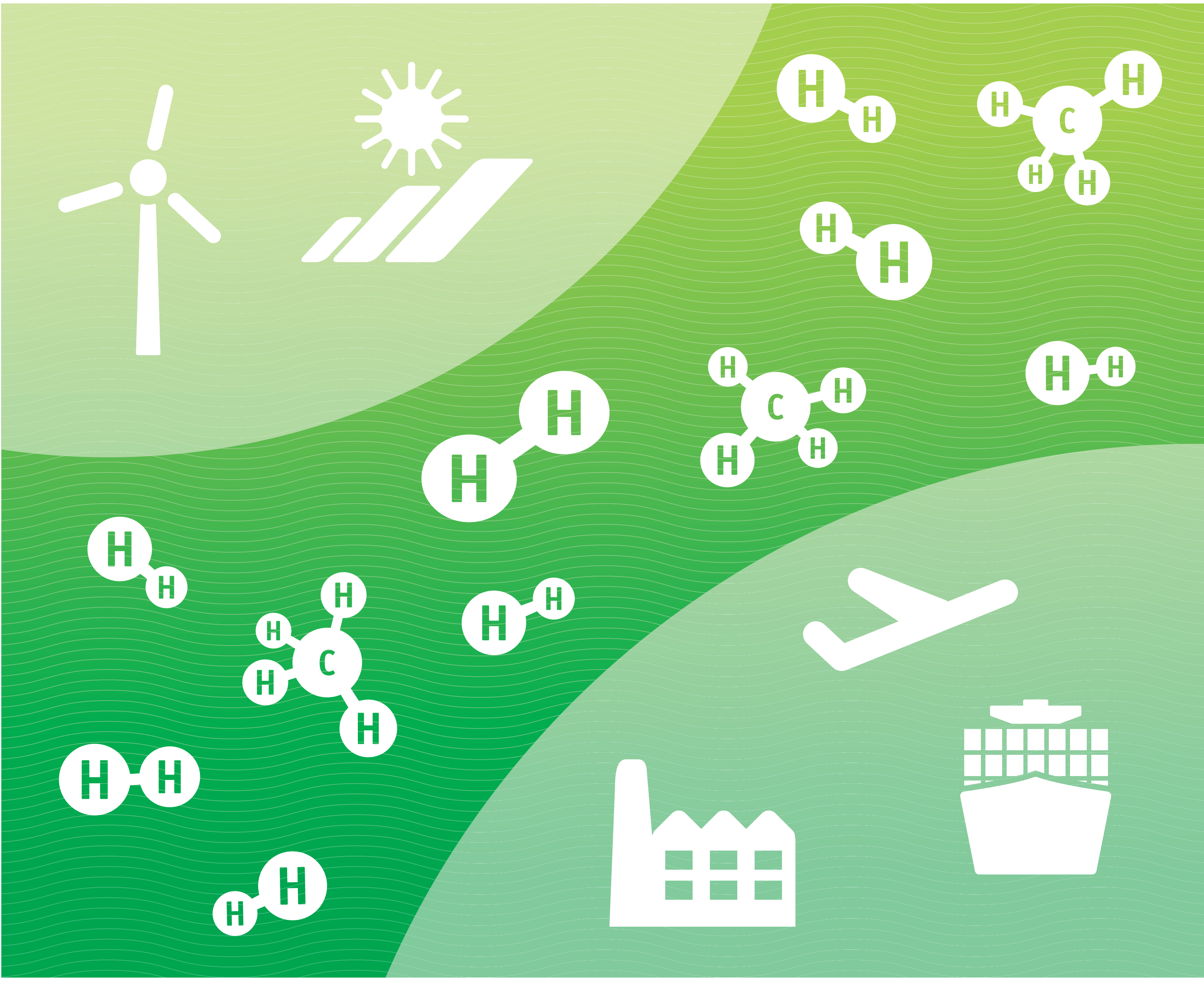
Deutsche Umwelthilfe



Hydrogen and Power-to-X

Ideas for a green hydrogen strategy

Position Paper | As of 20th April 2020

Introduction

To meet climate targets, rapid and comprehensive emission reductions across the energy, industry, building and transport sectors are necessary. To achieve these, we must expand renewable energy supply, increase energy efficiency and transition towards sustainable economies and lifestyles.

Renewable hydrogen and other synthetic energy carriers will play a role in this transition. In the current political debate, there is a lot of hype around hydrogen and power-to-X fuels, which are being touted as a means to reduce emissions for almost every sector.

Environmental Action Germany believes that hydrogen and PtX fuels can make an important contribution to defossilisation in some sectors – but they are no silver bullets. They can only contribute to reducing emissions in certain applications if they are produced according to stringent sustainability standards and entirely from renewable energy. In many sectors, their use would be inefficient and costly. The key challenges for climate policy are accelerating the transition to renewable energy, reducing energy demand, increasing energy efficiency across all sectors and switching to green mobility – these must be clear political priorities.

Here we use the term "PtX fuels" for green hydrogen and synthetic hydrocarbons based on it.

Our demands

» Climate and environmental aspects are the top priority for a hydrogen strategy.

» Only renewable hydrogen can support the green energy transition. Promotion or import of blue or turquoise hydrogen must be ruled out.

» Mandatory sustainability standards must be in place for the production of green hydrogen and PtX fuels.

» Domestic production of hydrogen and PtX fuels from additional renewable energy is the first priority. No imports while the power sector in exporting countries is not yet fully based on renewable energy.

» Only carbon from the air should be used for hydrogen refinement.

» The use of hydrogen and PtX fuels must be restricted to sectors in which no alternatives for defossilisation are available. All options to reduce demand and increase efficiency must be fully exploited at the same time.

» No preferential treatment of hydrogen and PtX fuels via special regulations.

» New gas infrastructure at national and European level must be compatible with climate goals.

» Key priorities are accelerating the renewable energy expansion and improving energy efficiency.

Our position and demands in detail: Hydrogen and PtX fuels as a component of the green energy transition

1. Climate and environmental aspects are the top priority for a hydrogen strategy.

There are three key factors which should guide all decisions around the scope of application for PtX technologies, production standards and policy instruments: (1) the potential for greenhouse gas (GHG) reduction, (2) efficiency and (3) sustainable availability and scalability.

- **Potential for GHG reduction: Do PtX fuels enable overall significant and real savings in greenhouse gases, and can they be produced and used emission-free?**

  It is important to consider PtX fuels in the context of the climate crisis and the necessary rapid transition to a zero-carbon economy. Given the net zero target, only PtX fuels which enable real GHG savings and are produced and used in a zero-carbon manner are sustainable options.

- **Efficiency: Is the use of PtX fuels energy and resource efficient, compared with all other mitigation options?**

  Renewable energy is a precious and scarce resource which must be used efficiently to enable cross-sector defossilisation. Due to large energy conversion losses, PtX fuels generally have a low degree of efficiency. Therefore, using electricity directly, increasing efficiency and reducing energy demand all take priority.

- **Sustainable availability and scalability: Can PtX fuels be produced sustainably (now and long-term), and are they – at least in the medium term – available in the relevant quantities to enable GHG savings?**

  It is also important to consider in which areas hydrogen and PtX fuels can be sustainable and scalable options. For example, to achieve the necessary rapid and extensive emission reductions in road transport, only sustainable solutions which are also available short-term at the required scale are relevant. When assessing sustainability, potential conflicts with the protection of ecosystems and biodiversity must be considered. When it comes to availability of resources, competition with other sectors (which also need to defossilise) must be factored in.

2. Only renewable hydrogen can support the green energy transition. Promotion or import of blue or turquoise hydrogen must be ruled out.

Green and blue hydrogen are sometimes summarised as "carbon-neutral" hydrogen, suggesting that both methods of producing hydrogen are equivalent from a climate perspective. This is incorrect. Blue hydrogen is based on fossil natural gas. To make it "carbon-neutral", the CO_2 is captured and stored permanently underground. But the Carbon Capture and Storage (CCS) technology is a risky pseudo-solution:

- Depending on the CCS method, up to 35% of the CO_2 still escapes into the atmosphere. In addition, there are high emissions associated with extracting and transporting natural gas. Storing CO_2 underground creates additional emissions. Overall, blue hydrogen generates up to 218 CO_2eq per kWh[1] – certainly not a climate-friendly, let alone "climate-neutral" option.
- The risk of leakages is high: There is no guarantee that underground carbon stores will remain intact for millennia, including in the event of seismic activity.
- CCS is extremely unpopular. In Germany, the attempt to establish CCS storage sites on land already failed in 2012 due to massive public resistance.

Turquoise hydrogen is also based on fossil natural gas and comes with the same high upstream emissions. It is entirely unclear which energy requirements, costs and risks would be associated with permanently storing solid carbon, and whether this could be done at industrial scale.

CCS does not help the climate but is used as a fig leaf for the long-term preservation of fossil business models. Instead of burdening future generations with CO_2 storage and the associated ecological and economic costs, we must stop using fossil energy sources. Only green hydrogen and PtX fuels based on renewable energy can contribute to protecting the climate.

From the point of view of industrial policy, green hydrogen has another major advantage: Importing blue hydrogen means that the entire value chain remains abroad, whereas domestic production of green hydrogen creates new opportunities for industries at home. Scaling up PtX technologies is necessary to make green hydrogen competitive on the market. But this cannot be achieved if at the same time the door is opened to technologies such as CCS. This underlines once again that using blue/turquoise hydrogen for the "transition" is the wrong path.

3. Mandatory sustainability standards must be in place for the production of green hydrogen and PtX fuels.

Green PtX fuels are no guarantee for reduced greenhouse gas emissions. In fact, there is a significant risk of increased overall emissions if regulation is not in place to ensure PtX fuels are produced in a sustainable and climate-friendly way.

Producing renewable PtX fuels is extremely resource intensive. To develop effective sustainability standards, all resource requirements as well as systemic and indirect effects of PtX production must be taken into account. Otherwise we risk repeating the biofuel disaster where the introduction of targets without sustainability standards led to the ramp-up and lock-in of environmentally highly damaging business models.

The key factors that determine the carbon footprint of PtX fuels are the source of electricity for electrolysis and the carbon source for subsequent hydrogen refinement.

In addition, PtX production requires further precious resources, in particular water and land surface. The demand for water for electrolysis could exacerbate existing water scarcity in dry regions and may require the installation of desalination plants. The requirement for large suitable areas for renewable energy generation and potentially additional area for CO_2 capture from the air creates competition with other forms of land use, including for renewable electricity generation for direct use, for agriculture or for nature conservation.

To avoid negative ecological or social impacts at local level, there must be a comprehensive evaluation of local impacts, involving local communities, before PtX projects are signed off either at home or abroad.

Some PtX fuels are themselves greenhouse gases. For these, leakages must be prevented as much as possible, in particular in the case of global supply chains and long transport distances. This is especially the case for the extremely potent greenhouse gas methane whose greenhouse effect is 84 times stronger than that of CO_2 over a period of 20 years, according to the IPCC. Even the leakage of small amounts of methane is highly damaging to the climate.

4. Domestic production of hydrogen and PtX fuels from additional renewable energy is the first priority. No imports while the power sector in exporting countries is not yet fully based on renewable energy.

While there are still relevant shares of fossil fuels in the electricity mix, substituting fossil fuels with PtX fuels can significantly increase overall emissions in the system. For example, based on today's electricity mix, a hydrogen-powered fuel cell vehicle generates 50% more emissions than a conventional diesel vehicle, while a vehicle using e-fuel even generates 250% more emissions[2].

To enable CO_2 reductions, PtX fuels must be produced with 100% additional renewable electricity. Surplus green electricity will not be available in sufficient quantities, so the expansion of renewable energies must be ramped up in parallel to establishing PtX production capacities. Simply buying renewable energy certificates does not make PtX fuels green. If the enormous electricity demand of PtX production leads to increased use of fossil fuels in other sectors, overall emissions will increase significantly. Additional expansion of renewable energy is therefore required, and this must be factored into renewable energy targets.

In the long term, Germany will need to import PtX fuels. But imports should only happen when the power sector in exporting countries is based on 100% renewable energy, or a strategy to achieve this is well advanced. The first priority in getting PtX production off the ground is scaling up domestic production in Germany.

Environmental Action Germany calls for establishing 5 GW electrolysis capacity in Germany by 2025 which could be funded through a tender scheme. In addition, there should be a pilot tender for hydrogen production in combination with offshore wind power.

Scaling up PtX capacities enables further cost reduction and supports plant construction in Germany. Potential legal targets for the use of hydrogen should not be established with respect to the entire gas network or overall gas consumption but should be set specifically for those sectors where the use of hydrogen or other synthetic fuels is necessary due to a lack of other defossilisation options.

5. Only carbon from the air should be used for hydrogen refinement.

To synthesise gaseous or liquid PtX fuels from hydrogen, carbon in the form of CO_2 must be added. The source of this CO_2 is an important factor that influences the carbon footprint of PtX fuels.

CO_2 from the atmosphere is the only sustainable source of CO_2 for PtX production. The technology to capture CO_2 from the air is immature, resource- and land-intensive and very expensive. Targeted policy measures to further develop and scale up this technology are necessary.

Environmental Action Germany rejects the use of CO_2 from fossil combustion in industrial processes. Establishing a market for CO_2 from fossil combustion undermines the defossilisation of industry and risks generating additional emissions overall. CO_2 emissions must be reduced in absolute terms, not shifted from one sector to another.

Using CO_2 from biomass combustion is not acceptable either. Crop planting for energy use causes enormous damage to climate and environment and must be phased out. The available quantities of sustainable waste biomass are too small to support a scale-up of PtX production. At prime locations for renewable energy generation there are typically no sustainable biogenic sources of CO_2 available[3].

6. The use of hydrogen and PtX fuels must be restricted to sectors in which no alternatives for defossilisation are available. All measures to reduce demand and increase efficiency must be fully exploited at the same time.

Due to large energy conversion losses, PtX fuels are significantly less efficient (and thus more expensive even in the long term) than direct use of electricity. For instance, a hydrogen-powered fuel cell vehicle needs three times more energy per kilometre than a battery electric vehicle, while a vehicle running on liquid e-fuel needs five to seven times more energy[4].

In some sectors in which direct electrification is not possible, green PtX fuels are the only option for defossilisation, besides reducing demand and increasing efficiency. These include the steel and chemical industries, high-temperature industrial processes, and aviation and shipping.

There will be strong competition for renewable hydrogen and PtX fuels among these sectors and on the global market in general. The necessary production capacities currently do not exist at all, and even with optimal scale-up there will only be limited quantities of green hydrogen and no relevant quantities of e-fuels available before 2030.

For these reasons – inefficiency, costs, competition for use and limited availability (even medium-term) – PtX fuels are only an option when no (more) alternative mitigation options are available, i.e.

- in sectors where fossil fuels cannot be substituted in a different way and
- as a last resort after all options to reduce demand (e.g. by recycling steel, shifting transport from air to rail etc.) and increase efficiency and sufficiency have been exhausted.

This becomes obvious when looking at the scale of the challenge: To meet current energy demand of aviation in Germany with e-fuels, renewable energy production in Germany would have to increase by 140%[5]. It is clear that we must primarily avoid air travel and shift to alternate modes of transport, while use of e-fuels can only be a final complementary measure to reduce emissions.

Wherever there are better alternatives, use of PtX fuels should be ruled out entirely. This is the case for heating buildings and passenger car transport where heat pumps and electromobility (in conjunction with efficiency, sufficiency and new mobility concepts) offer far more efficient, cheaper and less risky solutions which are readily available today. For heavy goods transport, the clear focus should also be on electric solutions due to their much greater efficiency – shifting transport from road to rail and developing battery electric trucks take priority over using PtX fuels.

The transport and storage infrastructure required for large-scale use of hydrogen in the transport sector does not exist in any case. It makes no sense to install this infrastructure in addition to charging infrastructure at high cost for a less efficient technology. False hopes in PtX technologies cost precious time. The automotive industry must focus on electromobility instead of betting on e-fuels and delaying the switch to green mobility. PtX fuels are not even available for the large CO_2 reductions that are necessary in the transport sector by 2030.

For buildings, counting on PtX fuels risks a lock-in of inefficient gas heating systems. Instead, the focus must be on reducing energy use for heating by increasing the speed and quality of retrofitting programmes and putting in place efficiency requirements for all new buildings. The installation of new gas heating systems must be prohibited by 2025.

7. No preferential treatment of hydrogen and PtX fuels via special regulations.

The existing regulatory framework must not be weakened by special regulations to promote hydrogen and PtX production. There are frequent calls for exempting operators of electrolysers and PtX plants from paying the EEG (renewable energy) levy and grid fees. But as consumers of renewable electricity and grid users, PtX producers must also make an appropriate contribution to the costs for expansion of renewable energy supply as well as grid maintenance and expansion. A special exemption from these fees for PtX producers would be at the expense of all other contributors, including private households and non-energy-intensive industries.

It would also be counterproductive to credit the use of hydrogen and e-fuels in the European CO_2 fleet targets or equate the use of PtX fuels with biogas for heating buildings. The CO_2 fleet targets are an important incentive for the automotive industry to switch to more efficient and increasingly electric vehicle technologies. Weakening this key regulation to promote inefficient PtX fuels undermines this incentive and would ultimately increase energy demand in road transport. In the building sector, it would undermine the “efficiency first” principle.

8. New gas infrastructure at national and European level must be compatible with climate goals.

The use of gaseous energy sources will decrease in the future. Existing gas infrastructure is long-lived, in part already written off and should continue to be used where necessary. For example, local hydrogen hubs (networks) could link PtX plants with industrial consumers. Existing long-distance connections may also be used to transport hydrogen. It is important that appropriate regulations provide certainty for investors and avoid "stranded investments".

In general, climate goals must be the priority when planning and expanding gas infrastructure. All infrastructure projects must be compatible with climate goals and the switch to hydrogen.

9. Key priorities are accelerating the renewable energy expansion and improving energy efficiency.

The production of green PtX fuels requires enormous amounts of additional renewable energy and is only useful in applications which cannot be defossilised through direct electrification. This underlines once more the urgent need to rapidly expand renewable energy supply and increase energy efficiency in all sectors. To enable the green energy transition, the German government must promote wind and solar energy much more decisively. If the government continues to put the brakes on renewable energy expansion, the vision of a green hydrogen economy fails automatically.

Technical background

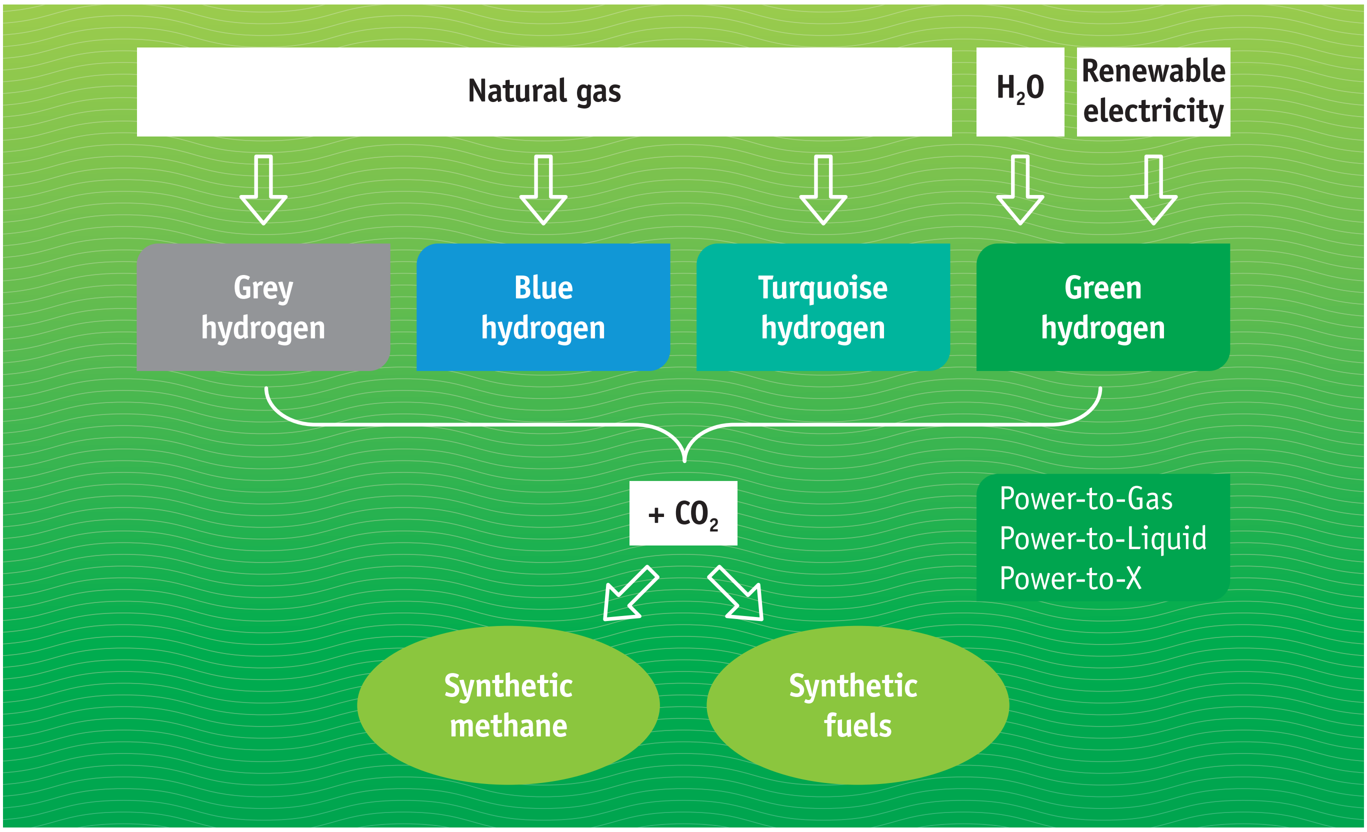
Hydrogen can be produced from water using electric energy (electrolysis). If the electricity comes entirely from renewable energy sources (green electricity), this hydrogen is called green or renewable hydrogen.

Currently only a very small fraction of the hydrogen used by industry is produced with electricity. Conventional methods of hydrogen production are based on steam reforming of fossil natural gas, resulting in significant greenhouse gas emissions. This hydrogen is called grey hydrogen.

Blue hydrogen is produced from natural gas in combination with carbon capture and storage (CCS). Storing the CO_2 underground is intended to prevent it from escaping into the atmosphere.

Turquoise hydrogen is also made from natural gas via thermal cracking of methane (methane pyrolysis). Instead of CO_2 this produces solid carbon which must be stored permanently.

Based on green hydrogen, gaseous methane or liquid hydrocarbons can be synthesised by adding carbon. These so-called e-fuels can replace fossil fuels in combustion engines. In general, the production of hydrogen and derived products based on electricity is referred to as Power-to-X (PtX) technology. Depending on the end product, the terms Power-to-gas (PtG) or Power-to-liquid (PtL) are also used.



Endnotes

1 Greenpeace Energy, 2020.
2 Agora Verkehrswende, 2019. Carbon footprint calculated based on the full vehicle lifecycle.
3 Agora Energie- und Verkehrswende, 2018.
4 Transport & Environment, 2017.
5 Energy use of aviation in Germany was 426 PJ / 118 TWh in 2017 (BMWi, 2019). Meeting this demand solely through e-fuels creates additional renewable energy demand of 311 TWh (based on a 38% efficiency of PtL production; Umweltbundesamt, 2016). Total renewable energy supply in Germany was 222 TWh in 2017 (EU Energy in Figures, 2019).

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water

climate targets

infrastructure

sustainability standard

efficiency

hydrogen

sector coupling

e-fuel

power-to-X

technology

scalability

carbon source

defossilisation

renewable energy

industry

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