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# POLICY BRIEF

*Low-Carbon Hydrogen: key elements for a  
common-sense approach*

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## 1. Context

The goal of this paper is to analyze and suggest key elements for a more inclusive low-carbon hydrogen regulatory framework, including an effective and comprehensive definition of low-carbon hydrogen that will support the development of the EU hydrogen market and make the EU competitive from the point of view of hydrogen technologies.

This paper includes key insights gathered from an expert focus group and a stakeholder consultation that involved (and was not limited to) industry, industry associations, NGOs, policy experts. This paper will also analyse and compare the EU and UK approach to low-carbon hydrogen. Additionally, an overview of the US approach will be provided.

## 2. Introduction to Low-Carbon Hydrogen

Low-carbon hydrogen can be produced through various pathways, such as steam methane reforming (SMR) or autothermal reforming (ATR) with carbon capture technologies (CCS), pyrolysis, and electrolysis. Low-carbon hydrogen emits significantly less CO<sub>2</sub> compared to unabated hydrogen, and its better environmental performance makes it a key contributor to industrial decarbonization. Additionally, low-carbon hydrogen is today a more cost-competitive option compared to renewable hydrogen, offering a valuable opportunity for decarbonizing hard-to-abate sectors like steel and ammonia production, where low-carbon hydrogen can play a crucial role in reducing emissions.

In order to ramp up the hydrogen market, a solid business model needs to be developed.

Effective regulation, harmonized standards, clear definitions, and certification schemes can contribute to drive market growth. A comprehensive and stable regulatory framework is also essential for attracting investments and imports that will enable to scale up the production and achieve the quantities of hydrogen needed for industrial decarbonization.

## 3. Key elements for a common-sense approach

In this paper, the EU and UK approaches to low-carbon hydrogen will be analyzed through these key elements:

- **Legislative Framework:** This involves examining the most relevant regulations containing provisions and targets for low-carbon hydrogen. The legislative framework should ideally facilitate the transition to low-carbon hydrogen and aim to create a stable, predictable environment for stakeholders and investors.
- **Definition<sup>1</sup>:** Establishing a clear definition of low-carbon hydrogen is essential, as it ensures a clear identification of what low-carbon hydrogen is. The definition should include specific criteria for greenhouse gas (GHG) emissions accounting, define lifecycle/system boundaries, accounting of emissions from different types of inputs, feedstocks, energy sources and pathways. Additionally, the definition should be tailored to align with the practical realities faced by market players and the overarching challenge of establishing a robust business model.
- **Monitoring, Reporting, and Verification (MRV):** Transparent and accurate Monitoring, Reporting and Verification of emissions data is needed to ensure compliance with the regulation and reliability of data as well as ensuring that projects can deliver climate benefits.

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<sup>1</sup> In this paper, by ‘definition,’ we refer both to the definition itself (Article 9.5 of the Hydrogen and Gas Package Directive) and to the methodology for GHG emissions accounting (upcoming Delegated Act).

Monitoring involves collecting data on emissions at different stages of hydrogen's lifecycle. Data should be submitted to relevant third parties, national or EU authorities in charge of data collection. Reporting of these data ensures transparency for stakeholders, regulators and the public. Verification ensures accuracy, supports accountability and credibility of low-carbon hydrogen carbon footprint.

- **Financial Incentives:** Financial incentives can take the form of grants, tax incentives, guarantees, contracts for difference, long-term agreements such as feed-in tariffs or power purchase agreements. State Aid can be used by governments to lower investment risk, make certain technologies more competitive, and support policy goals like decarbonization. Financial incentives are particularly relevant for low-carbon hydrogen as they can help bridge the cost gap between traditional, carbon-intensive hydrogen production and low-carbon alternatives. By reducing upfront and operational costs, financing incentives can make low-carbon hydrogen projects more financially attractive, fostering market ramp up and technologies deployment.
- **Business Model:** For low-carbon hydrogen to be commercially viable, establishing a business model is essential. Currently, low-carbon hydrogen is cheaper than green hydrogen but more costly than the fossil fuels it aims to replace. Low-carbon hydrogen has therefore to compete with both existing fossil fuels and alternative decarbonization solutions. Low-carbon hydrogen will be prioritized where it is the most cost-effective option. A solid business model is key for reaching decisions on investments and long-term planning. The regulator plays a critical role in creating the conditions that make this possible, particularly through clear definitions, robust monitoring, reporting, and verification (MRV) systems, as well as by allowing and providing financial incentives. An integrated approach that addresses both supply and demand is needed to create a business model that is profitable and sustainable in the long-term. Additionally, the business model provides the foundation for scaling up low-carbon hydrogen production, advancing hydrogen technologies, and reducing hydrogen costs. The private sector leverages the regulatory framework and plays a key role in market development by driving innovation, making investments, scaling production, and deploying infrastructure.

## 4. EUROPEAN UNION (EU)

### 4.1 Legislative framework

Currently, the European Climate Law has set a legally binding objective of achieving climate neutrality by 2050. The EU hydrogen strategy (COM/2020/301), published in July 2020, highlighted the importance of both renewable and low-carbon hydrogen in delivering emissions reductions. According to the roadmap suggested by the EU hydrogen strategy, the hydrogen that will be prioritized in the long-term is the renewable one, while low-carbon hydrogen can play a significant key role in the short-term, during the market ramp-up phase. Low-carbon hydrogen can help advance both the hydrogen market and the development of hydrogen technologies. Additionally, it can contribute to delivering the affordable quantities of hydrogen that the industry requires in the short term.

The most relevant piece of legislation when it comes to low-carbon hydrogen is the **Hydrogen and decarbonized gas market Package**<sup>2</sup> and the upcoming **Delegated Act** that will specify the methodology for assessing greenhouse gas (GHG) emissions savings from low-carbon fuels.

The Hydrogen and decarbonized gas market Package was officially approved in May 2024, and it entered into force in August. The package is composed by a Directive (EU) 2024/1788<sup>3</sup> ‘Common rules for the internal markets for renewable gas, natural gas and hydrogen’ (also called Gas directive) and a Regulation (EU) 2024/1789<sup>4</sup> on ‘the internal markets for renewable gas, natural gas and hydrogen’ (also called Gas regulation).

The goal of the package is enabling the market to decarbonize gas consumption, ensuring energy security, as well as improving market and infrastructure access for renewable and low-carbon gases and hydrogen and ensuring a more integrated network planning among electricity, gas, and hydrogen networks. Moreover, it aims to introduce a certification system for low-carbon gases, including hydrogen, which complements the certification of renewable gases and hydrogen (RFNBOs) which has been established by the Renewable Energy Directive (RED II) Delegated Acts<sup>5</sup>.

According to Article 2 of the gas Directive ‘*low-carbon hydrogen*’ means hydrogen the energy content of which is derived from non-renewable sources, which meets the greenhouse gas emission reduction threshold of 70 % compared to the fossil fuel comparator for renewable fuels of non-biological origin set out in the methodology for assessing greenhouse gas emissions savings from renewable fuels of non-biological origin and from recycled carbon fuels, adopted pursuant to Article 29a(3) of Directive (EU) 2018/2001<sup>6</sup>.

A detailed methodology for assessing greenhouse gas (GHG) emissions savings from low-carbon hydrogen is key to having a complete definition of what low-carbon hydrogen is. According to Article 9 of the Gas Directive the EU Commission has one year<sup>7</sup> to develop and

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<sup>2</sup> [https://energy.ec.europa.eu/topics/markets-and-consumers/hydrogen-and-decarbonised-gas-market\\_en#:~:text=European%20Green%20Deal,-The%20hydrogen%20and%20gas%20decarbonisation%20package,into%20force%2020%20days%20later.](https://energy.ec.europa.eu/topics/markets-and-consumers/hydrogen-and-decarbonised-gas-market_en#:~:text=European%20Green%20Deal,-The%20hydrogen%20and%20gas%20decarbonisation%20package,into%20force%2020%20days%20later.)

<sup>3</sup> [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L\\_202401788](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401788)

<sup>4</sup> [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L\\_202401789](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401789)

<sup>5</sup> Delegated Act 2023/1185 ‘establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels’ and Delegated Act 2023/1184 ‘establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin’

<sup>6</sup> [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L\\_202401788](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401788)

<sup>7</sup> By August 2025

adopt a Delegated Act specifying the methodology for assessing greenhouse gas (GHG) emissions savings from low-carbon fuels.

On 27<sup>th</sup> September the EU Commission launched a public consultation to gather feedback on the Delegated Act draft.

## 4.2 Definition

The Delegated Act on low-carbon fuels, for which low-carbon hydrogen is the key component, should provide a clear definition of what low-carbon hydrogen is and how emissions can be accounted.

When it comes to the methodology for assessing GHG emissions savings from low-carbon hydrogen the EU Commission is not working in a legal vacuum as a methodology and framework for RFNBOs and recycled carbon fuels (RCF) has already been approved under the RED II. To ensure consistency with the existing rules, the certification for low-carbon hydrogen will take the RFNBOs certification system into account and implement it for low carbon fuels.

The following paragraphs will discuss key elements for the low-carbon hydrogen definition.

### 4.2.1 EU Full Lifecycle Assessment (LCA)

The EU adopts a ‘well to wheel’ approach when calculating hydrogen GHG emissions. Therefore, the emissions of the whole value chain are taken into account. Important emissions come from the extraction of the inputs. When natural gas is the input, upstream GHG emissions represent significant emissions. The Delegated Act includes emissions both from rigid and elastic inputs. Additional emissions that need to be considered in the calculation come from the processing/pathway chosen to produce low-carbon hydrogen, including waste treatment and leakages. The EU’s Full Lifecycle Assessment includes the CO<sub>2</sub> emissions generated from the transport of the fuel from the production plant to the end consumer (emissions from transport and distribution). Regarding hydrogen transport, in most cases hydrogen needs to be compressed to be transported, and this is an energy intensive process. The reconversion process from liquid hydrogen to gaseous causes emissions too. The inclusion of transport emissions is particularly relevant when it comes to ensuring a level playing field between imported and domestic low-carbon hydrogen. Importing (cheaper) low-carbon hydrogen from distant locations may result in greater CO<sub>2</sub> emissions compared to EU-produced low-carbon hydrogen. Emissions from the manufacture of machinery and equipment shall not be taken into account.

As mentioned above, low-carbon hydrogen should meet the greenhouse gas emission reduction threshold of 70 % compared to the fossil fuel comparator. Regarding the reference for calculating the 70% emission threshold, the RED II RFNBO Delegated Acts foresee a GHG reference of 94 gCO<sub>2</sub>/MJ<sup>8</sup>. This value is also mentioned in the EU Taxonomy<sup>9 10</sup>. Keeping this reference will ensure consistency among regulations. With a Full Lifecycle Assessment (LCA) the Delegated act defines low-carbon hydrogen at the consumer stage.

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<sup>8</sup> The reference of 94 gCO<sub>2</sub>eq/MJ is the baseline or "comparator" representing the greenhouse gas emission intensity of fossil fuels. RFNBOs and RCFs must emit no more than 30% of what fossil fuels emit to be considered compliant with the defined emission standards (i.e. 28.2 gCO<sub>2</sub>eq/MJ which means 3.4 kgCO<sub>2</sub>eq/kgH<sub>2</sub>)

<sup>9</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02021R2139-20240101>

<sup>10</sup> However, this is a conventional value that was established before any clarification on the LCA methodology.

### 4.2.2 Technologies

The definition of low-carbon hydrogen will identify which technologies can be suitable for low-carbon hydrogen production and set parameters/benchmarks for each technology.

**Carbon Capture and Storage (CCS)** technologies can help avoiding substantial amounts of carbon continue to be released into the atmosphere when hydrogen is produced. The inclusion of an obligation to measure the CCS rate based on actual CO<sub>2</sub> captured and sequestered will ensure climate benefits. Moreover, only hydrogen produced from facilities that can abate enough CO<sub>2</sub> to meet the GHG reduction threshold should be classified as low carbon.

According to a recent study<sup>11</sup>, by 2030, low-carbon hydrogen produced in the EU by SMR with CCS will be significantly cheaper than RFNBOs hydrogen. To scale up the market and meet the 2030 targets, cost efficiency is crucial<sup>12</sup>. Indeed, the efficiency of SMR with CCS depends on the capture rate and the energy penalty associated with the capture process. Advanced solvents and sorbents can improve the efficiency of CO<sub>2</sub> capture. Additionally, integrating CCS with Autothermal Reforming (ATR) can provide higher efficiencies and lower emissions due to better heat integration and higher hydrogen yields. Without additional support, the cost of RFNBOs hydrogen is expected to remain higher than low-carbon hydrogen by 2030. Therefore, low-carbon hydrogen (when CCS enables emissions to be reduced to meet the 70% emission reduction threshold) could serve as a complementary solution helping to fast-track industrial decarbonisation<sup>13</sup>.

Alongside CCS, the methodology should specify emissions accounting for Carbon Capture and Utilisation (CCU) as well as clarify whether other carbon management solutions can be suitable for low-carbon hydrogen production. Clear requirements for CCS operations for producers outside the EU are also needed from the onset of publication of the Delegated Act.

When it comes to the storage of CO<sub>2</sub>, it is important to ensure that the storage of CO<sub>2</sub> is long-lasting, stable and secure and in line with the existing regulations for CO<sub>2</sub> storage (such as the Directive 2009/31/EC on the Geological Storage of CO<sub>2</sub>). Operation activities for carbon capture, transport of CO<sub>2</sub> and emissions from injection into the permanent storage site can produce emissions which need to be taken into account.

Additionally, the methodology should clarify the status for **nuclear** technologies in low-carbon hydrogen production and as well as which other possible low-carbon technologies can be qualified as eligible for low-carbon hydrogen production. Recognizing the role of nuclear energy as a low-carbon electricity source is instrumental to achieving technology neutrality. Furthermore, allowing hydrogen production via electrolysis using nuclear power can significantly contribute to the decarbonization goals.

Regarding the accounting of emissions from different inputs and technologies, the Delegated Act on low-carbon hydrogen set some default values which can be found in the Annex<sup>14</sup>.

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<sup>11</sup> <https://rebooteurope.eu/energy-climate-transition-how-to-strengthen-eu-competitiveness/>

<sup>12</sup> For RFNBO H<sub>2</sub> to reach cost parity with low-carbon hydrogen would require a 60% reduction in electrolyser capital expenditure (CAPEX) or electricity prices around €30/MWh. The EU Commission estimates a 12% reduction in electrolyser CAPEX between 2030 and 2040, and the IEA's World Energy Outlook 2023 ([link](#)) forecasts a levelized cost of electricity (LCOE) of €32/MWh for offshore wind in the NZE 2030 scenario ([link](#))

<sup>13</sup> <https://rebooteurope.eu/energy-climate-transition-how-to-strengthen-eu-competitiveness/>

<sup>14</sup> [https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14303-Methodology-to-determine-the-greenhouse-gas-GHG-emission-savings-of-low-carbon-fuels\\_en](https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14303-Methodology-to-determine-the-greenhouse-gas-GHG-emission-savings-of-low-carbon-fuels_en) (EC public consultation link)

However, the default values should be representative of the actual emissions and take into account the technological progress made for each technology.

For example, the nuclear fuel upstream emission factor per MJ of fuel on a net calorific value does not reflect advancements made in various stages of nuclear energy production, particularly at the extraction stage<sup>15</sup> (the main source of emissions in the upstream factor) and at the uranium enrichment stage<sup>16</sup>. These improvements have reduced CO<sub>2</sub> emissions. Studies, such as those from the French Alternative Energies and Atomic Energy Commission, indicate that the actual value is lower than the one stated in the Delegated Act. While the DA assigns an emission factor of 1.2 gCO<sub>2</sub>eq/MJ, these studies suggest it should be closer to 0.2<sup>17</sup> 18 or 0.3<sup>19</sup> gCO<sub>2</sub>eq/MJ, indicating that the carbon content is overstated in the DA.

Therefore, opening up to the possibility of accounting emissions according to project specific values will reward the progress made in each technology.

When it comes to low-carbon hydrogen produced from natural gas, upstream emissions can be significant depending on the sourcing methods and location. Allowing for project-specific emissions calculations can incentivize low-carbon hydrogen producers to source their natural gas from suppliers who can certify a low a greenhouse gas (GHG) footprint.

When it comes to **methane** emissions, the Delegated Act refers to the upcoming Methane Regulation. Before the adoption of this Regulation (planned for 2027) a default value is to be applied<sup>20</sup>.

For the **electricity** input, the Delegated Act mentions that electricity qualifying as fully renewable in accordance with Article 27(6), second subparagraph of Directive (EU) 2018/2001 is considered to count as zero GHG emissions. The electricity that cannot qualify as fully renewable can adopt one of the three alternative methods proposed by the Delegated Act:

- a) Default grid values
- b) GHG emissions values attributed on the basis of full load hours of the installation producing low-carbon fuels; if these hours are equal to or less than the hours when the marginal electricity price was set by renewable or nuclear sources in the previous year with reliable data, grid electricity in the production process is assigned an emissions value of 0 g CO<sub>2</sub>eq/MJ, but if this threshold is exceeded, the emissions value is set at 183 g CO<sub>2</sub>eq/MJ.
- c) GHG emissions value of the marginal electricity generating unit at the time of production (if the national transmission system operator has publicly provided this information)

Offering these three options will support low-carbon hydrogen producers by allowing them to select the method best suited to the specific characteristics of the country in which they operate and the nature of their investment project.

According to Article 3 of the draft Delegated Act the EU Commission will assess, by 1 July

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<sup>15</sup> In uranium extraction a new technique called "in situ leaching" (ISL), which consumes less diesel than open-pit and underground mining is more and more used according to the IAEA's Red Book ([link](#)).

<sup>16</sup> The ultracentrifuge gas process is now used for nearly all uranium enrichment globally, offering up to 50 times greater energy efficiency compared to the older gaseous diffusion process ([link](#)).

<sup>17</sup> <https://www.sciencedirect.com/science/article/pii/S0360544214002035>

<sup>18</sup> <https://www.edf.fr/groupe-edf/produire-une-energie-respectueuse-du-climat/lenergie-nucleaire/notre-vision/analyse-cycle-de-vie-du-kwh-nucleaire-dedf>

<sup>19</sup> [https://unece.org/sites/default/files/2022-04/LCA\\_3\\_FINAL%20March%202022.pdf](https://unece.org/sites/default/files/2022-04/LCA_3_FINAL%20March%202022.pdf)

<sup>20</sup> Where no methane intensity value is available, the Delegated act establishes an interim solution of applying a 40% increase on the relevant value for the upstream methane emissions per unit of fuel

2028, the impact of introducing alternative pathways for sourcing low-carbon electricity, particularly from nuclear power plants. The possibility of using a nuclear PPAs is therefore restricted until 2028. This brings market uncertainty as investors won't be provided with the necessary market visibility and to make investments today. PPAs will be deepened in section 4.5 *Financial incentives*.

| Draft DA                              | Technologies  |        |     |      |                   |
|---------------------------------------|---------------|--------|-----|------|-------------------|
|                                       | Electrolysers |        | SMR |      | Methane Pyrolysis |
|                                       | Nuclear       | Others | CCS | CCUS | CCS               |
| <b>Method</b>                         |               |        |     |      |                   |
| Full life cycle/Fossil fuel reference | X             | X      | X   | X    | X                 |
| Rigid/elastic inputs                  | X             |        | X   | X    | X                 |
| <b>Fossil fuels inputs</b>            |               |        |     |      |                   |
| Methane emissions                     |               |        | X   | X    | X                 |
| CCS emissions accounting              |               |        | X   |      | X                 |
| CCUS emissions accounting             |               |        |     | X    |                   |
| <b>Electricity Input</b>              |               |        |     |      |                   |
| Grid options                          | X             | X      | *   | *    | *                 |
| Temporal criteria                     |               | X      |     |      |                   |
| Long term contract - PPA              | No - 2028     | X      |     |      |                   |
| Default value                         | X             | X      |     |      |                   |

*Table 1 Low-carbon Hydrogen draft DA: Critical Impacts on Technologies*

Source: ERCST Analysis

\* = The electricity input is relevant for these technologies, but its impact is more significant on the electrolyzer technology

### 4.3 Monitoring, Reporting and Verification (MRV)

Having a low-carbon hydrogen clear definition and GHG accounting methodology will make MRV easier.

In the EU, a monitoring, reporting and verification system of emission data is done under the compliance cycle of the EU ETS<sup>21</sup>. Currently, it includes emissions from

- Scope 1 (Direct Emissions) eg. combustion of fossil fuels, process emissions, fugitive emissions.
- Scope 2 emissions (Indirect Energy-Related Emissions) eg. Emissions from the consumed electricity, heat, steam used by the company

To cover the full LCA mentioned in the Low-carbon hydrogen Delegated Act, the MRV should be enhanced to (partially) include

<sup>21</sup> [https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/monitoring-reporting-and-verification-eu-ets-emissions\\_en](https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/monitoring-reporting-and-verification-eu-ets-emissions_en)

- Scope 3 emissions (upstream or downstream additional emissions) eg. Emissions from transport of the good/fuel

The identification of who is in charge of this MRV is a key aspect to ensure market transparency as well as assessing the possibility of creating the link to existing databases such as the RED Union Database. In the EU, MRV happens annually. Operators of installations covered by EU ETS have to annually monitor and report their GHGs emissions and send them to their national competent authority. MRV ensure an harmonized approach being implemented across Member States.

For hydrogen producers, a well-defined MRV framework provides a clear, standardized methodology for tracking and reporting greenhouse gas emissions and is key to demonstrating compliance with EU regulations.

The MRV system should ensure that all hydrogen - adheres to the same climate standards. Outside the EU, CBAM should mirror EU ETS MRV. A clear and accessible EU MRV framework can provide guidance to foreign producers who wish to export hydrogen to the EU, offering transparency and predictability regarding compliance expectations. Such clarity enables exporters to align their production and reporting standards with EU regulations, promoting smoother cross-border trade and reducing administrative barriers. This consistency will enable equitable competition and ensure a level playing field between EU-produced and imported hydrogen.

#### 4.4 Financial incentives and State Aid

Financial mechanisms for low-carbon hydrogen are scattered among different national and EU financing instruments.

The **Innovation Fund (IF)**<sup>22</sup> supports the development and deployment of innovative low-carbon technologies that are crucial for achieving the EU's climate and competitiveness goals. The funding comes from the auctioning of EU ETS allowances<sup>23</sup> and is designed to support projects that contribute significantly to reducing greenhouse gas emissions across all energy-intensive industries listed in Annex I of the EU ETS Directive, along with initiatives in renewable energy, energy storage, carbon capture and storage (CCS), and carbon capture and utilization (CCU)<sup>24</sup>. The inclusion of CCS and CCU projects in the scope of IF financing indicates that this fund indirectly supports low-carbon hydrogen.

The Innovation Fund can cover up to 60% of the relevant costs of projects. For large-scale projects (with CAPEX exceeding EUR 7.5 million), the eligible costs include the additional capital and operational expenses associated with the innovation for the 10 years following the project's start of operations. For small-scale projects (with CAPEX below EUR 7.5 million), the eligible costs are considered to be the project's capital expenditures.

The most recent hydrogen funding mechanism under the IF, the Hydrogen Bank, is instead supporting green hydrogen projects only. So far<sup>25</sup>, low-carbon hydrogen is not eligible in the bidding process<sup>26</sup>.

**Important Projects of Common European Interest (IPCEI)** back large-scale, cross-border

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<sup>22</sup> Established by Directive 2003/87/EC

<sup>23</sup> Article 10a(8) of the EU ETS Directive 2003/87/EC

<sup>24</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02003L0087-20240301>

<sup>25</sup> First and second auctions.

<sup>26</sup> <https://ercst.org/ercst-commentary-european-hydrogen-bank-a-game-changer/>

initiatives that are vital for economic development, job generation, and the EU's global competitiveness. These projects enable member states to allocate substantial public funding while remaining compliant with competition rules, therefore preserving the integrity of the single market. Low-carbon hydrogen projects are not excluded from receiving support<sup>27</sup>.

Then other financing instruments are **Power Purchase Agreements (PPAs)** and **Contracts for Difference (CfDs)**.

Initially restricted by the EU due to concerns over potential foreclosure<sup>28</sup> effects, PPAs have been the subject of extensive discussion in the EU and afterwards considered eligible for renewable electricity. With a PPA a power producer and a buyer (the low-carbon hydrogen producer) establish the terms under which the buyer will purchase electricity at a predetermined price for a set period, typically ranging from five to twenty years. Allowing the use of PPAs, including those sourced from nuclear power, can provide low-carbon hydrogen producers with stable and predictable electricity prices, facilitating investment decisions and market entry. The possibility of using these low-carbon PPAs can be particularly relevant for producers located in EU Member States where accessing affordable electricity compliant with the DA rules is not always easy.

Similarly to PPAs, Contracts for Difference (CfDs) can support hydrogen production by offering price stability to investors. The signatories of the CfDs negotiate a range within which electricity prices can freely fluctuate. If market prices fall below the corridor, the State is required to compensate the producer, effectively paying out the commercial losses. If, on the other hand, market prices exceed the corridor, the State is entitled to capture the surplus revenues earned by the producer. This mechanism can encourage private investments by lowering the financial risks involved, allowing projects to secure funding that would be otherwise challenging due to high upfront costs and market volatility. Therefore, CfDs can reduce the overall cost of hydrogen production and are considered State Aid.

PPAs and CfDs are currently allowed for the production of RFNBO hydrogen only. As mentioned above, the draft Delegated Act on low-carbon hydrogen restricts nuclear PPAs at least until 2028. This can result in a missing opportunity to provide investors with the certainty they need to commit to low-carbon hydrogen projects. To promote technology neutrality and market efficiency, it is recommended to eliminate the restrictions on nuclear PPAs for low-carbon hydrogen production. Allowing immediate use of nuclear PPAs and CfDs would enable producers to access low-carbon electricity sources, reduce costs, and enhance the competitiveness of low-carbon hydrogen. Giving the possibility to use (PPAs) and Contracts for Difference (CfDs) for purchasing the electricity used to produce low-carbon hydrogen can bring price stability and help securing low-carbon electricity compliant with the CO<sub>2</sub> thresholds. Moreover, expanding the eligibility of funding mechanisms like the Innovation Fund and the Hydrogen Bank to include low-carbon hydrogen projects would provide essential financial support and signal the EU's commitment to a comprehensive approach. This inclusion would encourage a broader range of innovative projects and accelerate the scale-up of low-carbon hydrogen production.

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<sup>27</sup> <https://ipcei-hydrogen.eu/page/view/d85ef96a-4ae9-4f03-b51d-6e9bc4caf094/hy2tech>

<sup>28</sup> "Foreclosure" in this context refers to the risk that PPAs, could lock up large portions of demand or generation capacity, effectively preventing other competitors from accessing the market.

| Types of hydrogen (H2) | Innovation Fund             |                              |                 | PPAs | State Aid |        |
|------------------------|-----------------------------|------------------------------|-----------------|------|-----------|--------|
|                        | Hydrogen Bank First Auction | Hydrogen Bank Second Auction | Innovation fund |      | CfDs      | IPCEIS |
| <b>RNFBO H2</b>        | Yes                         | Yes                          | Yes             | Yes  | Yes       | Yes    |
| <b>Low-Carbon H2</b>   | No                          | No                           | Yes             | No   | No        | Yes    |

Table 2 Financial instruments

Source: ERCST Analysis

## 4.5 Business model

The EU does not adopt a technological neutral approach when it comes to hydrogen, as it has established clear targets exclusively for RNFBO hydrogen and the majority of the financing instruments prioritize this type of hydrogen. The Delegated Act on low-carbon hydrogen is still in a draft stage. When officially approved, it should provide clarity on the methodology for calculating GHG emissions savings from low-carbon hydrogen. However, if clear provisions are not provided now for certain crucial technologies<sup>29</sup>, this may delay investments.

Including low-carbon hydrogen into existing RED III targets can be an option to stimulate market development. Alternatively, establishing specific targets for low-carbon hydrogen may encourage the market to develop. However, given the challenges emerged in implementing renewable hydrogen targets, introducing an additional target on top of that might not be an effective solution.

While low-carbon hydrogen is more affordable than RNFBO hydrogen, the current EU carbon price is not high enough to make it more competitive than grey hydrogen. With the Climate targets that EU has today in place (and the EU ETS reform) the EU industry has 5 to 10 years to fully decarbonize its processes, often relying on technologies that are not yet commercially available. For a hydrogen market uptake, it is essential to first invest in and advance hydrogen technologies. Without an adequate supply of hydrogen, these technologies cannot be effectively tested. Low-carbon hydrogen can therefore play a role testing and developing the technologies. Low-Carbon Hydrogen can also serve as a solution for decarbonizing certain hard-to abate industry sectors such as steel and chemicals. These sectors are expected to absorb the majority of the hydrogen produced in the EU. They can therefore drive demand and supporting market development.

Moving to infrastructure, the Hydrogen and Decarbonised Gas Market package set a framework for the development of hydrogen infrastructure. The Package mandates an EU-wide Ten-Year Network Development Plan for hydrogen to be developed by ENNOH (European Network for Network Operators of Hydrogen). Moreover, provisions on hydrogen blending are included: transmission operators are obliged to accept gas with a hydrogen content of up to 2%. Voluntary agreements for higher blends are also possible. If implemented correctly, the Hydrogen and Decarbonised Gas Market package has the potential to advance the development and integration of hydrogen infrastructure across Europe.

Finally, as mentioned above, targeted support is provided for RNFBO hydrogen only (eg. Hydrogen Bank) and instruments such as PPAs and CfDs are restricted to renewable hydrogen production. This approach overlooks the significant potential of low-carbon hydrogen to contribute to the EU's decarbonization efforts, representing a missed opportunity to leverage all available solutions in the energy transition.

<sup>29</sup> The current version mentions that the possibility of allowing nuclear PPAs will be determined in 2028. For methane emissions there is a reference to the upcoming methane regulation

## 5. UNITED KINGDOM (UK)

### 5.1 Legislative framework

The UK is committed to reaching net zero by 2050<sup>30</sup>. A number of policies<sup>31</sup> have been adopted to reach this objective and hydrogen has been recognized as a key enabler for decarbonizing heavy industry and transportation, but also an opportunity for creating jobs, enhancing energy security, and providing a solution for storing renewable energy<sup>32</sup>.

In 2021, the UK published its Hydrogen Strategy<sup>33</sup> and updated it in 2023. The Strategy reiterates the UK ambition set out by the 2022 British Energy Security Strategy to reach 10 GW of low-carbon hydrogen production capacity by 2030 (at least 5GW from electrolytic hydrogen)<sup>34</sup>.

In 2023, the UK published the landmark Energy Act that created a legal framework for a cleaner, more affordable, and more secure energy system. The Act includes measures related to low-carbon hydrogen such as the creation of a framework and a business model for hydrogen and CO<sub>2</sub> transport and storage including strategic planning for energy infrastructure, a trial of hydrogen in home heating, government support mechanisms for hydrogen production and CCUS<sup>35</sup>.

Other relevant documents that will be explained in the next paragraphs are the Hydrogen Production Business Model (HPBM)<sup>36</sup> and the UK Low Carbon Hydrogen Standard (LCHS)<sup>37</sup>. This latter is the main piece of legislation when it comes to low-carbon hydrogen as it establishes criteria and conditions to be respected to classify hydrogen as low-carbon.

### 5.2 Definition

According to the LCHS ‘For a Consignment to be considered compliant with the Standard, the Consignment shall:

- *Have a Final GHG Emission Intensity that is less than or equal to the GHG Emission Intensity Threshold of 20 grams of carbon dioxide equivalent per megajoule of Hydrogen Product, using Lower Heating Values (20.0 gCO<sub>2</sub>e/MJLHV Hydrogen Product); and*
- *Be produced by a Hydrogen Production Facility which satisfies all of the Conditions of Standard Compliance.*’<sup>38</sup>

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<sup>30</sup> <https://commonslibrary.parliament.uk/research-briefings/cbp-9888/#:~:text=Download%20full%20report-.The%20UK%20is%20committed%20to%20reaching%20net%20zero%20by%202050,warming%20and%20resulant%20climate%20change.>

<sup>31</sup> Eg. the [Net Zero Strategy](#) (2021) and [Powering Up Britain: The Net Zero Growth Plan](#) (2023)

<sup>32</sup> <https://assets.publishing.service.gov.uk/media/65841578ed3c3400133bfcf7/hydrogen-strategy-update-to-market-december-2023.pdf>

<sup>33</sup> <https://www.gov.uk/government/publications/uk-hydrogen-strategy>

<sup>34</sup> <https://assets.publishing.service.gov.uk/media/626112c0e90e07168e3fdb3/british-energy-security-strategy-web-accessible.pdf>

<sup>35</sup> <https://bills.parliament.uk/bills/3311>

<sup>36</sup> <https://www.gov.uk/government/publications/hydrogen-production-business-model>

<sup>37</sup> <https://www.gov.uk/government/publications/uk-low-carbon-hydrogen-standard-emissions-reporting-and-sustainability-criteria>

<sup>38</sup> The *Conditions of Standard Compliance* specifies, among others, eligible production pathways, requirements for solid carbon outputs, GHG Emission Intensity Calculation Methodology, system boundaries, mandatory

The UK definition does not include a differentiation between hydrogen produced from renewables and other production pathways as the factor that determines compliance with the standard is the GHG Emission Intensity<sup>39</sup>.

The LCHS has been updated over time, and version 3 is now in place. While the principles and the Carbon intensity limit didn't change between the first and third version, the LCHS has become more detailed and precise in its last version. Key changes include refinement of the system boundary approach, inclusion of more production pathways, and inclusion of rules covering electricity storage<sup>40</sup>.

The following paragraphs will discuss key elements of the low-carbon hydrogen definition.

### 5.2.1 UK Lifecycle Assessment (LCA)

The LCHS specifies the GHG Emission Intensity Calculation Methodology and its boundaries.

The UK adopts a 'well to production gate' approach which includes feedstock's upstream emissions<sup>41</sup>, GHG emissions of the electricity input, heating/cooling, steam purchased for own consumption, other materials input (detailed in table 10 of the LCHS Annex)<sup>42</sup>, fugitive emissions, compression and purification, emissions from a fossil waste feedstock diverted from a counterfactual use.

Emissions from transport and distribution of hydrogen to the end consumer, equipment manufacturing are excluded from the calculation. Other types of emissions such as those from hydrogen storage and liquefaction shall be accounted for only if processes are located onsite at the Hydrogen Production Facility and Inputs or Outputs to these processes are not separately metered (or measured) from the Hydrogen Production Facility<sup>43</sup>.

After having calculated these emissions, the hydrogen with a GHG intensity equal or lower the LCHS GHG Emission Intensity limit of 20 gCO<sub>2</sub>e/MJ (which means 2.4 kgCO<sub>2</sub>e/kgH<sub>2</sub>) can be considered low carbon.

Future versions of the Standards might include a Global Warming Potential (GWP) impact and leakage rates from hydrogen production, within the GHG Emission Intensity calculation<sup>44</sup>.

### 5.2.2 Technologies

According to LCHS criteria the eligible Hydrogen Production Pathways for the production of low-carbon hydrogen are:

- Electrolysis

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reporting <https://www.gov.uk/government/publications/uk-low-carbon-hydrogen-standard-emissions-reporting-and-sustainability-criteria>

<sup>39</sup> <https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf>

<sup>40</sup> <https://www.oxfordenergy.org/publications/how-proper-measurement-of-low-carbon-hydrogens-carbon-intensity-can-reduce-regulatory-risk/>

<sup>41</sup> Depending on the feedstock, this may include extraction, cultivation, harvesting, collection, pre-processing, storage and transport

<sup>42</sup> <https://assets.publishing.service.gov.uk/media/6579cc770467eb001355f75b/uk-low-carbon-hydrogen-standard-data-annex-v3-december-2023.pdf>

<sup>43</sup> <https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf>

<sup>44</sup> <https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf>

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- Fossil gas reforming technologies - steam methane reformation (SMR), auto thermal reformation (ATR) and partial oxidation (POX) - with CCS
- Biogenic gas reforming, the use of CCS may or may not be necessary to meet the GHG Emission Intensity Threshold
- Biomass gasification, CCS may or may not be integrated into this pathway
- Waste (biogenic, fossil or mixed) gasification with the possibility of including CCS according to the feedstocks used
- Gas splitting producing solid carbon (novel technologies such as thermal pyrolysis, catalytic pyrolysis, plasma pyrolysis or plasma splitting are included in this pathway) feedstocks included in this pathway can be fossil natural gas, biomethane, and various other gaseous industrial wastes or residues.

Regarding the **electricity** input, which is the main input for electrolysis, the UK has a single electricity grid and Low Carbon Hydrogen Standard combines a strict 30-minute temporal correlation with the ability to average batches of hydrogen in terms of their carbon intensity. Regardless of the production method, the carbon intensity of each hydrogen batch is measured within each 30-minute interval. When hydrogen is produced using the same method, carbon intensities from different 30-minute intervals can be combined. As long as the weighted average carbon intensity of these combined batches meets the required standard, all the hydrogen qualifies for support. Additionality is not required by the LCHS<sup>45</sup>.

Specific rules and evidence requirements for are foreseen by the LCHS for calculating the GHG Emission intensity of electricity inputs according to whether the electricity is sourced from.

Electrolysis with electricity generated from nuclear energy is an eligible production pathway and its GHG Intensity calculation is regulated by the LCHS<sup>46</sup>. Finally, in the UK, PPAs can be used to source electricity for low-carbon hydrogen production<sup>47</sup>.

### 5.3 Monitoring, Reporting and Verification (MRV)

The LCHS establishes a MRV framework for low-carbon hydrogen to ensure that consignments of hydrogen from production facilities comply with greenhouse gas (GHG) emission intensity requirements to be classified low carbon. In the UK, this is based on a limited scope as the UK adopts a ‘well to production gate’ approach that does not take into account the full LCA. The MRV framework contains provisions for the facility’s pre-operational and operational phases, establishing minimum MRV requirements for monitoring, data provision, reporting, and verification.

Prospective hydrogen production facilities are likely to be required to prove future eligibility to the LCHS by showing, through calculations and evidence, that they can meet the GHG Emission Intensity Threshold. Although not sufficient to prove compliance, facilities can use the Hydrogen Emissions Calculator (HEC), a tool to estimate emissions and compliance potential for a projected year<sup>48</sup>. Before starting commercial operations facilities must also develop a Data Collection and Monitoring Procedure (DCMP).

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<sup>45</sup> <https://www.oxfordenergy.org/publications/how-proper-measurement-of-low-carbon-hydrogens-carbon-intensity-can-reduce-regulatory-risk/>

<sup>46</sup> When it comes to emissions accounting, the nuclear fuel shall begin the greenhouse gas (GHG) emission intensity calculations from exploration stage and include the mining of uranium ore, its processing and enrichment, the production of nuclear fuel rods, as well as storage and transport activities, extending through to the specific energy generation asset.

<sup>47</sup> <https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf>

<sup>48</sup> The HEC assesses the likely average Hydrogen Product GHG Emission Intensity and likely Standard Compliance according to the production pathway over the course of a future year of projected Facility operations.

Once operational, hydrogen production facilities shall monitor, record, calculate and hold available the GHG Emission intensity for each hydrogen consignment. The monitoring and reporting process requires hydrogen production facilities to submit data monthly, annually, and/or on an as-needed basis detailing their operational metrics and compliance status. Monthly reports provide the Delivery Partner with information on certain parameters such as emission sources, consignment compliance, biogenic content, and any indirect land-use change emissions. These reports include data on input and output volumes, sustainability criteria, and supporting documentation for mass balance and allocation factors. Annual reports cover broader metrics, such as fugitive emissions, the cancellation of REGO certificates, which document renewable electricity consumption, annual statements on private network electricity use. Additionally, facilities should update other information such as pathway shifts or infrastructure alterations only when operational changes occur.

This regular monitoring and reporting aim to ensure transparency for facilities operations and facilitate ongoing evaluation of compliance with the Standard's GHG intensity requirements.

All data submitted under the Standard is reviewed for completeness and reliability by an independent third party and through more frequent, risk-based verifications. This involves checks on emission intensity calculations and supporting evidence to validate the accuracy of reported data. Facilities are encouraged to conduct due diligence on third-party data sources to confirm data quality, which reinforces the credibility of submissions. Verification also includes possible site visits or audits, initiated particularly when inconsistencies in reporting are observed<sup>49</sup>.

## 5.4 Financial incentives

The UK has announced several financing instruments for low-carbon hydrogen.

**Net zero Hydrogen Fund (NZHF)**<sup>50</sup> (£240 million) aims to support first-movers and hydrogen projects in early stages, in order to foster the commercial deployment of new low-carbon hydrogen production projects. Therefore, the NZHF provides financial support to cover initial costs such as those associated with capital expenditure (CAPEX), development expenditure (DEVEX), front end engineering design (FEED) or post-FEED expenditures<sup>51</sup>. The support is allocated through rounds<sup>52</sup>.

The main instrument to support hydrogen production and bridge the gap between the cost of low-carbon hydrogen and cheaper fossil fuel alternatives is the **Hydrogen Production Business Model (HPBM)**<sup>53</sup> which provides a subsidy for low-carbon hydrogen following a Contract for Difference (CfD) model where the government provides financial support to hydrogen producers by bridging the gap between the strike price and the hydrogen reference

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<sup>49</sup> <https://www.gov.uk/government/publications/uk-low-carbon-hydrogen-standard-emissions-reporting-and-sustainability-criteria>

<sup>50</sup> <https://www.gov.uk/government/publications/net-zero-hydrogen-fund-strand-1-and-strand-2>

<sup>51</sup> <https://www.gov.uk/government/publications/net-zero-hydrogen-fund-strand-1-and-strand-2>

<sup>52</sup> In March 2023, the first 15 successful applicants for Strands 1 and 2 of the NZHF have been announced. The projects were awarded a total grant of up to £37.9 million to cover their FEED studies, post-FEED expenses, or to provide capital funding for construction costs.

<sup>53</sup> <https://www.gov.uk/government/publications/hydrogen-production-business-model>

price<sup>54</sup>. The HPBM requires compliance with the UK's Low Carbon Hydrogen Standard<sup>55</sup> prevailing at the time that the contract for subsidy is agreed between the government and hydrogen project<sup>56</sup>. Producers must secure an offtake agreement to be eligible for a subsidy. Contracts are awarded through hydrogen allocation rounds (HARs), open to electrolytic and alternative low-carbon hydrogen production technologies<sup>57</sup>. Hydrogen production which requires CCS can be part of the 'CCUS Cluster Sequencing process', initiative that aims to identify and provide funding to industrial clusters which are suitable for developing CCUS infrastructure<sup>58</sup>.

Other funding instruments for low-carbon hydrogen are part of the **Net Zero Innovation Portfolio**, which is a UK funding initiative to support innovative low carbon technologies and projects that can contribute to the goal of reaching net zero emissions by 2050<sup>59</sup>.

Examples of funding instruments under the Portfolio are

- the Low Carbon Hydrogen Supply 2 competition (£60 million) which aims to identify, support, and advance credible, innovative hydrogen supply or enabling technologies, driving significant progress in their development<sup>60</sup>.
- The Hydrogen BECCS Innovation Programme (£26 million funding) which aims to support the advancement of technologies that produce hydrogen from biogenic feedstocks with integrated carbon capture to accelerate negative emissions technologies to market faster<sup>61</sup>.
- Industrial Hydrogen Accelerator which provides funding to projects enabling fuel switching to hydrogen<sup>62</sup>.

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<sup>54</sup> The government provides financial support to hydrogen producers by bridging the gap between the strike price and a reference price.

- Strike price: price per megawatt-hour (MWh) that a producer needs to cover production costs and have a return on investments.
- Reference price: market price at which the producer sells the hydrogen (with a minimum set at the natural gas price).
- Floor price: benchmark for the reference price when calculating the difference amount. It is set as the lower of the strike price (or the gas reference price) for the relevant billing period.

<https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/10/ET39-Can-UK-green-hydrogen-contract-for-difference-CfD-match-the-cost-saving-success-of-renewable-electricity-final.pdf>

<sup>55</sup> <https://www.gov.uk/government/publications/uk-low-carbon-hydrogen-standard-emissions-reporting-and-sustainability-criteria>

<sup>56</sup> <https://www.oxfordenergy.org/publications/how-proper-measurement-of-low-carbon-hydrogens-carbon-intensity-can-reduce-regulatory-risk/>

<sup>57</sup> The first round (HAR1) concluded in 2023, provided support for 125MW of electrolytic production across 11 different projects. The funding amount depends on the project.

<sup>58</sup> <https://www.gov.uk/government/publications/cluster-sequencing-for-carbon-capture-usage-and-storage-ccus-deployment-phase-1-expressions-of-interest>

<sup>59</sup> <https://www.gov.uk/government/collections/net-zero-innovation-portfolio>

<sup>60</sup> <https://www.gov.uk/government/publications/low-carbon-hydrogen-supply-2-competition-successful-projects/low-carbon-hydrogen-supply-2-competition-stream-1-phase-2-summaries-of-successful-projects>

<sup>61</sup> <https://www.gov.uk/government/publications/hydrogen-beccs-innovation-programme>

<sup>62</sup> <https://www.gov.uk/government/publications/industrial-hydrogen-accelerator-programme#:~:text=The%20Industrial%20Hydrogen%20Accelerator%20Programme,industrial%20fuel%20switching%20to%20hydrogen.>

## 5.5 Business model

The UK has a technology neutral approach. Out of 10 GW of low-carbon hydrogen production capacity by 2030 (UK ambition), 5GW is expected to come from electrolytic hydrogen, while the remaining capacity can be met by any hydrogen production method that respects the low-carbon threshold of 20gCO<sub>2</sub>e/MJ.

The Low Carbon Hydrogen Standard (LCHS) offers clear guidance on greenhouse gas (GHG) emissions accounting methodologies, life cycle assessment (LCA) system boundaries, approved low-carbon hydrogen production pathways, and the monitoring, reporting, and verification (MRV) framework. This enables hydrogen producers and consumers to accurately identify and define low-carbon hydrogen.

Targeted support to the low-carbon hydrogen business model is provided via the Hydrogen Production Business Model (HPBM) which require recipients to meet the Low Carbon Hydrogen Standard (LCHS) carbon intensity limit of 20gCO<sub>2</sub>e/MJ measured on a ‘well to production gate’ basis. By providing subsidies bridging the gap between the cost of low-carbon hydrogen and fossil fuel alternatives, low-carbon hydrogen production is significantly supported. As long as the GHG emissions threshold is respected, a diverse set of technologies is eligible for support, ensuring technology neutrality.

The fact that the Hydrogen Production Business Model (HPBM) requires to have secured an offtake agreement to receive financial support results as a push for industrial demand.

In 2023, the UK government took a ‘strategic policy decision’ and permitted hydrogen blending in the UK distribution networks for up to 20% hydrogen by volume, provided that safety and quality standards are met. This move is expected to significantly support the growing demand for hydrogen by facilitating its integration into existing infrastructure.

When it comes to hydrogen infrastructure, the UK government has also published a Hydrogen Transport and Storage Networks Pathway<sup>63</sup> to outline a strategic planning for infrastructure development.

Finally, the UK's low-carbon hydrogen financing mechanisms are designed to fund various stages of the hydrogen value chain, fostering innovation and early deployment to drive the scale-up of the UK hydrogen economy and strengthen the domestic hydrogen market

## 6. GENERAL APPROACH OF THE UNITED STATES (US)

This section will analyze the US approach to give an overview of their system.

Given the remarkable differences between the US and UK, EU frameworks, this section follows a different structure.

### 6.1 Legislative framework, definition and financing

In the United States (US), the Inflation Reduction Act (IRA) enacted in August 2022<sup>64</sup> is the most relevant piece of legislation outlining provisions for defining ‘clean hydrogen’ and which are the criteria for determining hydrogen eligibility to tax credits.

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<sup>63</sup> <https://assets.publishing.service.gov.uk/media/66685e8ef5e751f1b786dad1/hydrogen-transport-and-storage-ts-networks-pathway.pdf>

<sup>64</sup> <https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf>

In the US, there is no clear distinction between low-carbon hydrogen and clean/green hydrogen like in the EU. The IRA, in Section 45V ‘credit for production of clean hydrogen’ defines ‘clean hydrogen’ as ‘hydrogen which is produced through a process that results in a lifecycle greenhouse gas emissions rate of not greater than 4 kilograms of CO<sub>2</sub>e per kilogram of hydrogen’. This hydrogen must be produced within the US or in a US possession. It should be produced by a taxpayer as part of its regular business operation for commercial purposes and the production, sale or use of such hydrogen should be verified by an unrelated party<sup>65</sup>.

Section 45V establishes that project eligibility for tax credits and other financial incentives depends on hydrogen’s life-cycle greenhouse gas (GHG) intensity.

The tax credit or investment tax credit amount reduces as carbon intensity increases. For example, a tax credit of up to 3 dollars is granted to the cleanest hydrogen (producing less than 0.45 kg CO<sub>2</sub>e/kg H<sub>2</sub>) while no credit for hydrogen exceeding 4 kg CO<sub>2</sub>e/kg H<sub>2</sub> (Table 3).

Hydrogen producers can choose between a production tax credit model (PTC) granting a fixed credit per kilogram of produced hydrogen or an investment tax credit model (ITC) where the support is granted for a fraction of the capital expenses<sup>66</sup>.

| Life-cycle GHG emissions (CO <sub>2</sub> e) | Production tax credit per kg of hydrogen | Investment tax credit in % |
|----------------------------------------------|------------------------------------------|----------------------------|
| Less than 0.45 kg GHG/kg of hydrogen         | \$3.00                                   | 30%                        |
| 0.45 to less than 1.5 kg GHG/kg of hydrogen  | \$1.00                                   | 10%                        |
| 1.5 to less than 2.5 kg GHG/kg of hydrogen   | \$0.75                                   | 7.5%                       |
| 2.5 to less than 4 kg GHG/kg of hydrogen     | \$0.6                                    | 6%                         |
| More than 4 kg GHG/kg of hydrogen            | \$0                                      | -                          |

Table 3: IRA tax credit

Source: ERCST Analysis based on the IRA

Additionally, a multiplier mechanism is foreseen when new facilities are built within a certain time period and compliance with labor standards is ensured, in particular with the prevailing wage and apprenticeship requirements (PWA)<sup>67</sup>. In case of compliance with these requirements, hydrogen producers can receive five times the baseline credit.

To be eligible for the tax credits of Section 45V other conditions need to be satisfied. For example, the construction of the facility should begin before January 1, 2033 and produce hydrogen after December 31, 2022. The credit can be attributed to any qualified hydrogen production facility which has been placed in service after December 31, 2012. The duration of the tax credit is 10 years. The tax credit can also be transferred, enabling hydrogen producers to sell any surplus credits to others<sup>68</sup>.

<sup>65</sup> <https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf>

<sup>66</sup> [https://publications.rifs-potsdam.de/rest/items/item\\_6003220\\_2/component/file\\_6003221/content](https://publications.rifs-potsdam.de/rest/items/item_6003220_2/component/file_6003221/content)

<sup>67</sup> The prevailing wage requirement require hydrogen producers to ensure that the wages paid to laborers and mechanics during the construction, modification, or repair of a facility within a 10-year period from its initial service date, are at or above the locally prevailing rates set by the Davis-Bacon Act. A minimum percentage of the total labor hours for building qualified facilities must be performed by certified apprentices, according to Department of Labor or relevant state apprenticeship rules. This will contribute developing skilled workers.

<sup>68</sup> <https://www.federalregister.gov/documents/2023/06/21/2023-12799/section-6418-transfer-of-certain-credits>

## 6.2 GHG Emissions Accounting

The US adopts a ‘well to production gate’ approach for calculating life-cycle GHG emissions of hydrogen<sup>69</sup>. The model is called GREET. A specific GREET model, the 45VH2-GREET has been developed by the US Department of Energy’s (DOE) Argonne National Laboratory<sup>70</sup>. Guidance on the application of the model and emissions accounting are provided in a document published in December 2023<sup>71</sup>.

As illustrated in the Figure 1, the 45VH2-GREET model encompasses emissions from the extraction, processing, and transportation of feedstock to the hydrogen production facility as well as emissions associated with the hydrogen production process itself, including electricity consumption at the facility and any carbon dioxide (CO<sub>2</sub>) capture and sequestration resulting from the hydrogen production process<sup>72</sup>.

Certain parameters such as upstream methane loss rates, and emissions associated with regional electricity<sup>73</sup> grids are fixed. These are called ‘background data’ and the model provides default values to be applied. When it comes to background data and hydrogen produced with natural gas plus CCS, recent studies have demonstrated that values considered fixed by the GREET model vary according to the spatio-temporal factors. US’ States have different degree of electrification and supply chain methane emissions vary according to the technology used and other factors. Consequently, fixed values are not representative of actual emissions. Regional or basin-specific modelling of the supply chain for natural gas can be a better option to determine current emissions<sup>74</sup>.

In the US, despite a series of background data, the majority of the parameters should be input by the hydrogen producer and are called ‘foreground data’. These include for example the quantity of hydrogen produced for which emissions are being evaluated as well as type and quantity of impurities or co-products.

In future revisions of the 45VH2-GREET model, background data may become foreground data. This will depend on the readiness of verification mechanisms and whether they will ensure that values can be accounted correctly.

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<sup>69</sup> <https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf>

<sup>70</sup> Multidisciplinary science and engineering research center, primarily funded by the US Department of Energy (DOE) <https://www.energy.gov/ea/argonne-national-laboratory#:~:text=Argonne%20is%20a%20multidisciplinary%20science,environment%2C%20technology%20and%20national%20security.>

<sup>71</sup> <https://www.govinfo.gov/content/pkg/FR-2023-12-26/pdf/2023-28359.pdf>

<sup>72</sup> [https://www.energy.gov/sites/default/files/2024-05/45vh2-greet-user-manual\\_may-2024.pdf](https://www.energy.gov/sites/default/files/2024-05/45vh2-greet-user-manual_may-2024.pdf)

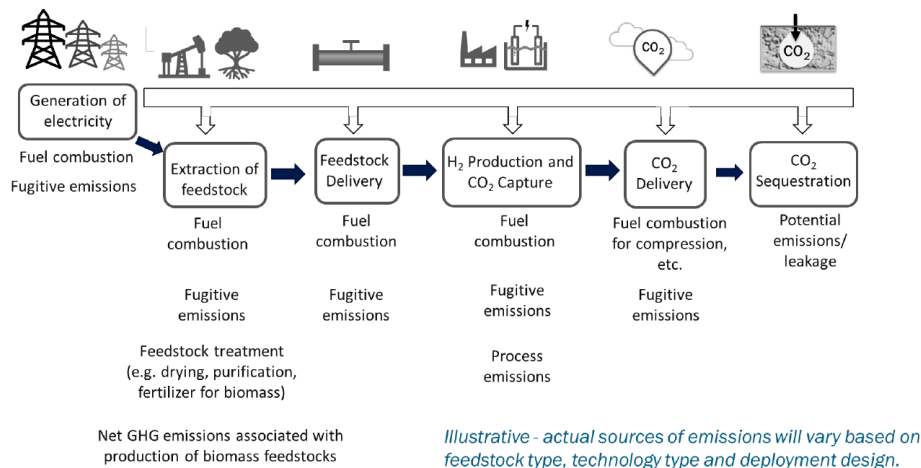
<sup>73</sup> In the United States, there are specific criteria for temporal correlation, geographic correlation, and additionality in hydrogen production. The goal is to ensure that the electricity used for hydrogen production comply with the thresholds. Guidelines regarding the criteria can be found in the IRA and in the guiding documents published in December 2023.

**Temporal Correlation:** Until December 31, 2028, temporal correlation is measured on an annual basis. After this date, however, the requirement tightens to an hourly basis, mandating a more immediate match between energy generation and hydrogen production to ensure precise alignment.

**Electricity Additionality:** Additionality is enforced through a requirement that the electricity used must come from sources that began operation within a maximum of 36 months before the electrolyzer itself.

**Geographic Correlation:** Geographic correlation requires that Energy Attribute Certificates (EACs) represent generation within the same region as the hydrogen production facility.

<sup>74</sup> <https://www.nature.com/articles/s41560-024-01653-0>



**Figure1: Examples of key activities related to GHG emissions within the well-to-gate system boundary for clean hydrogen production. Source: Guidelines to Determine Well-to-Gate (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET Rev. 3/2024<sup>75</sup>**

Hydrogen production pathways included in the 45VH2-GREET model are<sup>76</sup>:

- Steam methane reforming (SMR) of natural gas with potential carbon capture and sequestration (CCS)
- Autothermal reforming (ATR) of natural gas with potential CCS
- SMR of landfill gas with potential CCS
- ATR of landfill gas with potential CCS
- Coal gasification with potential CCS
- Biomass gasification with corn stover and logging residue with no significant market value with potential CCS
- Low-temperature water electrolysis using electricity
- High-temperature water electrolysis using electricity and potential heat from
- Nuclear power plants

Hydrogen producers whose hydrogen production technology and/or feedstock are not included in the most recent version of the 45VH2-GREET model<sup>77</sup> can request an emissions value from the Department of Energy (DOE) to petition the Secretary of the Treasury for a determination of a provisional emissions rate (PER) <sup>78</sup>. A guidance document on this matter has been published in December 2023<sup>79</sup>.

Overall, the US adopts a technology-neutral approach in which various hydrogen production technologies are eligible for tax credits. The tax credit awarded depends on the greenhouse gas (GHG) emission intensity of the hydrogen produced. While production pathways with lower GHG emissions (less than 0.45 kg CO<sub>2</sub>e/kg H<sub>2</sub>) receive greater incentives, support is also extended to other low carbon technologies that contribute to reducing carbon emissions. The final version of the two guidance documents mentioned in this section may be published by the end of the year.

<sup>75</sup> [https://www.energy.gov/sites/default/files/2024-05/45vh2-greet-user-manual\\_may-2024.pdf](https://www.energy.gov/sites/default/files/2024-05/45vh2-greet-user-manual_may-2024.pdf)

<sup>76</sup> <https://www.govinfo.gov/content/pkg/FR-2023-12-26/pdf/2023-28359.pdf>

<sup>77</sup> For example specific categories of biomass, or technologies used to drill for geologic hydrogen or trigeneration

<sup>78</sup> <https://energycentral.com/news/departments-energy-opens-emissions-value-request-process-clean-hydrogen-production>

<sup>79</sup> <https://www.govinfo.gov/content/pkg/FR-2024-04-11/pdf/2024-07644.pdf>

## 7. Comparison EU – UK approaches

This section will compare the EU and UK approaches to show similarities and differences between the two low-carbon hydrogen frameworks.

|                                           | EU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | UK                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low-carbon hydrogen Legislative framework | <ul style="list-style-type: none"> <li>- EU hydrogen strategy but no specific target in place for low-carbon hydrogen (targets are set for renewable hydrogen only)</li> <li>- Hydrogen and decarbonized gas market Package (approved)</li> <li>- Delegated Act on low-carbon fuels (to be approved) <ul style="list-style-type: none"> <li>➔ there is not a legal vacuum but the framework needs to be consolidated with the approval of the Delegated Act</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>- UK hydrogen strategy, 10 GW of low carbon hydrogen production capacity by 2030 (5GW electrolytic hydrogen, then any technology that meets the GHG threshold is eligible)</li> <li>- UK Low Carbon Hydrogen Standard (LCHS) <ul style="list-style-type: none"> <li>➔ consolidated framework, new versions of the LCHS can be published in the future</li> </ul> </li> </ul>                      |
| Low-carbon hydrogen definition            | <ul style="list-style-type: none"> <li>• Delegated Act on low carbon hydrogen <ul style="list-style-type: none"> <li>➔ Carbon intensity limit 28.2 gCO<sub>2</sub>e/MJ (3.4 kgCO<sub>2</sub>e/kgH<sub>2</sub>)</li> <li>➔ Renewable hydrogen and low - carbon hydrogen are two different categories</li> </ul> </li> <li>• The definition is not technology neutral</li> <li>• ‘Well to wheel’ approach - Full Lifecycle Assessment</li> </ul>                                     | <ul style="list-style-type: none"> <li>• UK Low Carbon Hydrogen Standard (LCHS): <ul style="list-style-type: none"> <li>➔ Carbon intensity limit 20.0 gCO<sub>2</sub>e/MJ (2.4 kgCO<sub>2</sub>e/kgH<sub>2</sub>)</li> <li>➔ The definition of low-carbon hydrogen includes renewable hydrogen</li> </ul> </li> <li>• The definition is technology neutral</li> <li>• ‘Well to production gate’ approach-Lifecycle Assessment</li> </ul> |
| Low-carbon hydrogen MRV                   | MRV included in the EU ETS (but gap – e.g. upstream methane emissions not covered)                                                                                                                                                                                                                                                                                                                                                                                                 | MRV included in the UK Low Carbon Hydrogen Standard (LCHS)                                                                                                                                                                                                                                                                                                                                                                               |
| Low-carbon hydrogen Financial incentives  | <ul style="list-style-type: none"> <li>- Innovation Fund</li> <li>- Important Projects of Common European Interest</li> <li>- No nuclear PPAs (at least until 2028) <ul style="list-style-type: none"> <li>➔ While some financing instruments for low-carbon technologies are in place, the majority of the hydrogen financing instruments focus on renewable hydrogen</li> </ul> </li> </ul>                                                                                      | <ul style="list-style-type: none"> <li>- Net zero Hydrogen Fund (NZHF)</li> <li>- Hydrogen Production Business Model (HPBM)</li> <li>- Contract for Differences (CfD)</li> <li>- Financing instruments under the Net Zero Innovation Portfolio <ul style="list-style-type: none"> <li>➔ low-carbon hydrogen financing instruments in place</li> </ul> </li> </ul>                                                                        |

## 8. Conclusions/recommendations

The analysis conducted in this paper shows that the EU, the UK, and the US adopt different approaches and methodologies for accounting for hydrogen's GHG emissions, defining LCA system boundaries, setting GHG emissions thresholds, developing hydrogen business models, and securing financing. While the US and the UK adopt a technology neutral approach, the EU prioritizes hydrogen from renewable energy.

Currently, North America has the largest expected production capacity of low-carbon hydrogen by 2030. Its pipeline is the most mature when it comes to clean hydrogen projects, with a committed supply of 2.4 million tonnes per year (80% of which Low-carbon hydrogen)<sup>80</sup>.

The EU and the UK have not made significant progress on the low-carbon hydrogen market deployment in 2023, and it is unlikely that they will meet their 2030 targets<sup>81</sup>.

The hydrogen market is not taking off in the EU under the current regulatory framework and the total hydrogen demand decreased by 3% year-on-year. While electrolysis capacity grew to 0.4 GWel, 95.5% of the 7.9 Mt consumed in 2023 was derived from fossil fuels<sup>82</sup>. Large-scale projects for electrolyser and fuel cell production are on hold, and industrial hydrogen-based initiatives, such as those by ArcelorMittal<sup>83</sup> and ThyssenKrupp<sup>84</sup>, have stalled.

The main obstacles stem from

- the industrial development of hydrogen production technologies,
- renewable and low-carbon hydrogen costs, and
- the lack of industrial demand<sup>85</sup>.

Will Europe's definition/recognition of low-carbon hydrogen change this landscape?

Certainly not entirely, but it is a necessary condition for bringing about a change in the market and needs to be paired with additional measures to have a meaningful impact.

It must be emphasized that the ERCST position is above all one that is market driven, and one that advocates that there are no half measures, and things need to be taken to their logical conclusion. So, if we go down this route, we need to also create demand for low carbon products. But that we also need to always keep in mind the consequences for EU society and economic well-being.

This Delegated Act, when looked in the context of what the US and UK are doing, must be seen as a misnomer. It is not about the definition of low-carbon hydrogen, but about "how to get the best bang for the buck" in the hydrogen life cycle. It seems to also, again, overlap with the "cornerstone of the EU climate policy", the EU ETS price signal, which should give an indication where hydrogen is best used, based on rational economic decision making and allocation.

It is yet another example of EU over regulation, with results which are now becoming visible in industrial activity. The caveat that always needs to be kept in mind, is that for the EU to be

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<sup>80</sup> <https://hydrogencouncil.com/wp-content/uploads/2024/09/Hydrogen-Insights-2024.pdf>

<sup>81</sup> <https://ercst.org/2024-state-of-the-european-hydrogen-market-report/>

<sup>82</sup> [https://hydrogeneurope.eu/wp-content/uploads/2024/11/Clean\\_Hydrogen\\_Monitor\\_11-2024\\_V2\\_DIGITAL\\_draft3-1.pdf](https://hydrogeneurope.eu/wp-content/uploads/2024/11/Clean_Hydrogen_Monitor_11-2024_V2_DIGITAL_draft3-1.pdf)

<sup>83</sup> <https://corporate.arcelormittal.com/media/press-releases/arcelormittal-provides-update-on-its-european-decarbonization-plans>

<sup>84</sup> <https://www.euronews.com/business/2024/10/07/german-steel-company-thyssenkrupp-may-rethink-plans-for-green-steel>

<sup>85</sup> <https://ercst.org/incentivising-hydrogen-demand-critical-challenges-and-opportunities-for-eu-policy/#>

able to drive societal trends, including decarbonization, it must have economic power. That position of economic power is being rapidly eroded in favour of Asia and US. Over regulation is part of the problem and is not the solution.

To achieve this change, the draft Delegated Act must undergo significant revisions<sup>86</sup>. The Delegated Act:

### **1. Must be technology neutral**

- Allowing all technologies that enable CO<sub>2</sub> emission reductions in line with the established GHG emission threshold to contribute to the energy transition<sup>87</sup>.
- Use GHG emission intensity as the only metric to determine whether hydrogen can be classified as low-carbon.
- Enable practical implementation of PPAs for nuclear power sourcing from the beginning<sup>88</sup>, facilitating access to CO<sub>2</sub>-compliant electricity.

### **2. Must be transparent and based on up-to-date scientific data**

- The GHG emissions accounting methodology should be based on current, precise scientific data (e.g., nuclear data and natural gas upstream emissions) rather than relying on averages. If these data are not available, the default values must be in line with those used to establish the reference value of the carbon intensity limit.
- Certification across the hydrogen value chain ensures market transparency and traceability, empowering consumers to make informed decisions based on a verifiable carbon footprint. It is important to have an accurate and practical MRV tailored for hydrogen.
- Guarantees of origin can play a critical role in certifying electricity used for hydrogen production, ensuring traceability, transparency, and compliance with GHG emission thresholds.

### **3. Must be cost effective and globally sustainable**

- Certified low-carbon hydrogen reduces carbon costs by lowering CO<sub>2</sub> emissions, thereby reducing the need for carbon credits or emission allowances, which can lead to substantial cost savings.
- Low-carbon hydrogen is competing with other means of decarbonisation (eg. Electrification) and with cheaper fossil fuels alternatives. However, in certain sector such as steel and chemicals production it is an option that can deliver immediate climate benefits by reducing CO<sub>2</sub> emissions at a reasonable cost. While these sectors can drive the demand, funding instruments are needed, especially in early stages, for the business model to develop. Including low-carbon hydrogen in existing funding instruments or creating ad hoc mechanisms is crucial to unlocking low-carbon hydrogen potential for decarbonization. Another option to create a hydrogen market

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<sup>86</sup> ERCST Feedback to the EU Commission Public consultation ‘Methodology to determine the greenhouse gas (GHG) emission savings of low-carbon fuels’ <https://ercst.org/feedback-to-the-eu-commission-public-consultation-methodology-to-determine-the-greenhouse-gas-emission-savings-of-low-carbon-fuels/>

<sup>87</sup> Technology neutrality should include all the consequences of the methodology (the methodology should not exclude technologies)

<sup>88</sup> In the current low-carbon hydrogen Delegated Act, Nuclear PPAs are restricted at least until 2028.

can be integrating low-carbon hydrogen into current targets (eg. RED III targets) or introducing a premium for end products made using low-carbon hydrogen, such as green steel. This could stimulate market development by incentivizing the purchase of sustainable products.

#### **4. Must ensure a level playing field on clean hydrogen markets**

- Compliance with international standards<sup>89</sup> is critical to enable the import and export of low-carbon hydrogen, ensuring a level playing field and reducing trade complexities caused by differing legislative and certification frameworks. CBAM can be a valuable instrument for creating a level playing field.
- Guaranteeing equivalence between standards across regions facilitates hydrogen trade and promotes harmonization of the global clean hydrogen market.
- A level playing field is essential for the competitiveness of EU industries, ensuring access to the most cost-effective solutions, and also supporting energy security

#### **5. Must be supported by a European clean/green industry strategy**

- Low-carbon hydrogen should be viewed as more than a tool for decarbonization. In fact, it can also play a pivotal role in testing and advancing hydrogen technologies, accelerating their scalability, and fostering the development of viable business models. Additionally, it offers considerable benefits across its value chain, including CCS, which is an invaluable instrument for efficiently decarbonizing industrial sectors such as cement<sup>90</sup>. Low-carbon hydrogen should be combined with a European clean industry strategy, in order to be used as a tool in the competition to master the clean technologies of the future.

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<sup>89</sup> Eg. ISO TS 19870 on Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate which originated from the IPHE work

<sup>90</sup> <https://ieaghg.org/publications/deployment-of-ccs-in-the-cement-industry/>