BIOMASS AND HYDROGEN ALLIES FOR NET ZERO

A joint IEA Hydrogen TCP and IEA Bioenergy TCP report

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Hydrogen TCP

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BIOMASS AND HYDROGEN: ALLIES FOR NET ZERO

Workshop Summary Report of workshop held on

15 May 2025 in Paris, France

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INDEX

KEY TAKE-AWAYS FROM THE WORKSHOP

The workshop 'Biomass and Hydrogen – Allies or Net Zero" concluded with a set of **actionable next steps** to accelerate progress:

- The sector needs to move from theory to practice
- Deployment must focus on hard-to-abate sectors
- Innovation must continue to be supported
- Policy and regulation must catch up with innovation
- Building alliances will accelerate progress
- Communication will play a central role in shaping public and political support

INTRODUCTION

Sustainable fuels such as **biofuels and hydrogen** will play an important role in **clean energy transitions.** They complement direct electrification and energy efficiency measures in reducing emissions in **sectors that are hard to abate**, while providing **energy diversification, security**, and economic development opportunities.

What is less known, however, is that **interesting synergies** emerge when **bioenergy and renewable hydrogen** are developed in a **more integrated manner**. Such opportunities were explored in depth in the Workshop **"Biomass and Hydrogen – Allies for Net Zero"**, that took place on May 15, 2025 at IEA HQ in Paris. It was organised by the IEA Hydrogen Technology Collaboration Programme and the IEA Bioenergy Technology Collaboration Programme, and supported by the International Energy Agency.

The aim of the workshop was twofold. Firstly, deepen the understanding of how **renewable hydrogen** can be produced directly from biomass, so-called **biohydrogen**, and its potential role within the energy system. It is an additional hydrogen production route to the well-known process via electrolysis, using renewable electricity. Production of hydrogen from biomass can potentially be integrated with **capturing of the biobased carbon** which would lead to so-called '**negative CO2-emissions'** when stored permanently underground. This would allow to effectively lower the concentration of CO2 in the atmosphere. The result is the availability of hydrogen with a **net negative carbon footprint,** which offers potential for financial rewards via **Carbon Credits.**

Secondly, hydrogen is already being used to produce biofuels today (e.g. in hydrotreated vegetable oils) and **replacing unabated fossil hydrogen with renewable hydrogen** in biofuel production pathways. This will further reduce their **carbon footprint**. It is expected that hydrogen will continue playing a key role to produce **advanced biofuels**, e.g. via hydrotreatment and to improve efficiency of fuel synthesis from biobased synthesis gas.

Moreover, renewable hydrogen can play a role to enhance the utilization of **biogenic carbon** in biobased conversion systems (e.g. gasification, anaerobic digestion, ethanol fermentation) where CO2 is generated as a co-product. By coupling renewable hydrogen to these CO2-streams **low-emission e-fuels** can be produced, providing the potential to substitute fossil fuel deployment. E-fuels are defined in the European Renewable Energy Directive as **RFNBO's: renewable fuels of non-biological origin,** based on the fact that the energy value originates from the renewable hydrogen. Several synergies are expected when **integrating the production of RFNBO into biobased conversion processes,** such as e.g. high CO2 concentrations and local infrastructure.

The workshop highlighted these **integration options and their synergies,** addressing opportunities and challenges, including environmental, socio-economic and regulatory aspects beyond the technological aspects.

The event underscored the importance of **diversifying hydrogen production pathways** beyond renewable electricity, highlighting the consideration of the **untapped potential of biomass- and waste-derived hydrogen** in supporting decarbonization, particularly in **hard-to-abate sectors** such as **heavy industry, aviation, and maritime transport.**

It also emphasized the potential and growing interest in **combining hydrogen produced from renewable electricity with biofuel processes** to enhance biofuel production.

CURRENT CHALLENGES TO DEPLOYMENT

Deployment of biomass conversion technologies for the production of hydrogen has recently gained certain traction as a possible means to contribute to **defossilizing**. However, their deployment is faced with **several challenges**, either for the individual technology components for biomass conversion, hydrogen production, and the **integration of both processes**, as well as to certain **non-technological aspects**, such as the **regulatory landscape**. Such challenges are e.g.:

1 Lower technological maturity:

While biomass conversion technologies, such as gasification, on the one hand, and renewable hydrogen production via electrolysis on the other hand are mature or near to mature technologies, many **biomass-to-hydrogen technologies** remain at pre-commercial stages. Further development to commercial status is yet hindered by **regulatory and financial barriers.**

2 Unclear regulatory context:

Biomass based hydrogen in regulation may be **treated differently than renewable hydrogen from wind and solar energy** for example. Furthermore, different regulations may also apply among **renewable hydrogen versus low-carbon hydrogen**. As example was given, that the **low-carbon hydrogen delegated act** is (at the time of the workshop) still pending to be approved.

3 Sustainability criteria and verification:

In the case of biomass feedstocks for the production of energy, in the European regulatory context, **compliance to sustainability criteria** (regarding type and origin of the feedstock, as well as the **GHG-performance** throughout the supply chains) has to be proven via verification. In case of renewable hydrogen, the **'renewability' has to be proven.** Given that hydrogen can also be used as input for non-energy processes makes the **assessment of sustainability more complex,** as **standardized sustainability criteria** beyond the energy sector remain uncertain. As project developer, aiming to comply to all regulatory requirements, finding the **optimal production option** is not easy, considering the large number of products and derivatives that should be considered in the equation.

STRATEGIC ROLE OF BIOMASS AND HYDROGEN

The strategic role of biomass and hydrogen technologies should serve as a **fundamental pillar of energy transition:**

- **Biomass** is a **key energy source** for regions with abundant forestry or agricultural residual resources.
- **Net zero- and net negative emission** energy scenarios indicate that **excluding biomass** from such energy systems may **increase overall system costs by up to 20%.**
- **Strategic selection of biomass applications** is essential to maximize added value, with special attention on **hard-to-abate sectors.**
- **Hydrogen production from biomass** is a **reliable complement** for hydrogen produced by solar and wind power, due to its **independence of weather.**

INTEGRATION OPPORTUNITIES

Hydrogen can be both a **product of biomass conversion** and a **key asset to improve several biomass process efficiencies. Smart integration** of hydrogen and bioenergy processes offers opportunities to **optimize resources, reduce costs and improve system flexibility.** In general, **renewable hydrogen integration** into biobased value chains can be done to **1) replace conventional, fossil hydrogen** use **2) upgrade the quality** of biobased products or **3) produce (additional) biobased products** and by-products. Examples for integration are:

- Hydrogen is essential in several processes like **hydrogenation, methanol synthesis or liquid fuel conversions** (like gasification plus Fisher Tropsch processes), but can also be combined into biomass pathways to **boost efficiency** (e.g.: reacting with CO or CO2).
- Hydrogen is crucial for **utilizing the captured CO_2** from **bioenergy with carbon and capture (BECC)** to provide additional products. This enables the **co-production of liquid and gaseous carbon products** alongside heat and power generation.
- **Co-location** of hydrogen production and bioenergy facilities could allow **infrastructure sharing** for different processes or **thermal integration** between exothermic and endothermic processes, which can improve **overall systems efficiencies.**

BARRIERS TO SCALE UP

Many biomass-to-hydrogen processes are still at low TRLs (2-6), therefore demonstration at industrial scale is required. But it is not just a matter of technology itself, also of economic, risk and policy issues:

Limited investment:

Investor interest is limited due to high production costs, lack of long term and stable policy frameworks and capital intensity, especially at smaller scales.

Regulatory imbalance:

Regulatory frameworks often favor electricity-based hydrogen and penalize biomass-based pathways, creating market distortions.

Standards and certification:

Lack of harmonized standards and certification schemes for biohydrogen, e-fuels, biofuels and other derivatives undermine comparability with other vectors, which makes it challenging for them to compete in the energy market.

Perceived risk:

Bio-based projects suffer from reputational and financial skepticism, often due to underfunding or lack of awareness.

STRATEGIC ALIGNMENT FOR DEPLOYMENT

Scaling up biohydrogen solutions depend not only on technological advances but also on **strategic alignment** across the innovative ecosystem:

- **Continued R&D** is essential in areas such as **catalytic materials, reactor design, and process integration.**
- **Harmonized KPIs** to evaluate hydrogen's role in bio-based systems, which will allow **better assessment and optimization** of its integration in the processes.
- **Policymakers, researchers, and industry actors** must align goals and terminology to foster a **shared direction.**
- **Funding mechanisms** should be tailored to each **technology's maturity level (TRL),** economic context, and contribution to **decarbonization targets.**

SYSTEMIC PERSPECTIVE AND INTEGRATION

The energy transition is not only a technical or economic challenge, but also fundamentally a **systemic one.** Success will depend on the ability to **coordinate multiple actors, technologies, and sectors** under a shared vision. Biomass and hydrogen technologies, despite their enormous potential, are often treated in isolation, competing for attention or funding instead of being understood as **complementary parts** of a broader **decarbonization strategy.**

A truly sustainable energy future requires to **move beyond silos** and embrace **integrated approaches.** That means planning **infrastructures, incentives, and resource allocation** in a coherent way. It also means recognizing that there is **no single silver bullet:** the path to **net zero** will be made of **context-specific combinations** of renewable energy solutions that respond to **local realities**, whether geographic, industrial, or political.

Achieving this level of integration will only be possible if **all actors are aligned.** Researchers, industry leaders, public and policymakers must find a **common language** and a **shared framework of objectives. Clear communication** between the scientific community and decision-makers is essential to ensure that **innovations do not remain trapped in laboratories**, and that **policies are grounded in evidence** and technical feasibility.

NEXT STEPS

The workshop concluded with a set of actionable next steps to accelerate progress:

- **The sector needs to move from theory to practice:** demonstration projects at relevant scale must be launched to validate the technical and economic viability of integrated hydrogen-biomass systems. These pilots will serve not only as technological benchmarks but also as proof-of-concept for investors, policymakers, and the public.

- **Deployment must focus on hard-to-abate sectors:** biohydrogen and related fuels (e-fuels, biofuels and e-biofuels) should target sectors where electrification is not a feasible short-term option and where these technologies offer real advantages, such as aviation, maritime transport or heavy industry.

- **Innovation must continue to be supported:** Continued funding for R&D will ensure that the technologies of today evolve into the scalable solutions of tomorrow. Special attention should be given to overcoming technical bottlenecks and reducing production costs to achieve commercial viability.

- **Policy and regulation must catch up with innovation:** current regulatory landscape favors electricity-based hydrogen production while imposing structural barriers on biomass pathways. A shift towards technology-neutral policies, where all low-carbon options are evaluated fairly, will be key to unlocking investment and deployment.

- **Building alliances will accelerate progress:** collaborative platforms that bring together universities, research institutes, industry, and public authorities are essential to facilitate knowledge exchange, co-develop solutions, and streamline project development. These networks must ensure a diversity of perspectives and scalability of solutions.

- **The establishment of harmonized metrics is important:** the development of clear, standardized KPIs will allow for fair comparisons across technologies and provide transparency to funders and regulators. These metrics should reflect not only technical performance and cost, but also carbon footprint, energy efficiency, and socio-economic impacts. Potential value-added co-products must also be taken into concern.

- **Communication will play a central role in shaping public and political support:** stakeholders must invest in clear and compelling narratives that explain the value of biohydrogen and biomass, not just as a clean fuel, but as a lever for regional development, circular economy, and energy security. Aligning scientific clarity with strategic, positive and simple storytelling can significantly boost societal and political acceptance.

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