ewi Institute of Energy Economics at the University of Cologne
Exploring energy markets – enhancing decisions.

The American University in Cairo

The BRITISH UNIVERSITY IN EGYPT

UNIVERSITÄT ZU KÖLN


# Cluster analysis for green hydrogen in Egypt

## A study from the project "Building a Sustainable Energy Future" (BaSEF)


October 2023

Institute of Energy Economics at the University of Cologne

**Institute of Energy Economics**
**at the University of Cologne gGmbH (EWI)**

Alte Wagenfabrik
Vogelsanger Straße 321a
50827 Cologne/ Germany

Tel.: +49 (0)221 650 853-60
https://www.ewi.uni-koeln.de/en

## Written by

| The American University in Cairo | The British University in Egypt | University of Cologne International Office | Institute of Energy Economics at the University of Cologne |
|---|---|---|---|
| Norhan Mobarak | Andrew S. Tanious | Karim Zafer | Antonie Reinecke |
| Mahmoud Ali | Basma Khaled | Thilo Zimmermann, PhD | Tobias Sprenger |
| Yasser Elshayeb, Prof. | Abdelrahman Mokhtar | | Patricia Wild |
| | Ahmed AbdelAzim, Prof. | | Tina Zeinlinger |
| | Rania Miniesy, Prof. | | |

# Foreword

The goal of the joint project is the development of an overview paper for green hydrogen in Egypt. The analysis was prepared by the American University of Cairo (AUC), The British University of Egypt (BUE), and the Institute of Energy Economics at the University of Cologne (EWI). Students from AUC and BUE contributed to the content. EWI coordinated the project and took over the project management.

The project is part of the exchange project by the Deutsche Akademische Austauschdienst e. V. (DAAD) "Building a Sustainable Energy Future" (BaSEF) between the University of Cologne (UoC), The British University in Egypt (BUE), and the American University in Cairo (AUC) (BaSEF, 2023). BaSEF seeks to establish a cultural exchange between Egyptian and German students and junior researchers by building a research network focusing on sustainable energy topics. The aim of the BaSEF project is to build up a long-term academic cooperation between the UoC, the BUE, and the AUC, namely between the EWI and the Economic Department of the Faculty of Business Administration, Economics and Political Science, and the Faculty of Engineering of the BUE, and the Department of Petroleum and Energy Engineering of the AUC (BaSEF, 2023).

The cooperation focuses on connecting junior scholars from UoC, AUC, and BUE to work together on fields regarding sustainable energy. By establishing an academic dialogue on sustainable energy, students and junior scholars from the partner institutes exchange and discuss their ideas and knowledge to develop solutions regarding sustainable concepts and frameworks for a global energy future. This academic dialogue is highly needed as it could contribute to finding solutions for climate change. This German-Egyptian cooperation on sustainable energy can contribute to stronger research and sustainable economic relations between both countries, hence promoting sustainability and prosperity between Germany/Europe and Egypt/Middle East and North Africa (MENA) Region (UoC, 2023).

### Focus of this analysis

This joint project discusses the relevance of hydrogen in future energy systems and the opportunities for Egypt to produce and export green hydrogen and its derivates. For this, the activities along the value chain of hydrogen are highlighted. Figure 1 depicts the three stages of the hydrogen value chain, thus the three steps of the market ramp-up in Egypt: production, infrastructure, and utilization. To assess the low-carbon hydrogen production capacities in the region, low-carbon hydrogen projects are reviewed, including their installed production capacity and location.

The analysis is structured as follows: Chapter 1 examines the relevance of green hydrogen for Egypt. In chapter 2, Egypt's political strategy regarding the expansion of renewable energies (RE) and low-carbon hydrogen is presented. Next, the hydrogen market ramp-up in Egypt is analyzed, starting with a discussion of the current fossil fuel and future renewable hydrogen production in Egypt in chapter 3. Subsequently, infrastructure projects are reviewed in chapter 4 to assess the hydrogen export potential of Egypt. In chapter 5, the hydrogen demand for the ammonia, steel, refining, and methanol production industry are analyzed. Finally, the challenges and opportunities regarding the expansion of hydrogen are discussed in chapter 6.

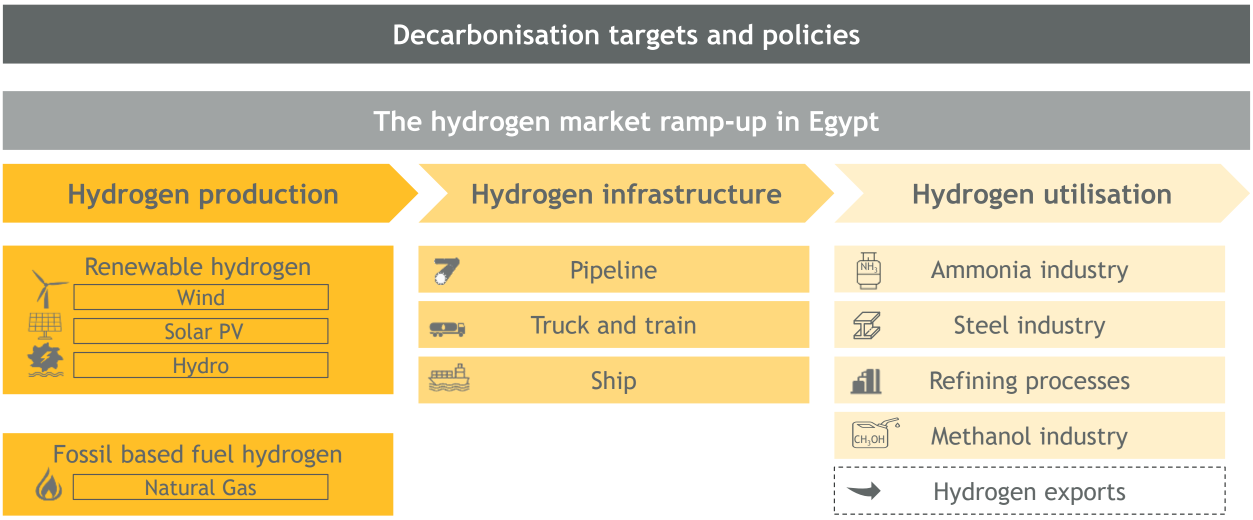


Figure 1: Graphical abstract

*Source: Own illustration*

# 1 Relevance of hydrogen in the future energy system

To meet climate targets as stipulated by the Paris Agreement 2015 and fight global warming, $CO_2$ emissions need to be cut significantly. Low-carbon hydrogen, in addition to electrification of end-use sectors, plays a central role in the decarbonization efforts of countries worldwide. Hydrogen, produced from renewable energies, can be used for multiple applications, and thereby contribute to the decarbonization of the transport, industry, and building sector, as well as for electricity provision and energy storage. Today, carbon-intensive hydrogen, produced from coal and natural gas, is used by countries worldwide as raw material in industry, e.g., for ammonia production or in refineries.

### The global hydrogen market ramp-up

In 2050, green hydrogen is expected to account for most of the hydrogen production (IRENA, 2022). Figure 2 provides an overview of various scenarios for global hydrogen demand in 2050, illustrating that - depending on the scenario - today's global hydrogen demand could multiply by a factor of 3 to 6 by 2050. About one-third of the green hydrogen used in 2050 could be traded across borders (IRENA, 2022).

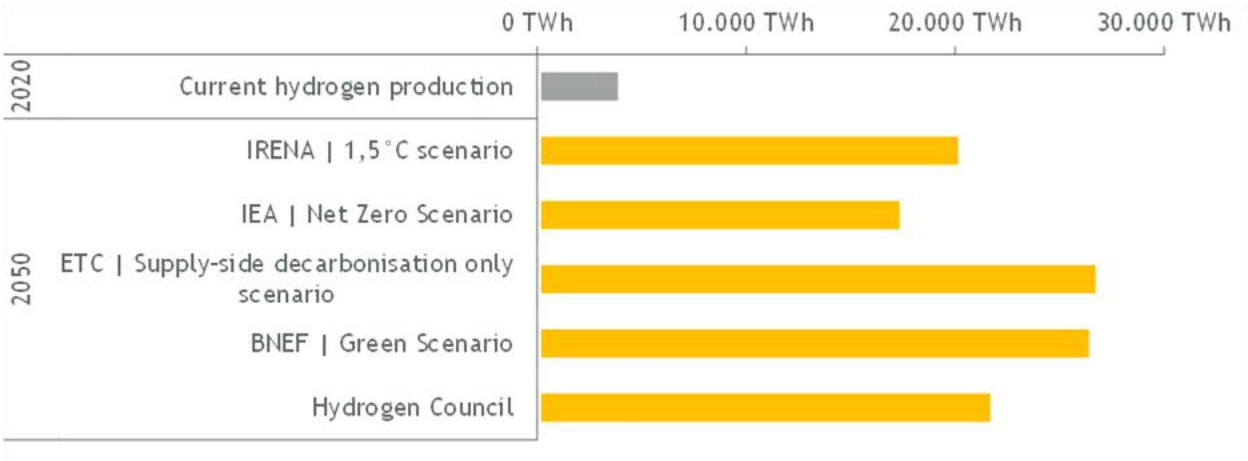


Figure 2: Estimations for the global hydrogen demand 2050

*Source: Own illustration based on IRENA (2022)*

While all countries worldwide have some RE potential, not all countries are equally endowed with RE sources. A country's potential to produce green hydrogen competitively primarily depends on its RE potential and its availability of water sources. Since hydrogen and hydrogen derivatives can be stored and transported over long distances, this opens new opportunities for countries endowed with major RE potentials (e.g. countries in Africa, the Middle East, Latin America, and Australia) to produce green hydrogen and transport it to major demand centers (e.g., in Europe or Asia).

### Egypt as potential hydrogen supplier

Egypt has significant potential for generating RE carriers from wind and solar. Around 30 % of the Egyptian land is suitable for wind farms (Hamid, 2011). Additionally, the country is endowed with major photovoltaic (PV) potential, which makes it possible to generate renewable at a competitive price (OIES, 2021). For countries endowed with major RE potential, such as Egypt, the production and export of RE-based hydrogen and hydrogen derivates could offer an attractive business case and opportunities for economic development.

Since hydrogen is not (yet) globally traded, market structures for global hydrogen trade still have to be established. Governments worldwide are increasingly facilitating the ramp-up of a global hydrogen economy by releasing hydrogen strategies and roadmaps or by introducing specifically targeted hydrogen support measures. Also, the private sector announced many projects around the globe.

As one of the largest economies in the MENA region, Egypt owns considerable energy sources, particularly natural gas (Esily, 2022). In recent years, Egypt's potential for hydrogen production is increasingly recognized, as can be seen by the vast amount of hydrogen projects that have been announced since then. Against this backdrop, there are two pathways for hydrogen in Egypt: On the one hand, hydrogen can be exported to large demand centers, e.g., Europe. On the other hand, it can be deployed for domestic consumption as the country has a significant demand for hydrogen used in fertilizer production, the steel, and refining industry.

# 2 Renewable energy and hydrogen policies in Egypt

The expansion of the RE sector is crucial for the decarbonization of a country and for producing green hydrogen. The following presents promotion measures of REs. After that, political initiatives for establishing a hydrogen market in Egypt will be introduced.

### Egypt's renewable energy policies

In 2014, the Egyptian government issued the first Renewable Energy Law (No. 203), governing four measures to encourage private investment into RE. One of the law's primary objectives is to enable a gradual transition from state-administered projects to privately financed projects. The measures include competitive bids, feed-in tariffs, and independent power production through third-party access (IRENA, 2018).

- **Competitive bidding:** Projects for the construction of renewable energy power are undertaken by the New and Renewable Energy Authority (NREA), and the electricity produced is sold to the Egyptian Electricity Transmission Company (EETC) at a price determined by the Egyptian Electric Utility and Consumer Protection Regulatory Agency.

- **Competitive bidding scheme for private companies:** Projects run by the EETC and open for private investment on a build-own-operate basis where generated electricity will be sold at a negotiated price between EETC and the plant owner.
- **Feed-in tariff support system:** Projects governed by a feed-in-tariff support system where private investors sell electricity to EETC according to the installed capacity and type of renewable.
- **Independent power production through third-party access:** Private producers are allowed direct selling to consumers conditioned by EETC approval and availability of grid network and subject to a grid access fee.

Additionally, the Egyptian government targeted the total phase-out of fossil fuel subsidies in 2018/2019 but later extended it to 2021/2022 and then to 2024/2025 (Ahram Online, 2022).

### Egypt's renewable energy targets

In February 2008, the Egyptian Supreme Council of Energy approved the first renewable energy target for 2020. This involved electricity generation from 20 % RE, consisting of 12 % wind, 6 % hydro, and 2 % PV (IRENA, 2018). This target, however, was extended to 2022.

In January 2013, the Government of Egypt initiated a 20-year strategy, the Integrated Sustainable Energy Strategy (ISES) 2015 to 2035, through a project financed by the European Union and established in cooperation with all relevant national partners. The ISES aims to ensure energy security, stability, and sustainability through the widespread expansion of renewable energy technologies. With the ISES to 2035, Egypt is increasing its RE target, aiming to reach over 40 % of installed RE capacity by 2035 (IRENA, 2018).

Based on the ISES to 2035, Egypt targets electricity generation from 55 % thermal power plants, 42 % RE, and 3 % nuclear energy by 2035 (see Figure 3). The breakdown for renewable electricity generation targets is as follows: 22 % from PV sources, 14 % from wind, 4 % from concentrated solar power (CSP), and 2 % from hydroelectric power. In particular, the target for PV increased significantly, displaying a shift in the strategy compared to 2008. Reports suggest that the revised timeline extending to 2040 will incorporate elements such as hydrogen production and a strategic plan for promoting a green economy in Egypt (Ersoy, S. R. and Terrapon-Pfaff J., 2022).

In 2020/21, Egypt had 88 % of its electricity generation from thermal power plants and 12 % from REs, composed of 7 % hydroelectric power, 2 % PV, and 3 % wind power (see Figure 3). By achieving a 2 % electricity generation from PV in 2020/21, the PV generation would effectively fulfill the target for 2022. Hydroelectric power would surpass its objective for 2022 by a margin of 1 %-points. Nonetheless, wind energy would fall below the target for 2022, with only a 2 % contribution to electricity generation in 2020/21, expected to fail its targeted 12 % share by 2022.

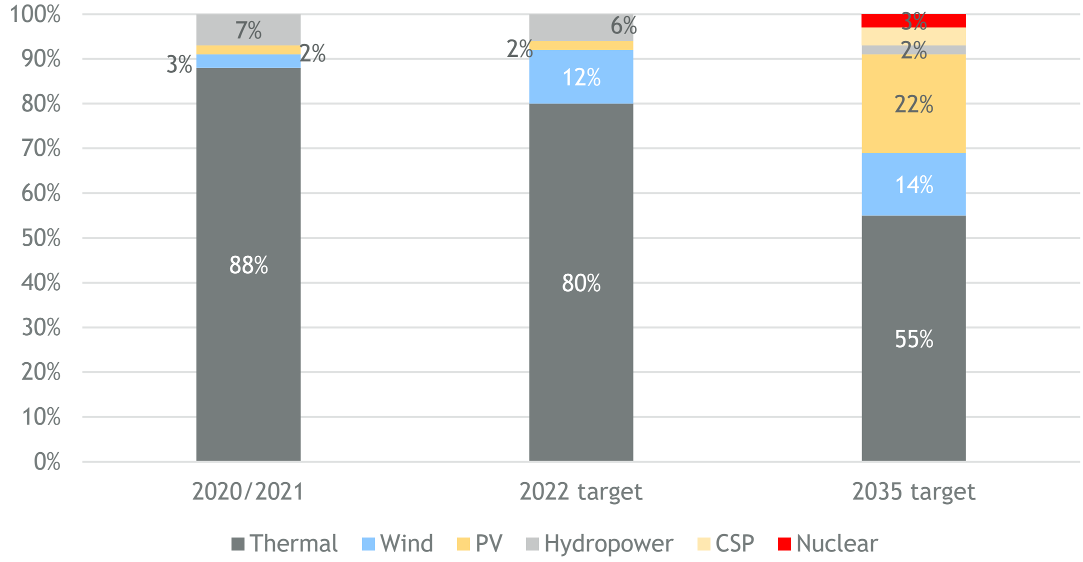


**Figure 3: Egypt's electricity mix and targets**

*Source: Own illustration based on IRENA (2023) and NREA (2023)*

### Egypt's hydrogen policies

There have been plans for Egypt to publish its first hydrogen strategy at the Climate Change Conference in 2022 (COP27) (Hydrogen Europe, 2022). Nevertheless, as of August 2023, Egypt has not yet released any national hydrogen strategy despite the intended plan. In the meantime, several agreements with international partners and companies for green hydrogen production, especially in the Suez Canal Economic Zone (SCZONE), have been signed.

Several hydrogen projects have been released during COP27 in 2022; their production facilities will be placed at SCZONE: East Port Said and Sokhna. Each of these projects focuses on generating a certain amount of hydrogen then increasing it annually, depending on the provided facilities added to the methods used in each project. The Egyptian authorities project their investments in green hydrogen initiatives to reach approximately USD 41.5 billion by 2030, with plans to increase this figure to USD 81.6 billion after that. Consequently, the government's contribution is anticipated to comprise 20 % to 25 % of the overall investment in the initial phase of these projects (Daily News, 2022).

Egypt has several partnerships with international corporations to establish a regional hub for green hydrogen production. For instance, Egypt Green consortium including the Norwegian RE company Scatec, plans to develop a green hydrogen production project in Ain Sokhna. The facility will become Africa's first integrated green hydrogen plant upon completion. It will encompass a 100 MW electrolyze capacity, powered by 260 MW of solar and wind energy (Energy & Utilities, 2022).

Egypt also announced in 2022 the setup of the Golden Licenses Unit, which is a legal framework to facilitate the licensing process for companies that contribute to the achievement of sustainable development. Green hydrogen projects (including production, transportation, storage, distribution, and export) also qualify for the license (GAFI Translation Department, 2022).

# 3 Hydrogen production

After presenting the political landscape of RE and green hydrogen policies, the following section elaborates on Egypt's various hydrogen production processes. Moreover, the costs of green hydrogen in Egypt will be outlined and compared with the MENA region.

Countries in the MENA region have significant hydrogen production potential. Figure 4 provides an overview of the hydrogen production potential of selected MENA countries in 2025. Particularly, Sudan (210,559 TWh), Saudia-Arabia (107,760 TWh), and Egypt (96,280 TWh) have high potential (EWI, 2022b).

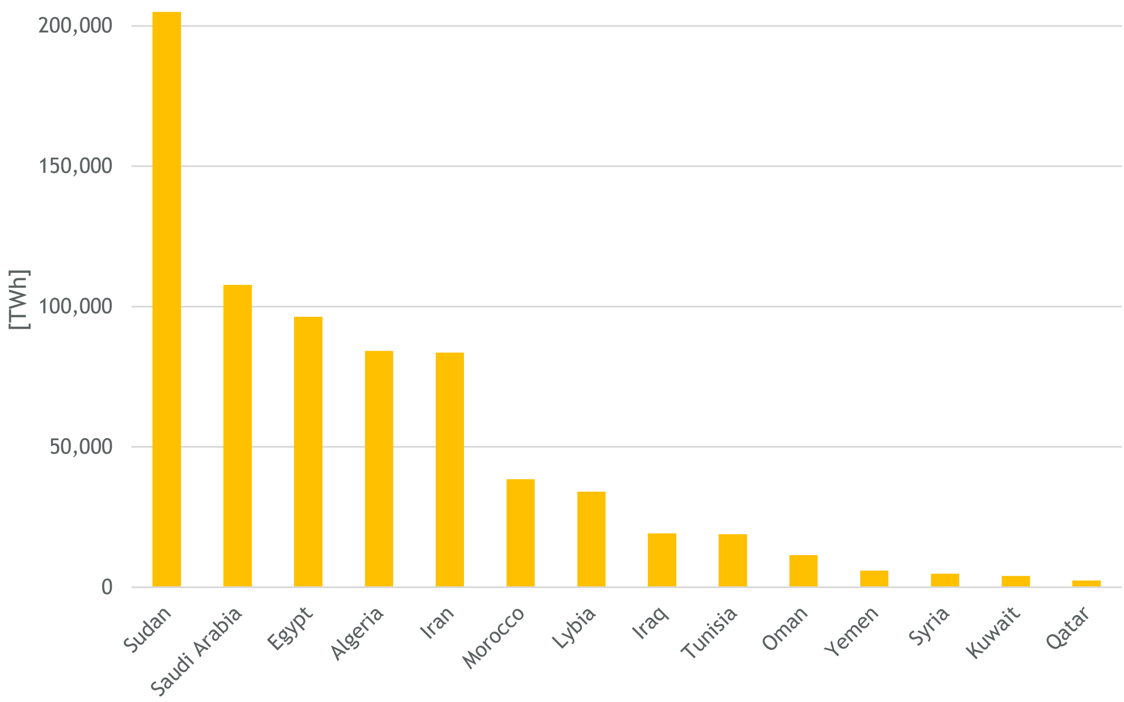


Figure 4: Hydrogen production potential in MENA countries 2025

*Source: Own illustration based on EWI (2022b)*

**Infobox: Hydrogen production pathways**

Hydrogen production can be achieved through various processes, with most of it currently coming from natural gas (76%) and coal (remaining share) as of 2019 (IEA, 2019). However, this conventional approach leads to significant $CO_2$ emissions, contributing to approximately 830 Mt$CO_2$ annually (IEA, 2019). Electrolysis hydrogen, on the other hand, accounts for only about 2% of global hydrogen production (IEA, 2019). Additionally, hydrogen is produced as a by-product in certain industrial processes like refineries or chlorine production.

To address the environmental impact, there is a growing push towards low-carbon hydrogen production, which can be achieved through three pathways.

- The first is blue hydrogen, which involves capturing and storing $CO_2$ emissions from hydrogen production derived from fossil fuels, primarily through steam methane reforming (SMR).
- The second pathway is green hydrogen, produced via water electrolysis using RE sources for electricity.
- Finally, there's 'turquoise' hydrogen, produced through pyrolysis of hydrocarbons with solid carbon extraction.

Currently, most low-carbon hydrogen projects are in the demonstration or pilot stages, but efforts to commercialize and scale up these technologies are underway.

Various electrolysis technologies are being explored, with some still under development. These include alkaline electrolysis, PEM electrolysis, and solid oxide electrolysis (not yet commercially available). These technologies hold significant potential in terms of efficiency and cost reduction. For example, the electrical efficiency of alkaline electrolysis, which was around 63-70% in 2019, is expected to reach up to 80% in the long term (IEA, 2019).

One mature electrolysis technology is chlor-alkali electrolysis, where sodium chloride (NaCl) is electrolyzed in brine to produce hydrogen, sodium hydroxide, and chlorine. As hydrogen is produced as a by-product in this process, it can be utilized by other industrial processes. When electricity from RE sources is used for chlor-alkali electrolysis, the produced hydrogen is classified as low-carbon.

An example of a chlor-alkali electrolysis plant was constructed by Nuberg EPCA for an Egyptian petrochemical project in Alexandria, Egypt, with a capacity to produce 228 temperature-programmed desorption of chlorine, soda, and chlorine derivatives (Nuberg, 2023). This plant has the potential to contribute to hydrogen production through the chlor-alkali electrolysis method. Initially, this process was performed using freshwater and conventional electricity, but to enhance its viability and sustainability, solar power will be employed to provide the required renewable electrical power for the electrolysis process.

Another method to generate low-carbon hydrogen is SMR with carbon capture storage (CCS). This process depends on the existence of the high temperature and steam, where the hydrogen is generated from a methane source. There is also a second stage for this process called “water-gas shift reaction” when the carbon monoxide reacts with the steam to release more hydrogen. As for Egypt, this process will require CCUS facilities which will cause a challenge for the Egyptian government; however, $CO_2$ will help in facilitating the Enhanced Oil Recovery (EOR) operation, and this will lead to enhancing the hydrocarbon production in Egypt. Global CCS stated that around the world there are only 27 CCS facilities, so this will increase the challenges to produce the hydrogen using the SMR.

According to a model projection by the EWI, Egypt has levelized costs of hydrogen (LCOH) ranging between 82 and 112 USD/MWh in 2030. The LCOH in Egypt can decline to 42 to 72 USD/MWh in 2050 (see Figure 5). The total cost for ammonia production from RE would decline to 95 USD/MWh in 2050 in an optimistic scenario (EWI, 2022b). However, despite the country's significant RE and hydrogen production potential, Egypt – in global comparison – is not ranking among the countries with the lowest LCOH. Besides the LCOH, the hydrogen supply costs to potential demand centres are determined by additional factors. In particular, transport costs for hydrogen and its derivatives play a central role in the potential to supply hydrogen cost-competitively.

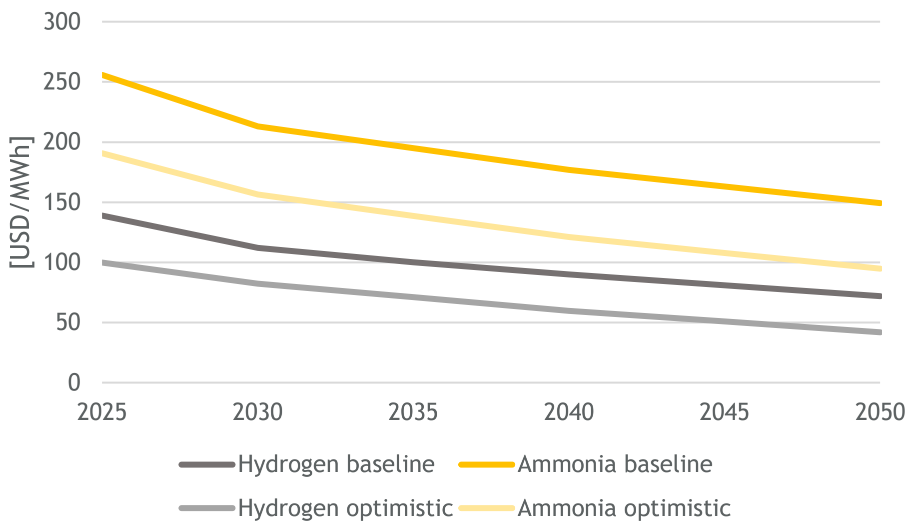


**Figure 5: Development of total production cost for hydrogen and ammonia in Egypt**

*Source: Own illustration based on EWI (2022b)*

# 4 Hydrogen infrastructure

With the increased momentum into green hydrogen production in Egypt, an efficient hydrogen infrastructure needs to be developed. As today hydrogen production is located where hydrogen is consumed, thus large infrastructures are not established yet. In the short term it is expected that green hydrogen will be produced in clusters to supply industrial facilities or refineries. Over time, however, to be structurally competitive with unabated fossil fuels the production of hydrogen moves further away from demand centers to areas with high wind and solar resources (IEA, 2022a).

When the potential in Egypt for generating renewable energy carriers from wind and solar is exploited, and a hydrogen industry is ramping up, a hydrogen infrastructure will be necessary for long transport distances.

For this, repurposed new natural gas as well as new pipelines can be used. The degree of repurposing, and thus the need for new construction, depends on the quantities of hydrogen to be transported in the future, the future localization of production and demand of hydrogen and the future demand for natural gas (for domestic use and for export).

A comprehensive hydrogen infrastructure project includes the facilities needed to produce, store, and transport hydrogen to end users either nationally or internationally. The distance between production sites, hydrogen facilities, and end users significantly affects the design and extent of an infrastructure project (Steen, 2016).

One potential approach to facilitate a cost-efficient establishment of hydrogen infrastructure involves repurposing existing natural gas pipelines. In a decarbonized economy, the demand for natural gas will be reduced drastically, which leads to lower utilization of natural gas pipelines in the medium to long term. For creating a viable hydrogen infrastructure, it is crucial to use precise data on the natural gas network, the natural gas demand, and the temporal patterns of these factors, alongside a dependable forecast of hydrogen supply and demand. Such comprehensive information is indispensable for developing a suitable hydrogen distribution system (EWI, 2022a).

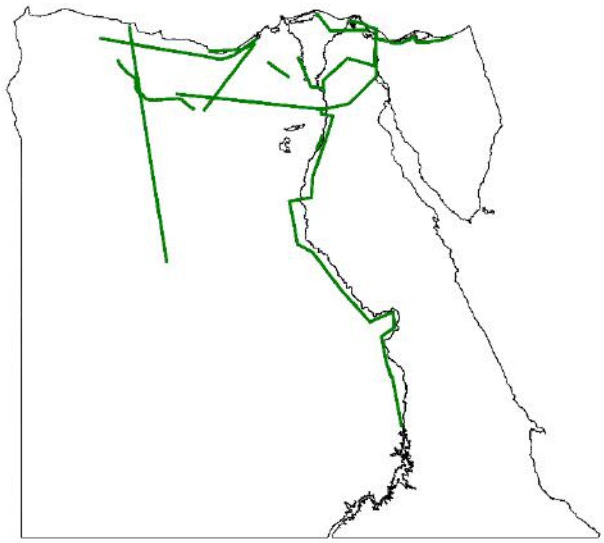

**Figure 6: Existing natural gas pipelines in Egypt as of December 2022**

*Source: Own illustration based on Global Energy Monitor (2022)*

Egypt's existing gas pipeline network, with 3,545 km in total, is illustrated in Figure 6. Additionally, Egypt has 290 km of pipelines under construction and 622 km of pipelines proposed (Global Energy Monitor, 2022). These New pipeline projects are expected to transform Egypt into a regional hub for the natural gas industry (Fatma, 2022).

# 5 Hydrogen demand

After examining hydrogen production and infrastructure in Egypt, this chapter sheds light on the country's demand for hydrogen. Therefore, the relevant hydrogen demanding industries are reviewed. This includes the fertilizer industry, the steel industry, and the petroleum-related industries. Several assumptions are made to determine the current demand for hydrogen in Egypt, which is entirely met by grey hydrogen. As the entire hydrogen production in Egypt is consumed domestically, we assume that production volumes can be roughly equated with the major consumption volumes (OIES, 2021).

### Hydrogen in the ammonia industry

The fertilizer industry uses hydrogen to produce ammonia, which is used to produce nitrogenous fertilizers. Egypt ranks among the top ammonia producers globally and is recognized as the largest ammonia producer in Africa.

In 2019, Egypt produced 4.2 million tons of ammonia (USGS, 2023). Until now, this demand has been met by carbon-intensive hydrogen. Thereby, the costs of natural gas are the dominating costs of ammonia production, accounting for up to 90 % (Agora Industry & Agora Energy Transition, 2023). Figure 7 shows the historical hydrogen consumption in the fertilizer industry from 2011 to 2019.

Starting in 1960, green hydrogen for ammonia production was generated in Egypt using electricity from hydropower supplied by the Aswan dam. However, the plant was decommissioned in 2019. A new plant commissioned replaced green hydrogen with grey hydrogen using SMR (Habib, 2021; Ammonia Energy Association, 2023).

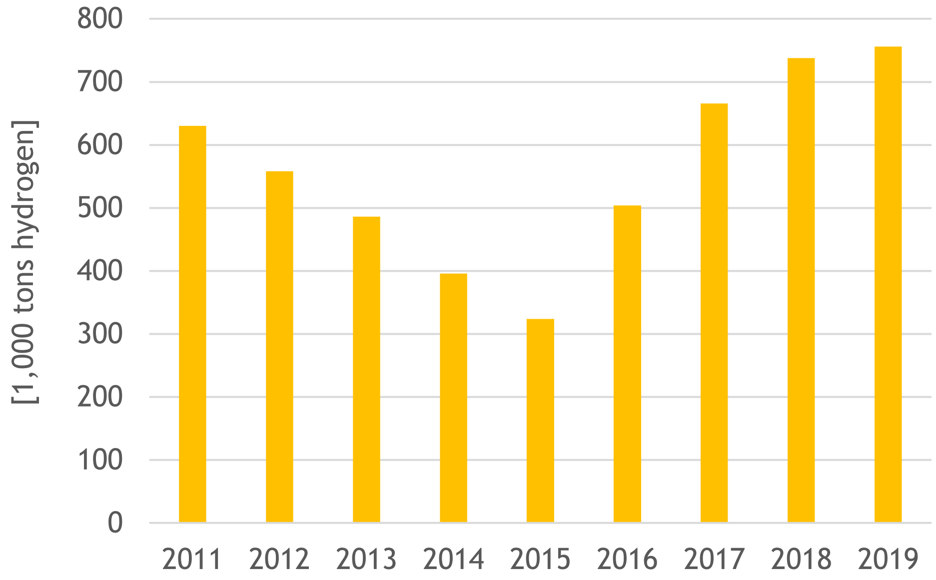


**Figure 7: Estimated hydrogen consumption in the ammonia industry**

*Source: Own illustration based on OIES (2021), USGS (2019) and USGS (2023)*

### Hydrogen in the steel industry

Today, the steel industry is the second biggest consumer of hydrogen in Egypt. Hydrogen is used in steel production in the Direct Reduction Iron (DRI) process (Habib, 2021). In the DRI process, oxygen is removed from iron in the solid state using hydrogen and carbon monoxide as agents. Egypt has an approximate total annual production capacity of 8.95 million tons of DRI (Habib, 2021).

Table 1 gives an overview of steel plants in Egypt. Currently, eight plants are in operation, and an additional one is under construction. Besides the DRI route, the Electric Arc Furnace (EAF) process also plays a role in Egyptian steelmaking, whereby no hydrogen is utilized (Global Energy Monitor, 2023).

Figure 8 shows an increasing demand for hydrogen by the DRI industry after 2016 (USGS, 2019; USGS, 2023). The increased demand for crude steel from the DRI process, and hence increased hydrogen consumption, is due to the increasing interest of the country in megaprojects that require huge amounts of steel, e.g., wind station project, Jabal Al-Zeit, in the Middle East with 580 MW (Magdi, 2018).

**Table 1: Steel plants in Egypt**

| Steel Plant | Company Name | Crude steel capacity [in thousand tons per annum] | Iron capacity [in thousand tons per annum] | Primary steelmaking process | Status |
|---|---|---|---|---|---|
| Egyptian Steel Beni Suef plant | Egyptian Steel | 600 | N/A | Electric | Operating |
| Al-Ezz Dekheila Steel Alexandria plant | Al Ezz Dekheila Steel Company Alexandria SAE | 3,200 | 3,100 | Integrated (DRI), EAF | Operating |
| Ezz Steel Rebar Sadat City plant | Ezz Steel Co SAE | 1,000 | N/A | Electric | Operating |
| Egyptian American Steel Rolling Company Sadat City plant | Egyptian American Steel Rolling C | 1,200 | N/A | Electric | Operating |
| Egyptian Sponge Iron and Steel Company Sadat City plant | Egyptian Sponge Iron & Steel Co | 3,000 | 2,000 | Integrated (DRI) | Operating |
| Suez Steel Solb Misr Attaka plant | Suez Steel Company SAE | 2,100 | 2,100 | Integrated (DRI) | Operating |
| Egyptian Steel Ain Sokhna plant | Egyptian Steel | 600 | N/A | Electric | Operating |
| Ezz Flat Steel Ain Sokhna plant EAF expansion | Al Ezz for Flat Steel Industries Company SAE | 1,600 | N/A | Electric | Construction |
| Ezz Flat Steel Ain Sokhna plant | Al Ezz for Flat Steel Industries Company SAE | 2,300 | 1,900 | Integrated (DRI) | Operating |

*Source: Global Energy Monitor (2023)*

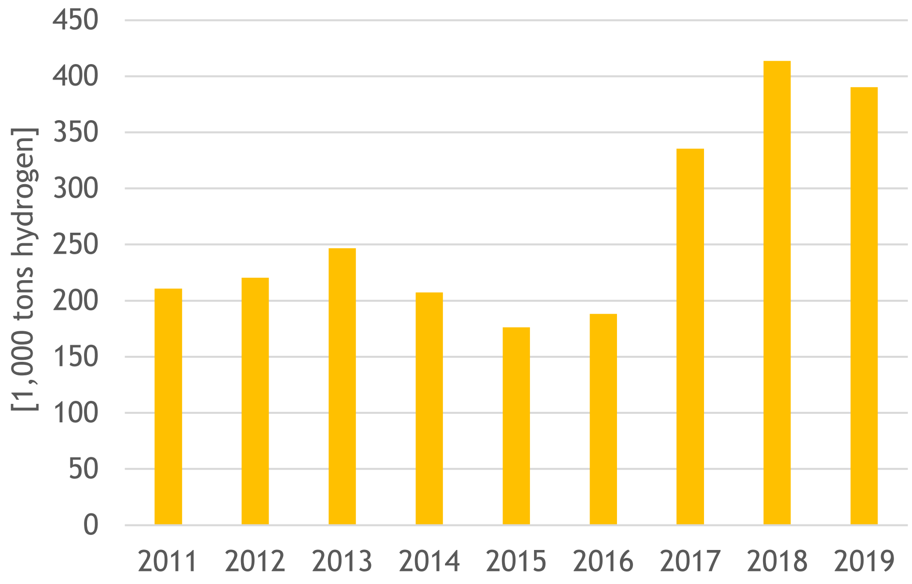


**Figure 8: Estimated hydrogen consumption in the steel industry**

*Source: Own illustration based on OIES (2021), USGS (2019) and USGS (2023)*

## Hydrogen in refining processes

Refineries utilize hydrogen to reduce the sulfur content in petroleum products, such as diesel fuel, kerosine, etc. (EIA, 2022; Habib, 2021). The refining industry is one of the earliest industries to be established in Egypt to supply the market with its needs for gasoline and diesel fuel and other products that shaped the core of the industrial transformation in Egypt.

Figure 9 shows the hydrogen demand for crude oil production for the years 2011 to 2019. After the 2011 revolution in Egypt, the demand for oil products increased slightly, thus increasing the hydrogen consumption. However, when considering the long-term development of crude oil production since 1993, it becomes evident that it has been consistently declining. One significant reason for this is the decreasing output from older onshore fields. In parallel, oil consumption has increased, leading Egypt to transition from a net exporter to a net importer since 2010 (Ahmed, D. A. & Ahmed, A. A., 2019).

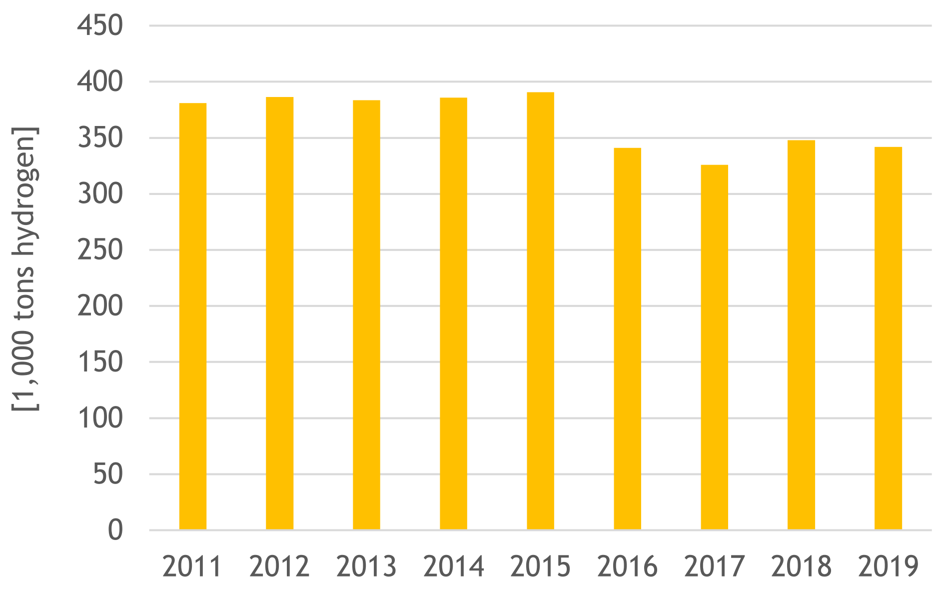


**Figure 9: Estimated hydrogen consumption in refining processes**

*Source: Own illustration based on OIES (2021), USGS (2019) and USGS (2023)*

### Hydrogen in the methanol production industry

The methanol production is considered as one of the major hydrogen consumers. Today, methanol is mainly produced as a product from natural gas using SMR (Borisut and Nuchitprasittichai, 2019).

In the first decade of the 21st century, methanol production through hydrogenation of carbon dioxide was very limited. In Egypt, the lone methanol production plant in the nation was founded in 2011. Situated in Damietta, this facility possesses a production capability of up to 1.3 million metric tons of methanol annually, primarily catering to domestic and European markets (Methanex, 2023).

Figure 10 shows the hydrogen consumption in methanol production in Egypt in 2018[1].

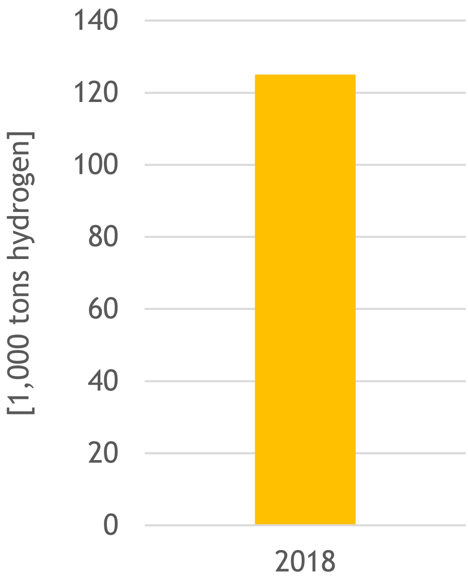


**Figure 10: Estimated hydrogen consumption in the methanol production**

*Quelle: Own illustration based on EGYPS (2019) and OIES (2021)*

[1] Production volumes on methanol are not publicly available for other years.

# 6 Challenges and opportunities

Hydrogen has increasing relevance in the future energy system. Low-carbon hydrogen is crucial for decarbonizing various sectors such as transport, industry, and energy storage. The global hydrogen market is expected to witness significant growth, with green hydrogen accounting for the largest share by 2050.

Egypt, with its significant potential for generating RE from wind and solar, could become a major hydrogen producer and exporter. The country holds both significant challenges and promising opportunities as it seeks to build up a hydrogen economy. The transition to a hydrogen-based economy presents various obstacles but also offers the country a chance to enhance sustainability, economic growth, and technological advancement. The conclusion highlights the main challenges faced by Egypt and the potential opportunities that lie ahead:

### Challenges

- **Water scarcity**: One of Egypt's most critical challenges for green hydrogen production is its limited water resources. Green hydrogen production requires water for electrolysis, which can strain already scarce water supplies. The government needs to adopt innovative water management strategies to ensure sustainable hydrogen production without exacerbating water scarcity issues. Desalination or direct use of salt water is one option since Egypt has two large sources of salt water - the Red Sea and the Mediterranean Sea (OIE, 2021).
- **Infrastructure development**: Establishing a hydrogen infrastructure capable of distributing and transporting hydrogen efficiently is a significant challenge and is associated with high investment costs. Repurposing existing natural gas pipelines can be an initial step, but further investment in new infrastructure for transport and export could be necessary, depending on the sources and sinks of low-carbon hydrogen.
- **Policy and regulatory frameworks**: To attract investments and foster the growth of the hydrogen sector, Egypt needs to create a robust and clear policy framework for renewable energies and hydrogen. This includes establishing supportive regulations, providing financial incentives, and ensuring a stable and predictable investment environment.

### Opportunities

- **Climate targets and sustainability**: Transitioning to green hydrogen aligns with Egypt's commitment to the Paris Agreement and its climate targets. Egypt can contribute to global efforts to combat climate change and enhance its environmental sustainability by reducing carbon emissions in sectors such as transportation, industry, and power generation.
- **Major renewable energy potential**: Egypt's vast wind and solar energy potential provides a significant opportunity for green hydrogen production. By exploiting its renewable resources, Egypt can produce hydrogen competitively.

- **Hydrogen demand in Egypt**: Egypt already has a considerable demand for hydrogen. Its demand is today mainly driven by industries such as fertilizers, steel, refining processes, and methanol production. As green hydrogen becomes more accessible, these industries should consider transitioning to low-carbon hydrogen to reduce emissions.
- **Growing number of announced projects**: The growing number of hydrogen projects announced in Egypt highlights the increasing interest and commitment to the hydrogen market ramp-up. These projects, which include green hydrogen production, ammonia, and other hydrogen derivatives, demonstrate the willingness of international corporations and partners to invest in Egypt's hydrogen future. The accumulation of these projects opens up possibilities for technology transfer, knowledge exchange, and economic growth through collaboration with global stakeholders. Furthermore, these projects provide a platform for local businesses and industries to adopt and integrate hydrogen technologies into their operations, fostering a culture of innovation and sustainability in Egypt.
- **Economic diversification**: The hydrogen economy offers Egypt an opportunity to diversify its economy and reduce its dependency on fossil fuel exports. Investing in green hydrogen projects can open up new fields of business, attract foreign investments, and generate job opportunities in the renewable energy and hydrogen industries.
- **Strategic geographical location**: Egypt's strategic geographical location, with the Suez Canal serving as a major international maritime trade route, presents an advantage for the hydrogen economy. The canal's proximity to major global demand centers in Europe and Asia provides Egypt with a competitive edge in exporting green hydrogen. By leveraging the Suez Canal as a hydrogen export gateway, Egypt could establish itself as a player in the emerging global hydrogen market, facilitating the trade of green hydrogen between continents.
- **Regional leadership and cooperation**: As one of the largest economies in the MENA region, Egypt has the opportunity to position itself as a regional leader in the hydrogen economy. The country could attract international partnerships and investments by developing a comprehensive hydrogen strategy, enhancing its standing in the global renewable energy market.

Egypt faces several challenges as it embraces the hydrogen economy, including water scarcity, infrastructure development, and policy frameworks. However, the country could also leverage its abundant RE potential, achieve economic diversification, and become a regional leader in the hydrogen market. By overcoming the challenges and seizing opportunities, Egypt can pave the way for a sustainable, low-carbon future while contributing to the global fight against climate change.

# References


Ammonia Energy Association. (2023). Technology status: ammonia production from electrolysis-based hydrogen. https://www.ammoniaenergy.org/articles/technology-status-ammonia-production-from-electrolysis-based-hydrogen/, published 1/31/2023

Agora Industry & Agora Energy Transition. (2023). Argentina as a hub for green ammonia A forward-looking development strategy for addressing the global energy and climate crises. *AET_284_Argentina-hub-green-ammonia_WEB.pdf (agora-energiewende.de)

Ahram Online. (2022, July 14). Egypt to spend EGP 55 billion in annual diesel subsidies despite raising fuel prices: PM. https://english.ahram.org.eg/News/471494.aspx#:~:text=Egypt%20was%20initially%20planning%20to,more%20gradually%20through%202024%2D2025

Ahmed, D. A., & Ahmed, A. A. (2019). The impact of energy prices on electricity production in Egypt. *International Journal of Energy Economics and Policy*, *9*(5), 194-206.

BaSEF. (2023). BaSEF Egyptian-German cooperation project between the University of Cologne in Germany, the British University in Egypt and the American University in Cairo funded by the DAAD. https://basef-network.com/

Borisut, P., & Nuchitprasittichai, A. (2019). Methanol production via CO2 hydrogenation: Sensitivity Analysis and simulation—based optimization. Frontiers in Energy Research, 7. https://doi.org/10.3389/fenrg.2019.00081

Daily News. (2022). Egypt seeks to activate MoUs for green hydrogen production at COP27. https://www.dailynewsegypt.com/2022/06/07/egypt-seeks-to-activate-mous-for-green-hydrogen-production-at-cop27/

EGYPS. (2019). The Egyptian Petrochemicals Industry. http://echem-eg.com/wp-content/uploads/2019/04/Petrochemicals-industry-current-threats-and-future-plans-.pdf

EIA. (2022). Hydrogen for refineries is increasingly provided by industrial suppliers. Homepage. https://www.eia.gov/todayinenergy/detail.php?id=24612#:~:text=Refineries%20use%20hydrogen%20to%20lower,regulations%20have%20become%20more%20stringent

Energy & Utilities. (2022). Egyptian green hydrogen breakthrough announced at COP 27. https://energy-utilities.com/egyptian-green-hydrogen-breakthrough-announced-at-news119410.html

Ersoy, S. R. and Terrapon-Pfaff J. (2022). Sustainable transformation of Egypt's energy system: development of a phase model. https://egypt.fes.de/fileadmin/user_upload/documents/publication/Wuppertal_Inst_Sustainable_Transformation_of_Egypt_s_Energy_System_final_ENG.pdf

Esily, R. R., Chi, Y., Ibrahiem, D. M. & Chen, Y. (2022). Hydrogen strategy in decarbonization era: Egypt as a case study. In International Journal of Hydrogen Energy, 47(43). https://doi.org/10.1016/j.ijhydene.2022.04.012

European Commission. (2022). European Union, Trade in goods with Egypt. https://webgate.ec.europa.eu/isdb_results/factsheets/country/details_egypt_en.pdf

EWI. (2022a). Development of a Hydrogen Market in Eastern Germany until 2045. https://www.ewi.uni-koeln.de/cms/wp-content/uploads/2022/02/20220209_EWI_Development-of-a-Hydrogen-Market-in-Eastern-Germany-until-2045.pdf

EWI. (2022b). Global PtX Cost Tool. https://www.ewi.uni-koeln.de/de/publikationen/globalesptx-produktions-und-importkostentool/

Global Energy Monitor. (2022). Global Gas Infrastructure Tracker. https://globalenergymonitor.org/projects/global-gas-infrastructure-tracker/

Global Energy Monitor. (2023). Global Steel Plant Tracker. https://globalenergymonitor.org/projects/global-steel-plant-tracker/tracker-map/

GAFI Translation Department. (2022). Golden License Guidebook. https://www.investinegypt.gov.eg/Fact%20Sheets/Golden%20License%20Guidebook.pdf

Hamid, R. H. A. (2011). A GIS-DSS for wind farms industry in Egypt. In 2011 International Conference & Utility Exhibition on Power and Energy Systems: Issues and Prospects for Asia (ICUE) (pp. 1-7). IEEE.

Habib, A., & Ouki, M. (2021). In Egypt's Low Carbon Hydrogen Development Prospects. Oxford; Oxford Institute for Energy Studies.

Hydrogen Europe. (2002). Egypt launches H2 strategy. https://hydrogeneurope.eu/egypt-launches-h2-strategy/

IEA. (2022a). Global Hydrogen Review 2022. https://www.iea.org/reports/global-hydrogen-review-2022

IEA. (2019). The Future of Hydrogen: Seizing today’s opportunities. https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf

IRENA. (2018). Renewable Energy Outlook: Egypt. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf

IRENA. (2022). Geopolitics of the Energy Transformation: The Hydrogen Factor. https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-TransformationHydrogen

IRENA. (2023). Energy Profile Egypt. https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Africa/Egypt_Africa_RE_SP.pdf

Nuberg. (2023). Chemicals & Fertilizers. https://www.nubergepc.com/index.html

Magdi, H. (2018). Egypt’s Mega Projects - Flanders Investment & Trade. Flanders Investment and Trade Market Survey. https://www.flandersinvestmentandtrade.com/export/sites/trade/files/market_studies/2018%20-%20Egypt%27s%20Mega%20Projects.pdf

Methanex. (2023). Egypt. https://www.methanex.com/about-us/global-locations/egypt/

OIES. (2021). Egypt’s Low Carbon Hydrogen Development Prospects. https://a9w7k6q9.stackpathcdn.com/wpcms/wp-content/uploads/2021/11/Egypts-Low-Carbon-Hydrogen-Development-Prospects-ET04.pdf

SCZONE. (2022). Green Fuel Ready. https://sczone.eg/events/sczone-in-cop27/

Steen, M. (2016). Building a hydrogen infrastructure in the EU. https://doi.org/10.1016/B978-1-78242-364-5.00012-9

UoC. (2023). DAAD BASEF Egypt. https://portal.uni-koeln.de/international/global-responsibility/projects/daad-basef-egypt

USGS. (2023). 2019 Minerals Yearbook. https://pubs.usgs.gov/myb/vol3/2019/myb3-2019-egypt.pdf

USGS. (2020). Mineral Commodity Summaries 2020. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf

USGS. (2019). 2015 Minerals Yearbook. https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb3-2015-eg.pdf

# List of abbreviations

| | |
|---|---|
| AUC | The American University in Cairo |
| BaSEF | Building a Sustainable Energy Future |
| BUE | The British University in Egypt |
| CCS | Carbon Capture Storage |
| COP27 | Climate Change Conference in 2022 |
| CSP | Concentrated solar power |
| DAAD | Deutsche Akademische Austauschdienst e. V. |
| DRI | Direct Reduction Iron |
| EAF | Electric Arc Furnace |
| EETC | Egyptian Electricity Transmission Company |
| EIA | U.S. Energy Information Administration |
| EOR | Enhanced Oil Recovery |
| EWI | Energiewirtschaftliches Institut der Universität zu Köln |
| IEA | International Energy Agency |
| IGU | International Gas Union |
| IRENA | International Renewable Energy Agency |
| ISES | Integrated Sustainable Energy Strategy |
| LCOH | Levelized Costs of Hydrogen |
| MENA | Middle East and North Africa |
| NREA | New and Renewable Energy Authority (NREA) |
| OIES | Oxford Institute for Energy Studies |
| PV | Photovoltaic |
| RE | Renewable Energies |
| SCZONE | Suez Canal Economic Zone |
| SMR | Steam Methane Reforming |
| UoC | University of Cologne |
| USGS | United States Geological Survey |

# List of figures



# List of tables