# A guide to 1.5°C-aligned hydrogen investments

## Practical steps to integrate 1.5°C criteria into investment decisions for hydrogen

## EXECUTIVE SUMMARY

**As the world's demand for hydrogen is expected to increase in coming decades, companies need to invest in production pathways with the lowest possible carbon intensity to ensure the energy system will reach net zero emissions by 2050. On a life-cycle basis, no production pathway can produce hydrogen with zero emissions. As such, it is essential to understand the level of emissions of the various hydrogen technologies and the best way to minimize them.**

This guide provides a framework for investments in different hydrogen production technologies to ensure their life-cycle emissions are aligned with the overall objective of limiting the global temperature rise to 1.5°C. It details three concrete criteria to help companies and their business partners identify projects in which to invest and encourages them to integrate these criteria into their investment decisions. This guide also illustrates how various hydrogen production and distribution pathways can implement carbon-intensity reduction measures to reach the lowest possible level of emissions in 2050 – whether at a project, portfolio or company level.

There are different ways in which a company can align with an emissions-reduction pathway leading to net zero emissions. For example, the Science Based Targets initiative (SBTi) has developed a methodology based on three pillars: a carbon budget method, an absolute emissions contraction approach and a sectoral decarbonization approach. The SBTi methodology requires companies to reduce their emissions by 90-95% by 2050 and then use carbon removals to neutralize any limited emissions they cannot yet eliminate.[1]

Exploring several normative scenarios, this is the first guide that details what it means for the hydrogen sector or individual hydrogen projects to be aligned with a 1.5°C scenario.

Inspired by the International Energy Agency (IEA) Net Zero Emissions (NZE) scenario curve[2] and the SBTi framework, we put forth three criteria that will enable the hydrogen sector to be 1.5°C-aligned. In our view, alignment with a 1.5°C scenario for hydrogen requires:

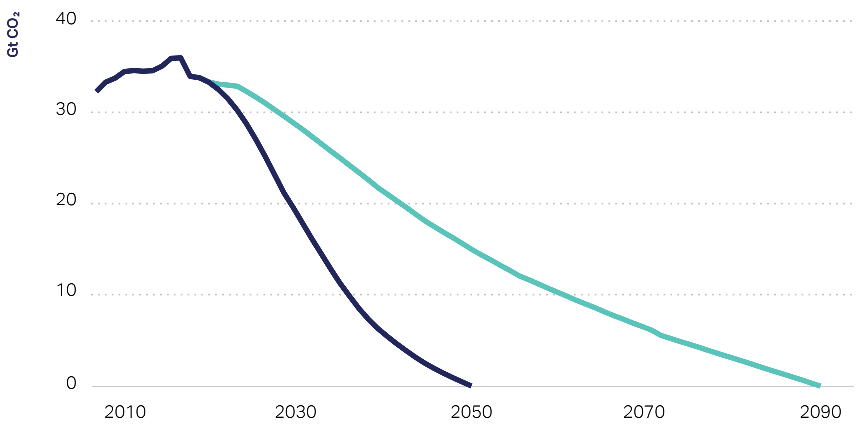
- **A rate of decarbonization (of life-cycle emissions associated with hydrogen) in line with the IEA's NZE curve,[3] reaching net zero life-cycle carbon emissions in 2050;**
- **Using hydrogen to decarbonize sectors where alternatives are ill-suited, less efficient or not available;**
- **Respecting two redlines for natural (fossil) gas-based hydrogen – no reliance on new (i.e., greenfield) fossil fuel exploration[4] or fossil fuel subsidies.**

The following sections describe how companies can use these criteria to support investment decisions.

### Rate of decarbonization in line with the IEA NZE scenario curve

The first criterion focuses on the IEA NZE scenario curve, charting the rate of decarbonization required to reach net zero emissions in 2050. We refer to this curve to illustrate the emissions reduction down to net zero for hydrogen.

**Figure 1:** Global energy-related $CO_2$ emissions in the net zero pathway and low international cooperation case




**Note:** Gt = gigatonnes.

**Source:** IEA[5,6]

Here are the steps to build this decarbonization pathway:

1. We use the **IEA NZE global emissions** curve to shape the evolution of emissions from a hydrogen project to be net zero in 2050.

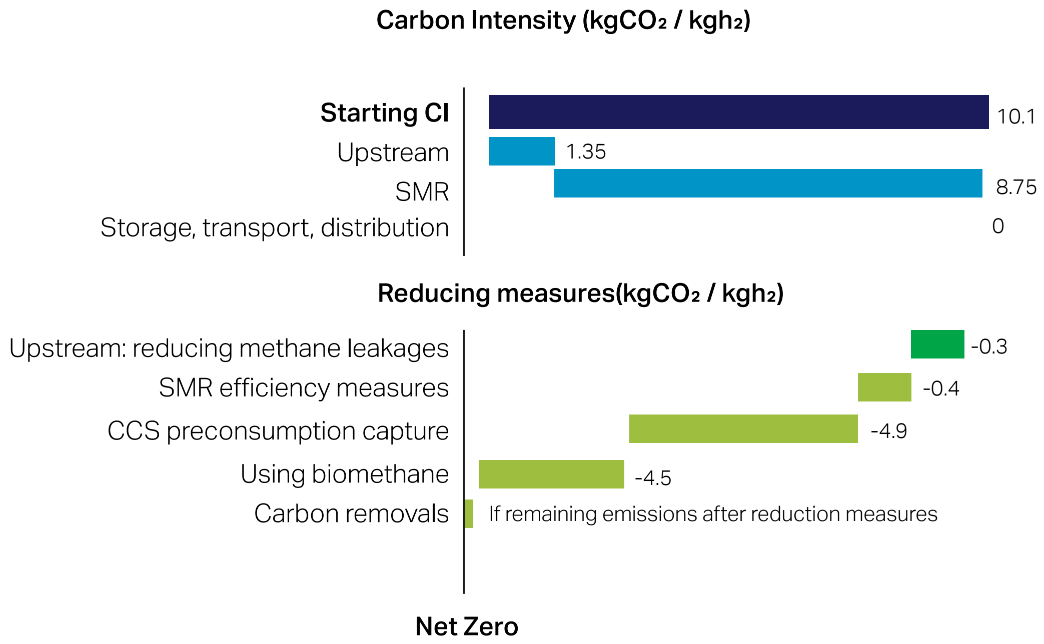
2. We **overlay** the carbon intensity of hydrogen on the Y-axis, matching the current existing grey hydrogen intensity (about 11 kgCO2e/kg H2) with the starting plateau around 2020.[7]

3. We then chart the life-cycle[8] carbon intensity of the specific hydrogen project under consideration (or portfolio of projects) **and investigate how to ensure its intensity curve follows the same shape or stays below the IEA net zero curve throughout the project's lifetime.**

Companies can achieve carbon intensity reductions by various means. Here, we detail the impact different measures have on different technologies (grey, blue and green hydrogen projects).
Figure 2 provides an example for the grey case based on a detailed analysis provided in Appendix 3 of the full report.

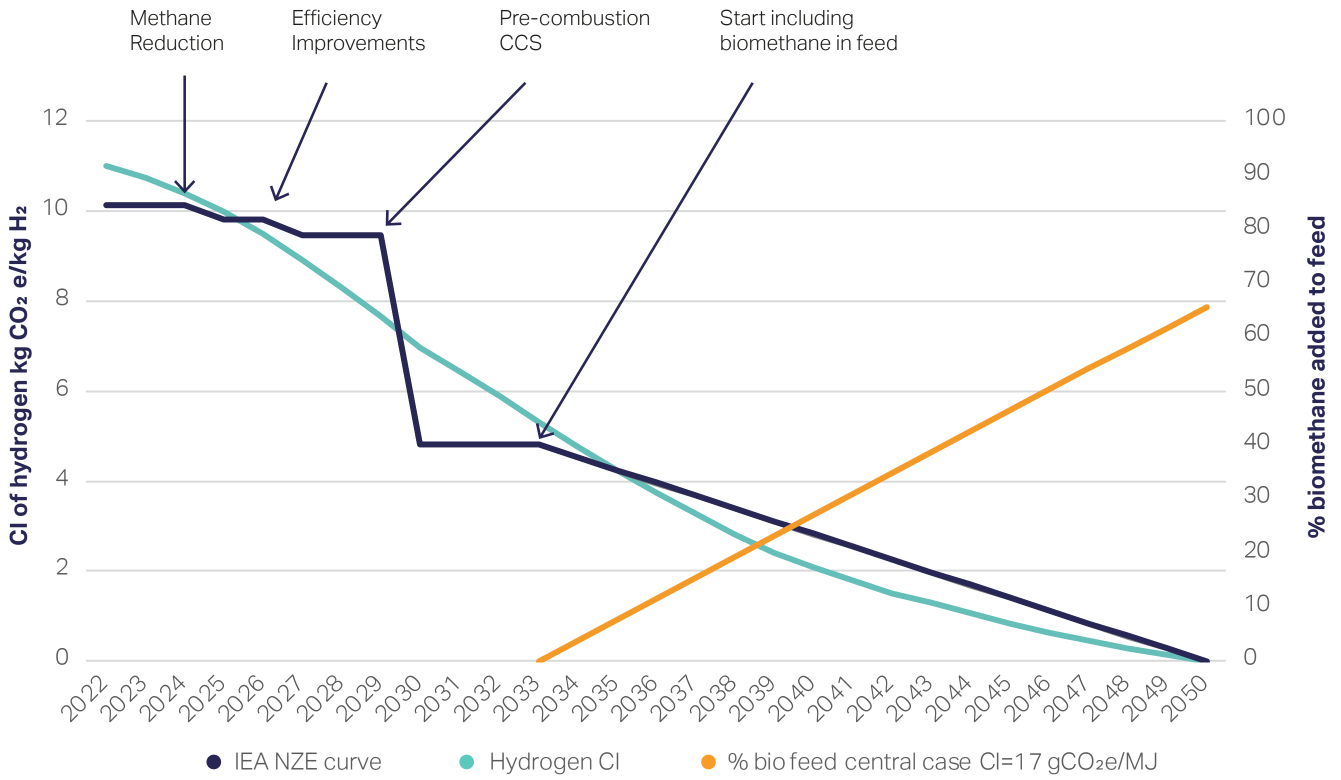
Note that, in many cases, reaching net zero emissions requires the use of carbon removals, also called neutralization offsets. While at this stage we do not give specific recommendations about when to use these offsets, it is critical for companies to see them as a last resort and to make reducing emissions a priority. We do, however, recommend that companies run sensitivity analysis on their life cycle using the 20-year global warming potential (GWP).

**Figure 2:** Carbon intensity of grey hydrogen production and emissions reduction measures



Companies can check on a timeline if the implementation of reduction measures fit the shape of the IEA NZE curve, as shown in Figure 3.

**Figure 3:** Example of an existing grey hydrogen project and its carbon intensity reduction




It is essential to mention that this example applies to existing grey hydrogen installations only. New installations should start from a much lower carbon intensity point (e.g. blue hydrogen).

If all of today's existing grey hydrogen production followed this path, it would save nearly 1 Gt of $CO_2e$ emissions a year – or 2% of global emissions.

## Using hydrogen for efficient decarbonization

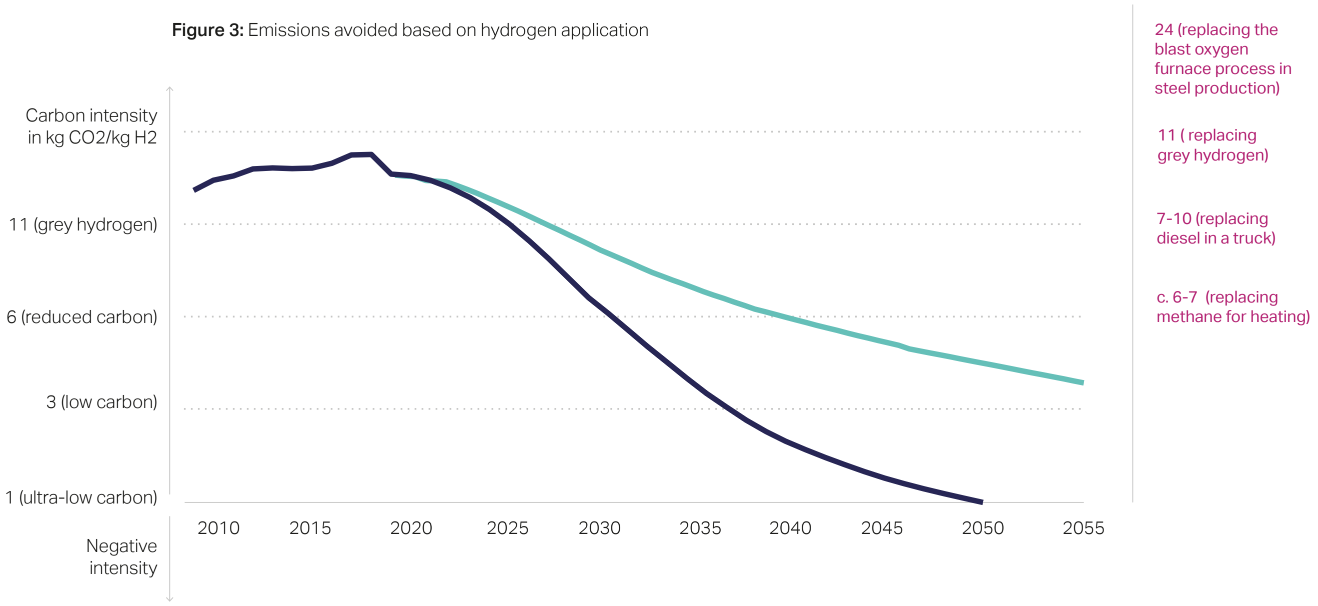
Our second criterion is to ensure the 1.5°C alignment is to deploy decarbonized hydrogen as a priority[10] in sectors with no viable alternative. This is to ensure that hydrogen does not compete with other decarbonization options, such as electrification, that are available, suited to the end-users and more efficient. To map the estimated reduction of emissions by using hydrogen on the same curve as above, we add a second Y-axis to show the reduction in $CO_2$ per kilogram of hydrogen depending on the application (see Figure 4).

It is important to underline that different uses of hydrogen lead to different $CO_2$ reduction quantities. Without considering the intensity of hydrogen itself, which needs to be subtracted to get the net level of emissions, every kg of hydrogen used[11] reduces:

1. Around 24 kg of $CO_2e$ in steel production if replacing the blast oxygen furnace (BOF) process with direct reduction of iron (DRI) using hydrogen and an electric arc furnace;
2. Around 14 kg of $CO_2e$ if replacing shipping fuel (using hydrogen as ammonia);
3. Around 12 kg of $CO_2e$ if replacing coal for high-temperature heat;
4. Around 11 kg of $CO_2e$ if replacing by hydrogen from steam methane reforming (SMR) (grey hydrogen) in the refining, fertilizer and chemical sector;
5. Around 7 kg of $CO_2e$ if replacing by natural gas for high-temperature heat.

Because we aim to focus on the whole value chain, our full report proposes an approach for companies to visualize the benefits of replacing other fuels with hydrogen.
It allows for the appreciation of the potential of decarbonization in kg $CO_2$/kg $H_2$ as the difference between the carbon intensity of the hydrogen production and the reduction of emissions related to its use.

**Figure 4:** Reductions on emission based on hydrogen application




## Redlines for natural (fossil) gas-based hydrogen

Finally, the third criterion is about redlines for natural (fossil) gas-based hydrogen. Because we remain technology-neutral and focus on achieving the lowest possible carbon intensity, it is essential to introduce guard rails for the use of fossil fuels. To ensure an effective reduction of emissions by 2050, we support certain "redlines" that help society move to a net zero energy system. These are:

1. According to the IEA NZE scenario, **no new (greenfield) exploration for fossil fuel (gas) resources.** In practice, this could not be easy to prove but a few solutions could help: generalizing guarantees of origin or certificates to track the origin of gas and its carbon intensity; including contractual clauses regarding the source of hydrogen production or the origin of the purchased hydrogen; implementing regulations to prevent the use of gas extracted from newly explored fields or new greenfield exploration.

2. According to WBCSD's Vision 2050 report,[12] **the removal of fossil fuel subsidies** is essential to transform the energy system and achieve net zero emissions.
   In practice, producers can respect this redline by not relying on fossil fuel subsidies in their business models, and purchasers can seek to source hydrogen (via contract/exclusion clauses) that was produced without fossil fuel subsidies. Note that we do not consider supporting CCS as a fossil-fuel subsidy unless it **actively incentivizes** new oil and gas exploration because its deployment is a vital transitional mitigation method in most net zero emissions pathways.

All companies, investors and policymakers involved in the hydrogen sector can refer to the carbon-intensity reduction pathway examples presented in the full report (as illustrated for grey hydrogen production above (Figures 2 and 3) to decide how to best align their investments with a 1.5°C scenario. Our guide will help them to design the infrastructure, policies, incentives and business plans that will lead the hydrogen economy to reach net zero emissions by 2050.

In light of all of this, we call on **companies making hydrogen** investments today and on **those who finance them to add "alignment with 1.5°C" criteria into their investment decisions**. We also call on **policymakers** to create support mechanisms that reward projects aligned with a 1.5°C scenario and with the objective of reaching net zero emissions by 2050.

**We urge users to require their hydrogen suppliers to source hydrogen with the lowest possible carbon intensity** and to demand the production and distribution of this hydrogen to comply with a 1.5°C scenario and the two red lines above.

We are aware that this is only a first step to define what it means for the hydrogen sector to be net zero and in line with the 1.5°C scenario. Because of this, we welcome further collaboration to deepen this topic.

*Full definitions of the terms used in this executive summary and background information about the life-cycle carbon intensity of various hydrogen production pathways are available in Appendix 1 of the full report.*

## REFERENCES


[1] Science Based Target initiative (SBTi) (2021). The Net zero Standard. Available at https://sciencebasedtargets.org/resources/files/Net zero-Standard.pdf.

[2] International Energy Agency (IEA) (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. Available at https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[3] International Energy Agency (IEA) (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. Available at https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[4] As per the International Energy Agency's Net Zero by 2050: A Roadmap for the Global Energy Sector scenario: "No fossil fuel exploration is required in the NZE as no new oil and natural gas fields are required beyond those that have already been approved for development" [as of 2021]. Available at https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[5] International Energy Agency (IEA) (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. Available at https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[6] International Energy Agency (IEA) (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. Available at https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[7] Note this is our own approach and the carbon intensities that we use are not necessarily equal to those the IEA models in its scenario.[8] For comparison, SBTi requires the use of offsets only after reducing 90-95% of emissions, which is a useful reference point.

[8] From cradle to grave, meaning including capital expenditure (CAPEX) emissions – i.e., infrastructure emissions, production, transport and storage, and use. See more details on life-cycle carbon intensity in Appendix 2 of the full report.

[9] For comparison, SBTi requires the use of offsets only after reducing 90-95% of emissions, which is a useful reference point.

[10] See Michael Liebreich's hydrogen ladder of uses, for example: "The Clean Hydrogen Ladder [Now updated to V4.1]". Available at https://www.linkedin.com/pulse/clean-hydrogen-ladder-v40-michael-liebreich/.

[11] Source: Rocky Mountain Institute (RMI) (2020). Hydrogen's decarbonization impact for industry. Available at https://rmi.org/wp-content/uploads/2020/01/hydrogen_insight_brief.pdf.

[12] WBCSD (2021). Vision 2050: Time to Transform. Available at https://www.wbcsd.org/Overview/About-us/Vision-2050-Time-to-Transform.


### ABOUT WBCSD

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future.

We do this by engaging executives and sustainability leaders from business and elsewhere to share practical insights on the obstacles and opportunities we currently face in tackling the integrated climate, nature and inequality sustainability challenge; by co-developing "how-to" CEO-guides from these insights; by providing science-based target guidance including standards and protocols; and by developing tools and platforms to help leading businesses in sustainability drive integrated actions to tackle climate, nature and inequality challenges across sectors and geographical regions.

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Together, we are the leading voice of business for sustainability, united by our vision of a world in which 9+ billion people are living well, within planetary boundaries, by mid-century.

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