

Electrolysis

How much hydrogen could Europe have produced in 2023 from electrolysis?

Electrolysis is a key technology for production of hydrogen and is one of the most advanced and commercially available technologies when compared to other technologies for hydrogen production. There are two main inputs needed for hydrogen production via electrolysis - water and electrical energy. Water being the source of the 'to be produced' hydrogen and electrical energy being the input needed to split water into its basic elements viz. *hydrogen & oxygen*.

Europe (the policy being driven by the EU) is pushing for green hydrogen production on a very large scale and this is detailed out in several of its documents [1,2]. However, one needs to do an analysis to understand where does Europe currently stand in terms of hydrogen production for its demand and this reality check is done by answering the following key questions:

1. How much is the electricity surplus/ deficit in Europe?
2. What is the hydrogen demand in Europe?
3. Can Electrolysis technology cater to this demand?

To answer the above questions, data from 2023 is taken so that one can have the latest information. The data pertains to electricity production and consumption, hydrogen demand in Europe and installed Electrolyser capacity.

How much is the electricity surplus/deficit in Europe?

Note: The reader is encouraged to refer to the 'Projection Map' of Europe available on www.venkacon.com for electricity data of the nations.

In this article and study, Europe, as a continent, is covered with 33 sovereign nations which include:

France, Lithuania, Russia, Czech Republic, Germany, Estonia, Latvia, Norway, Sweden, Finland, Luxembourg, Belgium, Spain, Denmark, Romania, Hungary, Slovakia, Poland, Ireland, United Kingdom, Greece, Austria, Italy, Switzerland, Serbia, Croatia, Slovenia, Bulgaria, Portugal, Iceland, Malta, Netherlands & Cyprus.

The nations NOT considered in the analysis and data include: **Ukraine, Belarus, North Macedonia, Albania, Kosovo, Liechtenstein, San Marino, Monaco, Andorra, Montenegro, Bosnia & Herzegovina & Moldova**. The reason for not including these nations in the analysis is because either they are too small to make an impact on the hydrogen market or they are currently not part of the EU.

Note: Of the nations included in the study, **Russia, Norway, United Kingdom, Iceland, Switzerland** and **Serbia** are not part of the EU but are included because of their strength when it comes to technology, the willingness to trade and market share.

Key facts:

- **Scenario 1: Surplus electricity when all 33 nations were taken into account: 111.345 TWh**
- **Scenario 2: Surplus electricity when 27 EU nations were taken into account: 25.898 TWh**
- **Scenario 3: Surplus electricity when including 32 nations (except Russia): 72.545 TWh**

In 2023, Europe (with the 33 nations considered in the study) generated a surplus electricity of 111. 345 TWh but this number drops down to a mere 26 TWh when considering only the 27 EU nations. Without Russia, the countries as a whole have generated a surplus of 72.5 TWh. The good news is there is a surplus of electricity which can be put to good use.

The sources of electricity for every country is quite mixed and not 100% from renewable sources. The reader is encouraged to refer to other sources/ references for detailed information on the electricity mix for each of the nations. For eg. France got its bulk share of the production from nuclear power whereas Norway got its bulk share from hydro power. Hence, whatever surplus is left for each country it is a mix between fossil and renewable electricity.

What was the hydrogen demand in Europe in 2023?

The exact statistic for hydrogen demand in Europe for 2023 could not be obtained however the number for 2022 was 8.2 million tonnes [3]. Let us assume that either demand stayed the same or increased by an optimistic value of 20 %. Now that brings the total hydrogen demand in Europe close to 10 million tonnes for 2023.

Can Electrolysis technology cater to this demand?

If the excess electricity generated were not to be dumped but instead put to use for hydrogen production via electrolysis (by means of Electrolysers) then the amount of hydrogen generated is as follows:

- **Scenario 1: Hydrogen produced when all 33 nations are taken into account: 2.227 million tonnes**
- **Scenario 2: Hydrogen produced when all 27 EU nations are taken into account: 0.518 million tonnes**
- **Scenario 3: Hydrogen produced when all 32 nations are taken into account (except Russia): 1.45 million tonnes**

Brief calculation methodology:

1. It takes roughly 50 kWh of electrical energy to produce 1 kg of hydrogen.
2. Excess electricity from three different scenarios is then used to calculate the 'kg' of hydrogen produced.

3. The 'kg' of hydrogen is then converted to 'million tonnes'.

	H2 produced from excess electricity in 2023 (million tonnes)	% of total demand in 2022	% of total assumed demand in 2023
Scenario 1	2.227	27.16	22.227
Scenario 2	0.518	6.3	5.18
Scenario 3	1.45	17.68	14.5

Table 1: Amount of hydrogen produced in three scenarios

With the above three scenarios, Europe would have managed to produce just 22.3 % of its total demand in the best case when taking into account all 33 nations, a mere 5.2 % when including just the 27 EU nations and just 14.5 % when including all 32 nations except Russia. This means, inspite of having excess electricity in the TWh range, Europe still needs to rely on natural gas steam reforming for meeting its remaining hydrogen demand. With the idea of not depending on Russia for natural gas or any other means, the task ahead is gigantic for Europe.

The above calculations are based on the assumption that there is sufficient Electrolyser capacity already installed in Europe. As of 2023, Europe had a total installed Electrolyser capacity of 191 MW [4]. This in turn translates to a production of just 3820 kg of hydrogen which is an extremely tiny fraction of the total assumed demand of 10 million tonnes.

Conclusions:

The conclusions that can be drawn from the data that is available from 2023 for hydrogen production via electrolysis for Europe as a whole is as follows:

- There is surplus electricity in the TWh range when considering the 33 nations. This surplus drops down significantly if one were to exclude Russia as the contribution from Russia to the total electricity surplus is close to 35%.
- Even if this surplus electricity were put to use solely for hydrogen production via electrolysis, it still doesn't meet the hydrogen demand of Europe, making them rely on natural gas steam reforming or imports for the remaining demand.

- Installed Electrolyser capacity is under 200 MW and there is ample scope for increasing this capacity. This is good news for Electrolyser manufacturers but doesn't serve the broader purpose of meeting hydrogen demand via electrolysis because the amount of excess electricity is just not enough let alone green electricity (produced solely from renewables).
- By including the nations not considered in the study, the results and conclusions are not going to vary drastically. One can add a few percentage points to the values if these nations are considered.

So what needs to be done in the light of this? First of all, excess electricity needs to be even higher to meet the assumed demand of 10 million tonnes of hydrogen, the excess electricity needs to be roughly 500 TWh. This is a humungous task and quite a capital intensive one and appropriate techno-economic studies need to be carried out to analyse if Europe should go down this path.

References:

[1] https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

[2] https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen/european-hydrogen-bank_en

[3] Clean Hydrogen Monitor 2023, a 168 page report published by Hydrogen Europe

[4] https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/water-electrolysis-and-hydrogen-growing-deployment-prospects-europe-and-beyond-2023-11-24_en#:~:text=In Europe – including the EU,of August 2022, estimates show.

Source of data for 'Projection Map':

<https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html> (Electricity Production - France, Germany, Portugal, Spain, Italy, Belgium, Netherlands, Norway, Sweden, UK, Poland, Russia, Romania, Czech Republic, Denmark)

<https://tradingeconomics.com/lithuania/energy-production-of-electricity-eurostat-data.html> (Electricity Production - for Lithuania, Estonia, Latvia, Austria, Finland, Luxembourg, Hungary, Ireland, Greece, Slovenia, Bulgaria, Croatia, Malta)

<https://www.swissgrid.ch/en/home/operation/grid-data/generation.html#energy-production> (for Switzerland - Electricity Production & consumption)

<https://lowcarbonpower.org/region/Slovakia> (Electricity production - Slovakia)

[https://www.statista.com/statistics/1260553/eu-power-demand-country/#:~:text=Power%20demand%20in%20the%20European%20Union%20\(EU\)%202023%2C%20by%20country&text=Germany%20is%20the%20largest%20electricity,demand%20of%20464%20terawatt%2Dhours.](https://www.statista.com/statistics/1260553/eu-power-demand-country/#:~:text=Power%20demand%20in%20the%20European%20Union%20(EU)%202023%2C%20by%20country&text=Germany%20is%20the%20largest%20electricity,demand%20of%20464%20terawatt%2Dhours.) (Electricity consumption data, except Russia, Norway, UK)

<https://www.statista.com/statistics/322874/electricity-consumption-from-all-electricity-suppliers-in-the-united-kingdom/#:~:text=The%20United%20Kingdom's%20electricity%20use,%2C%20at%20266%20terawatt%2Dhours.> (Electricity consumption of UK)

<https://tass.com/economy/1737381> (Electricity consumption of Russia)

<https://lowcarbonpower.org/region/Norway> (Electricity consumption of Norway, data was deduced)

<https://lowcarbonpower.org/region/Iceland> (Electricity production & consumption - Iceland)

<https://www.worlddata.info/europe/serbia/energy-consumption.php> (Electricity production and consumption for Serbia, available for 2021)



Disclaimer:

This article has been written by Dr. Vikrant Venkataraman, Director & Founder of VenkaCon Consulting. The analysis and data are based on pure facts that is available on the internet and the views expressed are solely meant for providing a practical and holistic view on the whole electrolysis topic which is receiving great attention as on date.