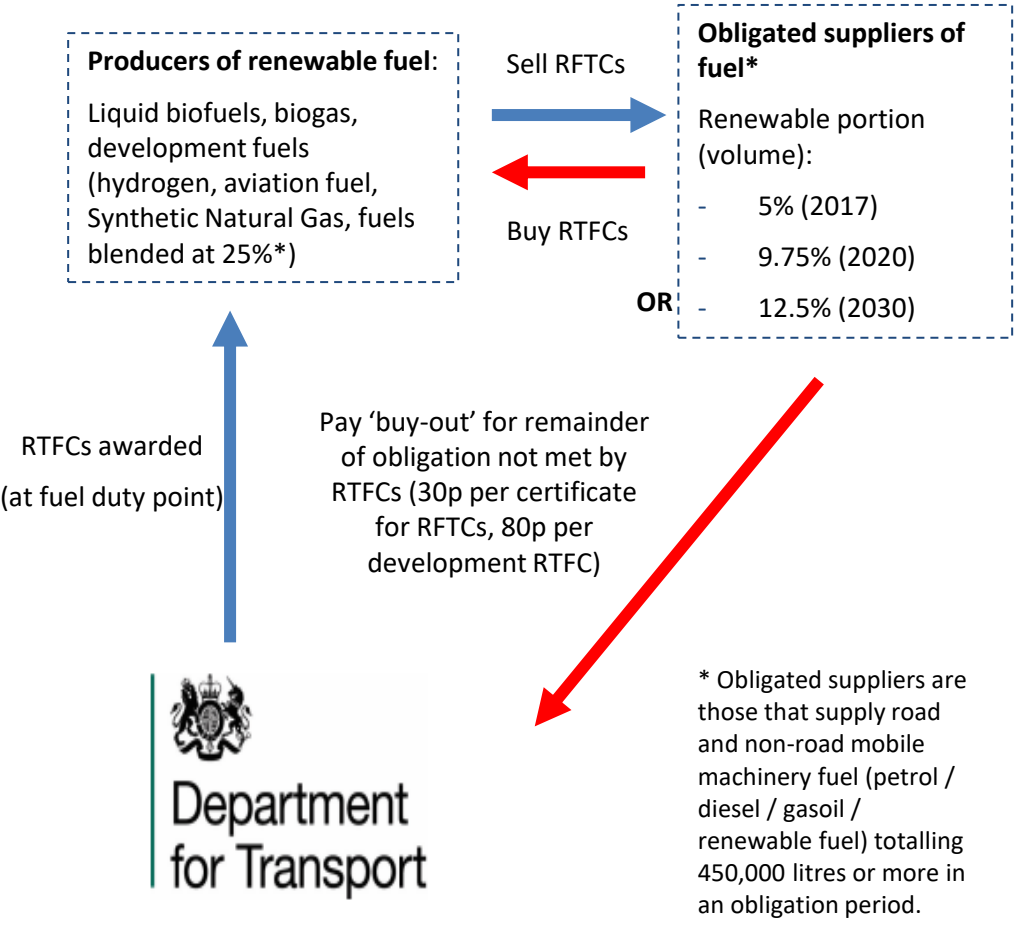
- The table below highlights some of the most prominent examples and their interpretation by member states for hydrogen:

EU Directive	Member State Policy Example	Description of policy
Renewable Energy Directive II (RED II)	UK - Renewable Transport Fuels Obligation (RTFO)	Policy which obliges fuel providers to blend a given share of biofuels into their total fuel sales to meet the UK target of 12% renewable energy in transport by 2030[1]. The system is monitored using Renewable Transport Fuel Certificates (RTFCs). The number of certificates granted to producers is based on the amount of renewable they produce and the type of fuel. Fuels which are less mature, such as hydrogen, are given 'development fuel' status and are assigned more certificates per unit produced. Fuel suppliers must submit RTFCs to comply with the obligation or pay a "buy out" price. This creates a market for RTFCs, which can be traded. More details on the scheme and how it is structured is provided on the following slide.
Emissions Trading Scheme (ETS)	France – 'Contribution Climat-Energie'	EU scheme. Works on a 'cap and trade' system and includes >11,000 power stations and industrial plants across the EU. A cap is set on the total amount of certain greenhouse gases that can be emitted by installations in the system. Companies receive or buy emission allowances which they can trade with one another. After each year, companies must surrender enough allowances to cover all their emissions, or face fines. The carbon price in 2020 varied between €15 to €30 per tonne CO_2 (or equivalent). This can indirectly support the transition of industry to hydrogen, increasing the cost of fossil fuel centric processes. Member States also use at least 50% of ETS revenues to support actions to transition to cleaner technologies.

1. Department for Transport (2019): RTFO Guidance
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/880023/rtfo-guidance-part-1-process-guidance-year-2019-guidance-document.pdf

The Renewable Transport Fuels Obligation in the UK provides a first example of a country interpreting RED II into legislation

Renewable Transport Fuels Obligation



- The diagram shows the key mechanism / financial flows between parties.
- The RTFO has some intricacies to account in calculating certificate values, including:
  - Some particularly beneficial biofuels such as those produced from wastes and residues are assigned two RTFCs per unit fuel, this is known as '**double counting**'.
  - Other biofuels produced from crops are undesirable as they have been shown to lead to land use change which can increase emissions. The proportion of the obligation that can be met using these fuels is therefore **capped using a system called the 'crop cap'.**
  - New advanced biofuels, known as 'development fuels' are supported through the **'development fuels' sub-target** (a proportion of the total target must be met using 'development fuels'). This is tracked using development RTFCs (dRTFCs) and must reach 2.4% of total transport fuel demand by volume by 2030.
- In this instance, renewable hydrogen can be defined as a 'development fuel' if it meets the defined production criteria (e.g. additionality, no connection to grid etc.).

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As EU funding schemes for a green transition and recovery are announced, debate is on-going on how the EU and member states can support hydrogen

Supporting policies for hydrogen

- At present, the business case for low or zero carbon hydrogen production is limited by the low cost of fossil fuels and the current policy and regulatory space which inhibits the commercialisation of the fuel.
- The European Union has announced many **funding schemes for the upcoming period (2021–27)** to support a 'green transition' of the economy and energy systems (see Appendix for upcoming funding schemes). If hydrogen is to play a role in the transition, **member states need to devise policies which can support a long-term business case** for the production, and use, of low- or zero-carbon hydrogen.
- To date, there is **no consensus on how to reform/support the sector** and many policy papers remain vague on how policy can be implemented. Examples/recommendations are provided below:

IRENA – Green Hydrogen: A guide to policy making[1]

Key policy suggestions for the supply chain including:

- **Electrolysis:** Set capacity targets, offer loans, introduce feed-in premiums, allow participation in ancillary markets.
- **Infrastructure:** Collaborate on global trading of hydrogen, identify priorities for conversion, align blending targets, provide financing.
- **Industry:** Offer dedicated loans, develop public procurement of green products, phase-out high emission technologies.

European Commission – A hydrogen strategy for a climate-neutral Europe

Key action points defined by the European Commission:

- Explore additional support measures including **demand-side policies** in end-use sectors building on the Renewable Energy Directive (by June 21).
- Introduce a **common low-carbon threshold** or standard for the promotion of hydrogen production (by June 21).
- Work to introduce a comprehensive terminology and European wide **criteria for the certification** of renewable and low-carbon hydrogen.
- Develop a **pilot scheme for a carbon contracts for difference**, in particular to support the chemical industry.

1. Irena (2020): https://www.irena.org/publications/2020/Nov/Green-hydrogen 2. Hydrogen Europe (2020): https://hydrogeneurope.eu/news/eu-hydrogen-strategy-hydrogen-europes-top-10-key-recommendations * Not exhaustive

Policy research indicates that there are four key business models to consider to support hydrogen production

Defining new legislation/policy support

- Recent research funded by the UK's Department for Business, Energy & Industrial Strategy (BEIS) noted that **four key business models can be considered suitable to support hydrogen production and its end uses.**

- A high-level description of the business models can be found in the table below. The following slides provide examples of policy strategies for each category.

Business model category	High level description
Contractual payments to producers	The hydrogen producer receives a subsidy which covers the incremental cost of low carbon hydrogen above the carbon-intensive alternative fuel.
Regulated returns	Regulated returns model allow the hydrogen producer to earn a regulated return on investment.
Obligations	An obligation is imposed on parties outside the hydrogen production sector (e.g. fuel suppliers and end users) to supply or consume a certain quantity of low carbon hydrogen.
End user subsidies	An on-going technology-neutral subsidy is provided to end users for carbon abatement.

Table from Frontier Economics (2020) 'The Future of Low Carbon Hydrogen Production – Frontier Economics' http://www.frontier-economics.com/uk/en/news-and-articles/news/news-article-i7615-the-future-of-low-carbon-hydrogen-production/

Contractual payments to producers are gaining traction across the EU, with Contracts for Difference frequently cited as a suitable option for policy support

Contractual payments to producers

- The hydrogen producer receives a subsidy which covers the incremental cost of low carbon hydrogen above the carbon-intensive alternative fuel. Example support mechanisms are provided below:

Support mechanism	High-level description	Level of implementation
Contracts for difference	Long term contract with a public counterpart which can provide certainty over the wholesale price of a product (e.g. natural gas price, diesel price, carbon price etc.). The mechanism can also renumerate the investor by subsidizing the difference between an agreed base price and the price available on the market.	EU and/or national. *Example*: ETS Innovation Fund Pilot programme launched in Germany and SDE++ scheme in Netherlands (see slide).
Direct tax revenue support: Grant or incentive	Premium or grant paid to the producer funded from tax revenues. This aims to reduce the cost premium of the technology both in terms of capital and operational expenditure.	National. *Example*: SDE++ in the Netherlands (see slide).
Market reform to provide payments for sector integration	Create a market which rewards electrolysers for the services they provide to the energy system (e.g. flexibility services, augmenting renewable production levels, reducing burden from renewable incentives)	National. *Example*: UK National Grid (see slide).

- Contractual payments are expected to be a good option for support as they can provide sufficient **certainty to producers** to invest in the technology without increasing the price premium for customers. The model also comes at a **limited cost** to governments and tax payers and can be **supported through existing schemes** such as the ETS.

Regulated returns have also been deemed as an attractive policy option, with analogous examples found in large scale energy investment projects

Regulated returns

- A regulated returns model allows the hydrogen producer to earn a regulated return on costs which is decided upon by regulatory/governmental bodies. There are three key types of ex-ante price controls: **price caps, revenue caps and rate of return regulation.**

- Some key policy mechanisms are outlined below:

Support mechanism	High-level description	Level of implementation
Carbon Price Floor	Set a minimum price for the cost of carbon to accelerate an industrial transition.	EU and/or national
Carbon Border Adjustment	Tax imports based on their carbon footprint. This aims to limit emissions leakage and level the playing field for domestic industries that produce goods with lower green house gas emissions.	EU
Regulated asset base	Provides a secure payback from public entities and a return on investment for investors from sales. Investor receives a license from an economic regulator which grants it the right to charge a regulated price to users in exchange for **provision of infrastructure.**	National

- This business model provides an opportunity for regulatory bodies/governments to play a role in defining the market. However, this is expected to be more complex than contractual payments and will likely provide less certainty to investors due to the way regulated return models are usually administered (e.g. through license agreements).

Obligations are mandatory targets set by the EU or member states – they can provide significant incentives for transition to low- or zero-carbon H_2

Obligations

- An obligation is imposed on parties outside the hydrogen production sector (e.g. fuel suppliers and end users) to supply or consume a certain quantity of low carbon hydrogen.

Support mechanism	High-level description	Level of implementation
Minimum obligations	Set a minimum share or quota for renewable hydrogen or its derivative in specific end-use sectors allowing demand to be driven in a targeted way. This could be easily included in RED II or farm-to-fork strategy going forward.	EU and/or National. *Example*: RTFO in the UK (see slide).
Public procurement of low carbon hydrogen	Member state runs an auction process for the supply of low carbon gas or product (e.g. ammonia, fuel etc.). The winning producer receives a payment for each unit of low carbon hydrogen produced.	National. *Example*: 'H2Global' to support electrolyser projects abroad and import hydrogen for domestic use[1].
Low carbon market creation	Create market demand for low carbon products either through standardised certification or regulation of end products.	EU and/or National. *Example*: CertifHy scheme.
Phase out carbon intensive industries	Set stricter regulations on carbon intensive industries by implementing strict taxes on their operations.	EU and/or National.

- Although obligations provide an important incentive to government and industry to transition to low or zero carbon hydrogen it is expected that for a large scale transition **additional support mechanisms, principally funding support, will be required** to make obligations achievable.

1. H2 Global project (2021): https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/031721-germany-launches-h2global-system-to-galvanize-green-hydrogen-imports

End user subsidies are expected to play a role in the longer term future, when hydrogen products become more commonplace

End User Subsidies

- An on-going technology-neutral subsidy is provided to end users for carbon abatement.

Support mechanism	High-level description	Level of implementation
Product taxes based on CO_2 intensity	Product CO_2 taxes based at point of sale on the carbon intensity (tCO_2/t product) relative to a product benchmark.	EU and/or National.
Grant support for adoption of hydrogen equipment	Grant support provided to end users to increase the demand of hydrogen (e.g. subsidy to support the cost premium of fuel cell technologies).	EU and/or National.

- The impact and effectiveness of end user subsidies are expected to be **limited in their support to scale up hydrogen production** as they cannot provide a significant and reliable signal to the market to transition to low or zero carbon production methods.
- It is expected that in the near-term **focus should centre on supporting industry to develop their production capacities** and reaching a scale at which the product sale to the end user is as cost effective as possible.
- However, it is important that demand-side subsidies are developed when hydrogen becomes more commonplace (e.g. as a transport fuel) on the market to ensure that all barriers to commercialisation are addressed.

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To support the wide-spread uptake of low- or zero-carbon hydrogen clear policies need to be introduced on an EU and member state scale

Conclusion

- Today there is **limited direct support for hydrogen** within the EU or member state landscape. The majority of applicable tools relate to increasing the role of renewable energy in the energy mix and decreasing emissions from the most carbon-intensive industries.
- Efforts to increase the production of low or zero-carbon hydrogen in recent years have focussed on **research and deployment projects** which have been vital in facilitating technological developments and price reductions. However, their impact on improving the commercial mass-market offer for hydrogen production has been limited as projects have been small scale and unable to create a viable business case based on only capital support.
- Conscious of the need to reduce emissions in line with the Paris Agreement the European Union is becoming focussed on increasing the role of low or zero-carbon hydrogen into the market's energy mix. This has led to a **plethora of directives in which hydrogen could be deemed eligible** and work is on-going to **expand the scope of financial incentives** granted to hydrogen production, and use, through the Green Deal.
- In order for the directives and funding to be effective, **member states need to take action and integrate hydrogen into their national policy frameworks**. This will require careful revisions of legislation and tailored support for industry. Action has already been taken in **Germany and the Netherlands** with schemes introduced to reduce the production cost of hydrogen via first-of-a-kind operational subsidies and the reduction of taxation and consumption duties on green electricity supplied to electrolysers.
- There are **many different ways national governments can provide subsidies** and unfortunately there is not one defined option which can be recommended for Europe-wide implementation. However, it is expected that **contractual payments to producers will play a role in the near-future** to accelerate low or zero carbon production and to get to the scale required to achieve cost reductions. This is starting to be demonstrated in a pilot '**Carbon Contracts for Difference**' project in Germany supported by the Innovation Fund.

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Three key schemes are available today which clearly reference, or target, support for hydrogen

Active funding streams

Intervention Name	Description	Example projects
H2020 Research and Innovation programme (Fuel Cells and Hydrogen Joint Undertaking)	EU funding body which received ~€80bn funding between 2014 to 2020. A proportion of funding was dedicated to the hydrogen and fuel cell sector and has been distributed (via FCH2 JU) across a variety of sectors and includes R&D and deployment support. Funding support focusses on reducing the capital cost of hydrogen equipment.	*REFHYNE* -10MW electrolyser in Germany *H2ME* – deployment of up to 1,400 cars and 49 hydrogen refuelling stations
CEF Blending Facility	Cooperation framework between the European Commission and implementing partners to support blending operations (i.e. combining grants with partner financing via loan, debt, equity or any other repayable form of support). Hydrogen funding has been as part of CEF Transport (€298m budget supported by Cohesion fund) and focusses on alternative fuels for transport and their supporting infrastructure.	*H2Nodes* – deployment of HRS network along the North Sea-Baltic corridor. *H2Bus Europe* – deploy 600 fuel cell buses across the UK, Latvia and Denmark
Innovation Fund (2020-2030)	Focus on innovative low-carbon technologies, renewable energy generation and carbon capture processes. Hydrogen is eligible for funding support of up to 60% of the additional CAPEX and OPEX linked to large-scale projects and up to 60% of the capital cost of small-scale projects. ~€10billion is available between 2020-2030.	Active. First call for large-scale projects closed Oct 20 (projects tbc). Small-scale project call on-going (deadline 10th March 2021).
Clean Hydrogen Partnership	Part of the European Commission plan to launch 10 new European Partnerships to invest €10billion into the green and digital transition. The Clean Hydrogen Partnership is one workstream and will build on the work of the FCH JU to accelerate the development and deployment of a European value chain for clean hydrogen.	No projects to date. Partnership expected to be approved in October 2021.

There are many funds which low or zero-emission carbon can access should member states recognise and prioritise hydrogen

Funds where hydrogen can play a role

Intervention Name	Description	EU budget	Status
Modernisation Fund (2021-2030)	Programme to support 10 EU Member States (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia) in their transition to climate neutrality by helping to modernise energy systems and improve energy efficiency. The fund is the responsibility of the member state who will submit investment proposals to the European Investment Bank and decide the form of support (e.g. grants, premium, loans or capital injections etc). Can be used in conjunction with other funds.	~€14bn between 2021-30. Budget is highly dependent on carbon price and contribution from Member States	Active. Member states sent investment plans to EC in January 2021.
Invest EU (2021-2027)	5 dedicated 'windows' for policy development including sustainable infrastructure and strategic investment. Funding will be used to mobilise public and private investment via grants and government backed loans. Investment aims to trigger €650bn in additional investment.	~€75bn with ~68% dedicated to areas where hydrogen could play a role.	Pending. Scope, priority areas and governance not fully defined

There are many funds which low or zero-emission carbon can access should member states recognise and prioritise hydrogen

Funds where hydrogen can play a role

Intervention Name	Description	EU budget	Status
Just Transition	Part of €1 trillion European Green Deal to support a fair transition to climate neutrality across European member states.	€40bn	Active 2021-2027
EU Regional Development Fund	Promotes balanced development in the different regions of the EU. Implemented across different sectors but includes minimum investment targets for 'low-carbon economy' projects. Fund managed by member states in a partnership agreement with the European Commission.	Combined €234 billion for regional development and cohesion fund	Active 2021-27
Cohesion Fund	Funds transport and environment projects in countries where the gross national income (GNI) per inhabitant is <90% of the EU average. In 2014-20 this included Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. Fund managed by member states in a partnership with the European Commission.		
Recovery and resiliency facility	Tool designed to help countries tackle the effects of COVID-19. Plans would be eligible for funding if they are consistent with the 6 EU priotities (including 'green transition',) with an aim to spend at least 37% of budget to climate and biodiversity.	€672.5bn in grants and loans for 4 years	In place from 1st Feb 20

There are many funds which low or zero-emission carbon can access should member states recognise and prioritise hydrogen

Funds where hydrogen can play a role

Intervention Name	Description	EU budget	Status
EU Renewable Energy Financing Mechanism	Mechanism designed to facilitate the roll-out of renewables across the EU, allowing member states to invest in projects in areas (countries) that have greater access to natural resources or are better suited for it in terms of geography. This 'collective approach' aims to allow countries to work together to reach the EU target of 32% renewable energy share by 2030. The mechanism links countries that voluntarily pay into the mechanism (contributing countries) with countries that agree to have new projects built on their soil (hosting countries). Countries will share the 'statistical benefit' of the produced energy and can include a share of it in their own renewable energy target[1]. The full scope of the financing is still to be determined but it is expected that electrolysis directly coupled with new renewable energy sources could be eligible for support.	Variable. Depends on member contribution.	On-going

1) European Commission (2020) EU renewable energy financing mechanism: https://ec.europa.eu/energy/topics/renewable-energy/eu-renewable-energy-financing-mechanism_en

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