# The EU Hydrogen Cooperation Accord

the European Union and the League of Arab States

The European Green Deal aims to transform the Union into a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases by 2050, economic growth is decoupled from resource use and no person, and no place is left behind. The energy system must become climate neutral or better. An energy and resource system based on 50% renewable electricity and up to 50% green hydrogen could be a feasible solution to achieve climate neutrality by 2050 and replace hydrocarbons (see Annex). The green hydrogen shall consist of 50% green hydrogen produced in Europe, complemented by 50% hydrogen imports, which cuts energy imports roughly in half compared to the current situation. This approach guarantees optimized use of (existing) infrastructure, has lower risk and cost, improves Europe's energy security through among other things cost-effective seasonal hydrogen storage, and supports European technology leadership.

To help transform the global energy landscape and safeguard energy supply, the European Union is to launch an initiative called the **EU Hydrogen Cooperation Accord (EU-HCA)**, providing a framework for cooperation on global trade of hydrogen and hydrogen fuels. The founding signatories to the EU-HCA would be the European Union and the League of Arab States, which includes countries in North Africa and the Gulf. However, the Accord is an open platform and shall not be exclusive.

The EU Hydrogen Strategy, released in July 2020, refers to a wide range in predictions for the share of hydrogen by 2050, from less than 2% to 23%. The Annex contains an analytical view on some of these scenarios, which tend to underestimate the potential role hydrogen can and should play in Europe. Direct electrification will grow from 20% to 50% and given the intrinsic advantages of hydrogen over additional electrification, CCS or biomass, hydrogen is expected to cover at least as much of the energy demand as direct electrification. For that volume of hydrogen, a minimum additional capacity of 2,000 GW of solar and 650 GW of wind is required, yielding an overall capacity requirement of at least 4,000 GW of solar and 1,300 GW of wind capacity. This will not all be built on European territory for two reasons: Europe doesn't have the necessary space and quality resource and other regions have better renewable energy conditions combined with ample low-cost land, providing for lower-cost hydrogen, as explained in the Annex.

## Import of hydrogen

In 2050, the import of hydrogen into the EU will be up to 25% of all final energy demand, amounting to 2,500 TWh. It is imperative that the EU starts preparing for this by launching the EU Hydrogen Cooperation Accord, a platform for engaging with potential suppliers of hydrogen and hydrogen fuels to the EU. The hydrogen exporters include countries in North-Africa, the Middle East, Turkey and Eastern Europe, which could connect to the European gas pipeline system, but hydrogen can also be shipped from further away in liquid form, as ammonia or methanol, from Gulf countries or even sub-Saharan countries, Chile or Australia.

Signatories to the EU-HCA shall commit to cooperating in the following areas:

- **Infrastructure**. Signatories shall commit to supporting appropriate infrastructure for the production and trade of hydrogen and hydrogen products. Pipelines are the most cost-effective way to transport energy over longer distances and joint projects will connect hydrogen generation to the European gas grid via gas pipelines. However, investments shall also include ports facilities, tank storage systems, salt caverns, etc. In addition, EU-HCA signatories shall provide rolling 10-year forecasts of infrastructure investments that support trade.

- **Joint scenarios**. If massive investments in hydrogen production for export are going to be made in a signatory country, visibility on the market opportunity is required. Joint scenario building will support such visibility. These scenarios will also support investments in Europe, e.g. in import facilities (storage facilities in ports, ammonia cracking facilities, regasification terminals etc.). Signatory countries shall provide information on planned future supply or demand volumes of hydrogen based on commonly agreed methodologies.

- **Technology cooperation**. Europe is a global leader in green hydrogen technology. Many emerging economies aim to extend the value chain inside their borders and want to develop beyond a situation where they merely buy foreign made technology. Such cooperation could comprise local manufacturing, technology transfer or academic cooperation/joint R&D.

- **Standards**. If hydrogen and hydrogen-based fuels are to become globally traded commodities, mutually agreed standards are required. These standards cover aspects of safety, product quality, carbon content etc. Beyond the definition of standards, mutually agreeable systems of certification and accreditation need to be developed.

- **Investments and finance**. Signatories to the EU-HCA will commit to contributing to a multilateral EU-HCA hydrogen infrastructure development fund (H2-Fund). Europe's development finance institutions such as the EIB and EBRD, complemented with similar banks in EU member states and EU-HCA signatories should seed the H2-Fund, that will support investments providing technical assistance, loan guarantees, concessional finance and insurance. The H2-Fund shall aim to initially mobilize €2bn/a.

- **Market development and trading platforms.** The EU-HCA shall support market development through the initiation of exchanges for the trading of hydrogen and hydrogen fuels, connecting supply with demand. The range of products shall also include non-physical products such as certificates linked to hydrogen guarantees of origin.

- **Education and Training.** Signatories to the EU-HCA shall cooperate on the development of curricula for education and training at various levels, starting from vocational training for technicians, to university degrees supporting scientific advancement of hydrogen as an energy carrier of the future.

## Timeline

| | 2021 | 2022 | 2023 | 2023 |
|---|---|---|---|---|
| Elaborate and initiatie the EU HCA | ■ | | | |
| Development of first joint scenarios | ■ | ■ | | |
| Initiate joint cooperation | | ■ | | |
| Inititate joint work on standards | ■ | | | |
| Develop and launch hydrogen fund | ■ | ■ | | |
| Initiate infrastructure investments | | ■ | ■ | |
| Initiate trading platforms | | | ■ | |
| Development of curricula for training | | ■ | ■ | |
| First hydrogen trades into EU | | | | ■ |

# Annex

## Energy in Europe

Europe is a net energy importer, with more than 50% of the primary energy needs met by imports, consisting of petroleum products, natural gas and solid fuels. Although Europe is working ambitiously to become less dependent on energy imports, it is unlikely that Europe can become entirely energy self-sufficient. Most scenarios, including BP's Energy Outlook 2019[1] indicate that Europe shall remain a net importer of energy until mid-century and beyond. Given the population density and comparatively limited potential for renewable energy, the expectation is that Europe shall continue to import energy, also in a future renewable energy system. However, instead of fossil fuels, over time Europe shall import energy in the form of green electrons and molecules.

The following table contains the current final energy mix in Europe[2] (2015)

*Table 1 EU Final Energy*

| Fuel | TWh/a | % |
|---|---|---|
| **Solid fuels** | 534 | 4 |
| **Oil** | 5,000 | 40 |
| **Gas** | 2,666 | 21 |
| **Electricity** | 2,752 | 22 |
| **Other** | 1,682 | 13 |
| **OVERALL** | **12,634** | **100** |

In 2020, the European Commission released the EU Green Deal, a set of policy initiatives with the overarching aim of making Europe climate neutral in 2050. The Green Deal is also crucial to meet its obligations under the Paris Agreement.

Several recent scenarios exist for Europe's energy system in 2050, including Shell's Sky Scenario[3], The Hydrogen Roadmap for Europe[4], DNV-GL's Energy Transition Outlook 2018[5] and the "Global Energy System based on 100% Renewable Energy – Power Sector" by the Lappeenranta University of Technology (LUT) and the Energy Watch Group (EWG) [6]. But also, several renewable energy industry associations have assessed the role of renewable energy in the European energy mix by 2050, among which are EWEA[7] and GWEC[8]. The following table contains a summary of the most ambitious scenarios in each of these modeling exercises:

[1] https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2019.pdf

[2] https://ec.europa.eu/eurostat/

[3] https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html

[4] https://fch.europa.eu/sites/default/files/Hydrogen%20Roadmap%20Europe_Report.pdf

[5] https://eto.dnvgl.com/2018/

[6] http://energywatchgroup.org/wp-content/uploads/2017/11/Full-Study-100-Renewable-Energy-Worldwide-Power-Sector.pdf

[7] http://www.ewea.org/fileadmin/files/library/publications/position-papers/EWEA_2050_50_wind_energy.pdf

[8] http://files.gwec.net/register?file=/files/GlobalWindEnergyOutlook2016

*Table 2 Solar and wind energy in the European Union in 2050*

| Scenario | Solar Energy [TWh/a] | Wind Energy [TWh/a] | Solar Capacity [GW] | Wind Capacity [GW] |
|---|---|---|---|---|
| **Shell Sky Scenario** | 3,472 | 3,089 | 2,300 | 1,000 |
| **DNV GL Energy Transition Outlook 2018** | 1,077 | 1,662 | 718 | 554 |
| **LUT/EWG** | | | 2,000 | 560 |
| **EWEA** | | 1,950 | | 600 |
| **GWEC** | | | | 590 |

It should be noted that to achieve the binding Paris Agreement, Europe's electricity sector needs to be fully decarbonized by 2050 and other energy sectors to a large extent also. This is a prerequisite for the Shell, GWEC and LUT/EWG scenarios. However, the DNV-GL ETO scenario is not compatible with keeping global warming well below 2 °C. The EWEA scenario focused on the feasibility of a certain share of wind power in the energy mix and the resulting outcome is compatible with other scenarios. It is reasonable to assume that for the DNV-GL scenario to be compatible with the Paris Agreement, the amount of solar energy would be closer to the results of the other scenarios. Analyzing and comparing these scenarios, one can assume that some 2,000 GW of solar and 650 GW of wind energy capacity is required to decarbonize Europe's electricity sector by 2050, generating roughly 3,000 TWh of solar energy and 2,000 TWh of wind energy per year. The estimations for Europe's final energy demand in 2050 range from 9,000 to 13,000 TWh per annum. Assuming an estimated overall final energy demand in Europe of 10,000 TWh, 50% would then be covered by electricity from solar and wind. In most scenarios, additional electricity is generated by nuclear and hydropower.

Most scenarios consider a drawn-out transition process, with a continuing dependency on fossil fuels, most of them imported, that will last for decades and would lead to climate chaos if released in the atmosphere. Since the associated emissions are incompatible with the Paris Agreement or the European Green Deal, several scenarios therefore feature massive investments in carbon capture and storage as well as future carbon sinks, mostly achieved through forestation. The Shell Sky scenario for example, contains a staggering 10,000 CCS projects necessary to limit $CO_2$ emissions. There are currently 18 CCS projects in the world and less than 7,000 coal fired power plants, so it would require a huge effort, technically, financially as well as regarding popular sentiment, to realize this many CCS projects. The question is whether there are no better alternatives altogether.

## Hydrogen in Europe

As explained above, we assume that Europe's final energy demand will amount to 10,000TWh/a, of which 50% will be covered by direct electrification. The following are the options to complement 50% electricity by 2050:

- **Electrification beyond 50% of final energy**. A cost-effective and feasible solution for the future electricity system is based on offshore wind in northwestern Europe and solar everywhere, but predominantly in southern Europe. The expand from the current 20% to 50% of final energy covered by electricity already requires massive expansion of the grid. However, already today, several bottlenecks in the European high voltage grid persistently block the development or use of renewables. Such bottlenecks are reported almost everywhere in Europe, including Germany, France, Belgium and the Netherlands. The long lead times and popular opposition against massive expansion of overhead power lines makes it difficult and expensive, if not impossible, to expand electricity delivered to all consumers beyond a share of 50%.

- **Curbing demand**. Increasing energy efficiency and reducing demand is usually cost-effective with many additional benefits and should be done first, why some even call it "the first fuel". However, efficiency improvements across many parts of our energy system are counter-balanced by projected economic growth that is still associated with increased energy demand. The overall impact is therefore limited in absolute numbers.
- **Carbon capture and storage (CCS)**. CCS, in which $CO_2$ is captured and permanently stored underground allows the continuation of using carbon fuels to produce power or in industry. Although CCS adds to the cost of conventional carbon processes, in absence of a cost-reflective carbon price, such solutions may be more competitive than green alternatives in the short term. An example is blue hydrogen, which is hydrogen made from natural gas coupled with CCS, which is currently cheaper than green hydrogen, made from renewable electricity and water. However, the cost of green hydrogen will come down with increased deployment following the learning curves of solar, wind and electrolysis, the price for carbon is expected to go up (blue hydrogen still emits carbon), so green hydrogen is expected to be competitive within the decade. This makes the current investment climate in blue hydrogen risky. Also, CCS requires appropriate geological structures which are not found everywhere throughout Europe. Lastly, the vast majority of hydrocarbons will need to be imported in the future, so there is little strategic value to continued combustion of hydrocarbons with an emission problem to solve.
- **Biomass.** Biogenic energy sources include energy crops, wood or forest waste, waste from food crops, horticulture, food processing, animal farming, or human waste from sewage plants. Given that not all biomass is automatically sustainable and due care should be taken regarding the water footprint and potential competition with food, biomass will play an important but not dominating role. It should also be noted that with the progressing energy transition, the production of fossil fuels will decline and eventually carbon will become a much scarcer commodity than today. So, it remains to be seen whether carbon from biomass or waste will be available for energy purposes, or rather be used for higher value applications such as plastics.

There is no doubt some CCS will remain part of the portfolio of solutions, even in 2050. And biomass, especially waste, will grow in significance. However, none has the intrinsic qualities and potential of hydrogen, so green hydrogen is expected to constitute the bulk of energy in addition to direct electrification. Green hydrogen can be produced in electrolysers using renewable electricity, can be transported using the natural gas grid and can be stored in salt caverns and depleted gas fields[9] to cater for seasonal mismatches in supply and demand of energy. Like with natural gas, underground storage would be seasonal, while line-packing

[9] https://forschung-energiespeicher.info/wind-zu-wasserstoff/projektliste/projekt-einzelansicht/74/Wasserstoff_unter_Tage_speichern/ (in German)

flexibility provides some short-term storage. It should be noted that blue hydrogen, hydrogen produced from fossil fuels with CCS, can play an important role in an intermediate period, helping kickstart hydrogen as an energy carrier alongside the introduction of green hydrogen.

An important question is what the share of hydrogen import versus domestic European production will be. The following chapter contains an analysis done by Prof. Dr. Ad van Wijk and Charlie Groenewegen from Delft University of Technology.

## Low-cost hydrogen export and import potential, Europe and the Mediterranean region

### Hydrogen exporting and importing regions

Groenewegen and van Wijk recently carried out a study using a GIS (Geographic Information System) modelling tool and data, mapping the Levelized Cost of Hydrogen production as a function of the solar and wind resources for Europe and neighbouring countries. The studfy will be published in 2021, below is a summary.

For solar, the lowest cost hydrogen production areas can be found in southwestern Mediterranean areas. In southeastern Mediterranean areas low cost hydrogen can be produced, while in northern Mediterranean countries the hydrogen production cost are moderate to low. The hydrogen production cost from wind show a more dispersed cost pattern. In southwestern Mediterranean areas there are very low, low and moderate hydrogen production cost areas. In north and southeastern Mediterranean areas there are some dispersed areas with low cost hydrogen from wind production potential. It should be noted that especially offshore wind resource conditions in the eastern part of the Mediterranean are excellent, and have the potential for low cost hydrogen production.

But even when the resource is good, large scale low-cost hydrogen production requires space, which must be available. To produce between 0.5 to 2 million ton hydrogen requires about 500 $km^2$ for solar PV and about 1,000 $km^2$ for wind. For solar, the land area is almost fully covered with solar modules, while for wind only a limited amount of space is in use by the wind turbines. The GIS modelling tool has looked to these area sizes for solar and wind, whereby the following land areas were excluded:

- areas with more than 100 people/$km^2$,
- mountainous areas and areas of natural beauty,
- and built-up areas, cities, industrial sites and airports with a 15 km exclusion zone

When above mentioned areas are excluded, the GIS analysis clearly shows that the available space for low-cost hydrogen production in the European Union, especially in northwest and central Europe is limited. However, around the Mediterranean Sea, especially in the southwestern Mediterranean area, the resources for both solar and wind are excellent and abundant space is available.

The analysis concludes that the European Union has a potential to produce low-cost hydrogen on land, especially hydrogen from solar PV. The potential for hydrogen below 1.5 €/kg in 2040 is about 2 times the total EU27 primary energy consumption. (It has to be noted that offshore wind hydrogen production is not taken into account.) Especially in northwestern and central European countries, the potential for large scale low-cost renewable hydrogen is practically zero, due to resource but also available land area restrictions. Therefore it is expected that these countries will become net importers of low-cost hydrogen.

The Mediterranean countries and especially the southwestern Mediterranean countries have a huge potential for hydrogen production; more than 1.1 million TWh hydrogen can be produced, which is more than 7 times global primary energy consumption and over 68 times the EU27's primary energy consumption. Hence, this region certainly has the potential to become one of the leading hydrogen production and export regions in the world.