

# FROM GREEN ENERGY TO GREEN HYDROGEN: THE ROLE OF CHINESE INVESTMENTS IN EGYPT'S FUTURE ENERGY LANDSCAPE



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## About The International Institute of Green Finance (IIGF)

The International Institute of Green Finance (IIGF) of Central University of Finance and Economics (CUFE) is an independent and non-profit think tank established in Beijing, China. It conducts research within a range of areas of green finance such as credit, bonds, insurance, carbon-trading, information disclosure, as well as risk assessment. The IIGF works with numerous stakeholders in green finance both within and outside China.

## Authors

Han Chen, International Institute of Green Finance

Wei Shen, International Institute of Green Finance

Dalia Ibrahiem, Cairo University

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This report is the second of the series of Report Series on China and Africa's Energy Transition. Our first report is *Advancing Mineral-Energy Nexus for Development (MEND) in Africa: From a Concept to Practices*.

## Executive Summary

- Superior wind and solar energy sources and strategic locations make Egypt an ideal destination for developing both renewable energy and green hydrogen capacities. In the past decade, it has attracted large amounts of foreign investments to tap the potential in these two strategic sectors for its low-carbon energy transition and green industrial development.
- With a policy goal of nurturing a world-leading green energy and hydrogen market, the Egyptian government has developed a comprehensive policy and institutional framework, including the National Green Hydrogen Strategy and a recently established National Green Hydrogen Council.
- As the new entrants in Egypt's growing green hydrogen market, Chinese companies have applied their rich experience and existing networks accumulated through their long-term engagement with renewable energy markets in the country. Chinese companies serve as the major technology suppliers and EPC contractors in several wind and solar energy projects. They enjoy a reputation for delivering quality projects on time, as a result of notable technological and cost advantages in the development of green infrastructure projects.
- The Chinese central government has exhibited its willingness to scale up green investments in Africa. Green hydrogen projects are closely aligned with China's recent policy priority of promoting 'small and beautiful' activities along the Green BRI strategy.
- At the micro (or project) level, the complex structure of green hydrogen investments involves multiple implementation stages, extending from developing renewable energy infrastructures and hydrogen production facilities, and managing transportation and distributive networks with end users. Such a multi-phase project cycle presents notable challenges for the host government and investors alike. A more efficient and supportive system is required from both parties.
- At the macro (or national) level, Egypt is currently amid some significant economic challenges since the COVID-19 pandemic. The war in Ukraine and Gaza pushed up food prices and inflation and drove significant currency devaluation. The rising borrowing costs

are affecting Egypt's public financing capacity and debt service prospects. Risk perceptions of Chinese financiers are therefore crucial for the bankability of the prospective investments.

- For Chinese companies to be more active in engaging Egypt's green hydrogen markets, more innovative financial and policy support is needed. A wide range of financial instruments should be explored to complement conventional project finance and EPC finance. A combination of green bonds, carbon finance, and development finance should be experimented with, particularly in dealing with different components and stages of a green hydrogen investment.
- To nurture capacities of innovative and flexible solutions, Chinese financial institutions are expected to work more actively with the regional and international Multilateral Development Banks (MDBs) and commercial lenders. Syndicated financing, despite its higher transactional cost to convene, can be more effective and resilient for risk sharing, compared to the existing model where Chinese financiers often act as the sole lender.
- Egypt should incentivize domestic green hydrogen end-users and consider phasing out its grey hydrogen capacity at home. The government needs to balance the short-term goal of generating foreign exchange revenues from the sales of green hydrogen overseas, and a long-term quest of nurturing domestic green industrial capacity as the basis for a low-carbon economy. To this end, supportive policies should be crafted to enhance domestic demand for consuming green hydrogen/ammonia. Additionally, training programs and educational initiatives should be provided to drive technological progress and innovation at home.



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## 1. Introduction

Green hydrogen, generated from electrolysis powered by renewable energy, has emerged in the past years as one of the promising solutions to achieve a net-zero energy and industrial system. Amid notable controversies, green hydrogen is viewed by many governments as a transformative force in their green industrialization agenda, as it presents versatile solutions for various industrial end users and applicable scenarios, ranging from energy storage to transportation (Wappler, et al., 2022). In the past decade, renewable energy generation, hydrogen, and fuel cell technologies have all experienced significant progress regarding their cost, efficiency, and reliability. The tremendous benefits of a combined solution from these new technologies, in the form of green hydrogen or its sister product green ammonia, have been increasingly appreciated and encouraged by governments and market practitioners worldwide.

For developing countries with abundant and exploitable renewable energy sources, the green hydrogen solution provides an alternative pathway towards a low-carbon energy landscape and development trajectory. As a result, an increasing number of countries in the Global South have announced ambitious strategies for developing green hydrogen capacities. It is noted that Middle East and North African (MENA) and sub-Saharan African (SSA) regions in particular, including countries like Morocco, Oman, Saudi Arabia, South Africa, Kenya, and Egypt, to name but a few, have exhibited tremendous enthusiasm in piloting green hydrogen activities, given the unparalleled renewable energy potential in these regions.

However, it should be noted that the actual implementation of green hydrogen strategies in the developing context could encounter significant institutional, financial, and technical challenges. These internal and external difficulties would require tremendous efforts from both the host and investing parties to get over with. In this report, these specific challenges and efforts are examined, by using Chinese investments in the Egyptian green hydrogen market as a case study. We hope the investigation will provide useful insights into the broader implications and prospects of investing and governing complex and integrated infrastructures that link renewable energy and hydrogen production in the Global South context.

Egypt is hand-picked as the case study because it is standing at a crossroads of its energy transition and sustainable development. It hosts the largest economy on the African continent by

GDP (PPP) (IMF, 2022), which is predominantly sustained on fossil fuels (IEA, 2023). Egypt is also the second largest country in terms of CO<sub>2</sub> emissions in Africa (after South Africa), largely due to its massive gas power generation capacities (Global Carbon Project, 2022). Meanwhile, Egypt is one of the most susceptible countries to the consequences of climate change.

Intergovernmental Panel on Climate Change (IPCC) highlights the Nile Delta as one of the three most critical areas with ‘extreme’ vulnerability to climate-related challenges on the planet (IPCC, 2022). However, Egypt is blessed with the best wind and solar energy resources in the region, and it is building up renewable energy capacity at an unprecedented pace. The official commitment is to achieve 42% renewable electricity generation in its energy mix by 2030, as pledged in the Nationally Determined Contribution (NDC) under the Paris Climate Agreement.

However, a closer look at Egypt’s current energy strategy reveals that its development ambition is far beyond the phase out of the current hydrocarbon-based energy system. Rather, the Egyptian government aims to further exploit its rich wind and solar resources to nurture a world-leading green hydrogen industry as a pillar of Egypt’s long-term low-carbon development strategy. As the host of COP27 in 2022, Egypt signed 23 green hydrogen MoUs. During COP28, three landmark agreements were further signed scale up investments in green methanol, green ammonia, and green fertilizer (Ahram Online, 2023). The Egyptian government vows to become a key global player in this emerging sector by securing a 8% share of the global commercial market for green hydrogen by 2040. The question, however, is how such ambitions can be implemented on the ground, given notable challenges both internally and externally.

At the outset, creating a robust green hydrogen industry requires a comprehensive institutional framework that aligns climate, energy, and industrial policies and development goals.

Coordinated development of both the renewable energy infrastructure and green hydrogen production is needed. In addition, these new institutions would inevitably interact with the existing ones that oversee the incumbent oil and gas sectors, which often present structural incoherences if not struggles. Besides these domestic challenges, external support would be crucial in terms of funding and technology. Like most developing countries, Egypt currently does not have homegrown industrial and technological capacities for either renewable energy or green hydrogen production, which means that it would continue to rely heavily on foreign direct investments to deliver both technical and financial solutions. Yet, like many countries in the



global South, Egypt is currently amid notable economic difficulties given the impacts of the COVID-19 pandemic, the war in Ukraine, and the more recent devastating conflicts in its neighboring Gaza Strip. Inflation, currency devaluation, and rising borrowing costs are damaging its public borrowing capacity and debt service prospects. These institutional and economic challenges need to be properly handled to achieve its green hydrogen strategy.

Among all the foreign investors, Chinese companies have long been major players in developing renewable energy infrastructures in the country. Some Chinese companies also exhibited a growing interest in the green hydrogen sector. Therefore, it would be important to investigate Chinese actors' risk perceptions motivations and actual practices in developing both green energy and green hydrogen activities. On the other hand, Egyptian stakeholders' acceptance of Chinese technology and investments in these two strategically important sectors is also crucial due to intense competition from European and MENA investors and financiers. Such an investigation, as we argue, would reveal the prospects of the Chinese involvement in unleashing the green hydrogen potential in Egypt.

Our analysis is based on qualitative methodologies that include deskwork and field investigation between March and September 2023, during which semi-structured interviews and focus groups were conducted with Egyptian officials, Chinese companies and financiers, international practitioners, and leading experts in both renewable energy and green hydrogen sectors. We also collected 161 survey responses among Egyptian stakeholders regarding their expectations from the Chinese investors in these areas. To safeguard research ethics, all names (including individual participants, places, and organizations) are kept anonymous in this report.

## **2. The Green Hydrogen/Ammonia Hype in the Global South**

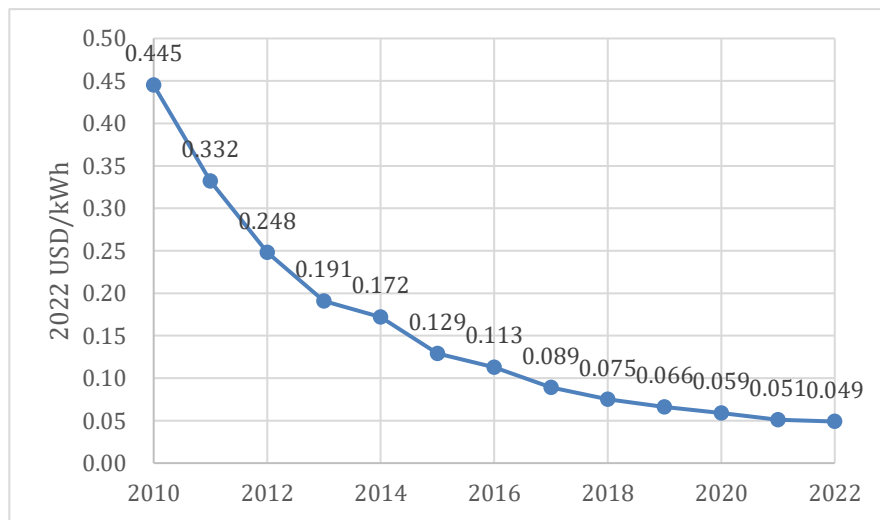
Hydrogen (and its sister gas, ammonia) has long been used for industrial activities such as crude oil refining and fertilizer production. Its high energy intensity can also be utilized as a fuel without emitting greenhouse gas (GHG) and other air pollutants<sup>1</sup>. As of 2022, around 99.6% of

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<sup>1</sup>Hydrogen is not directly a greenhouse gas, but its chemical reactions increases the abundances of the greenhouse gases methane, tropospheric ozone, and stratospheric water vapor, leading to a global warming effect (Sand, et al., 2023).

hydrogen produced globally was grey hydrogen (produced from fossil fuel sources), while only 0.4% was blue hydrogen (with a carbon storage and capture facility). This is mainly due to cost-effective concerns, as grey hydrogen is normally below \$3 per kilogram. However, the sharp decline in the cost of renewable energy generation and electrolysis gives hope for the commercialization and scalability of green hydrogen in the foreseeable future. It is estimated that under the 1.5°C scenario, by 2050, the demand for hydrogen will reach 613 Mt (74 EJ) per year, with at least two-thirds of which should be green hydrogen (IRENA, 2023). Reaching such a goal requires a significant scale-up of electrolyzer manufacturing and renewable energy deployment simultaneously, meaning that around 160 GW of electrolyzers need to be installed annually on average up to 2050. A positive estimation is that green hydrogen will be commercially viable around the mid-2030s, when it can be manufactured at a cost of less than EUR 2 per kilogram (European Investment Bank, 2022). However, it is generally understood that a more modest trajectory of green hydrogen market development is expected before the ‘tipping point’ (World Energy Council, 2021).

*Figure 1. Global weighted average levelized cost of electricity (LCOE) for PV has been decreasing*

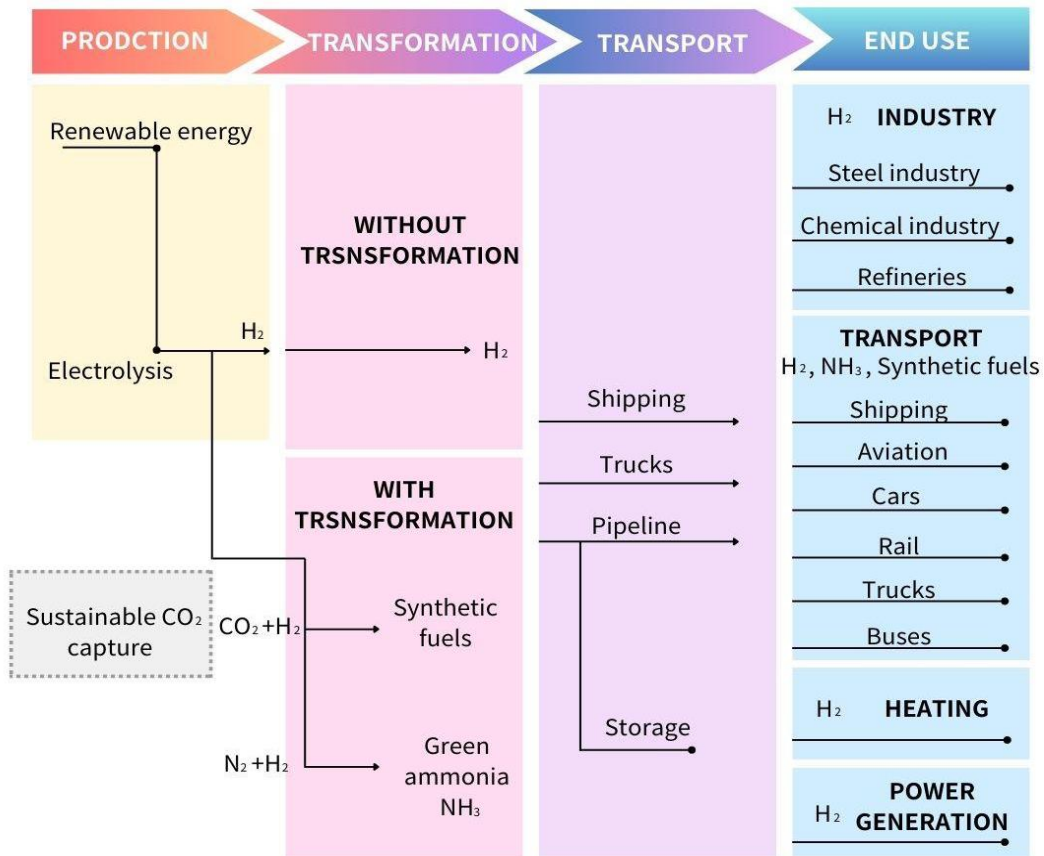


*Source: IRENA (2023)*

Although green hydrogen has the potential to revolutionize a variety of industries and play a major role in the global energy transition, the current market demand is limited. In 2022, the global demand reached around 95Mt, representing a 3% increase compared to the previous year

(IEA, 2023). Most of this demand is from the transportation sector, whereas other applicable scenarios remain largely theoretical. In addition, the complex value chain of green hydrogen investments extends from the planning and construction of specific renewable energy infrastructures to the eventual sales of hydrogen or ammonia gases to the end-users (Figure 2). Such a long project cycle presents notable challenges for different actors involved in the project implementation stages. For developing countries, the investors, contractors, financiers, transporters, and end-users are all likely to be foreign entities, which increases the coordination barriers. Consequently, green hydrogen investments would inherently involve more complex contractual, legal, and financial relations compared to conventional energy infrastructure or industrial investments, which would result in higher transaction costs.

Figure 2. The Value Chain of Green Hydrogen Production



Source: Authors' creation based on IRENA (2021)

Government support and a proper policy framework are hence critical in nurturing this infant

sector, by providing clear policy signals to reduce uncertainties associated with prospective investments. As of September 2023, a total of 41 governments announced their hydrogen strategy, among which the majority are developed countries, plus four countries from the MENA region: Oman, UAE, Morocco, and Jordan (IEA, 2023). The regulatory and policy frameworks for supporting green hydrogen development are inherently comprehensive, covering both the production and consumption ends. However, most of the existing policy instruments seem to focus mainly on the production end, such as subsidies for electrolyzer manufacturing or storage facilities, leaving the consumption ends less incentivized. Developing countries need to introduce additional incentives for attracting FDIs, such as by offering tax breaks, tariff exemptions for equipment imports, or concessional land access. In most cases, policy instruments for supporting renewable energy deployment need to be coordinated with hydrogen production, adding another layer of regulatory complexity. The promotion of the green hydrogen sector should be considered within broader industrialization strategies among many developing countries, particularly for manufacturing capacities around wind, solar, or electrolysis equipment (UNIDO, 2020). This includes a mix of financial incentives, regulatory measures, and capacity-building initiatives. As a result, managing all these policy goals requires tremendous state capacity and integrity, due to the complexity of the tasks and the large amount of rents to be created during the processes (Schmitz, et al., 2015).

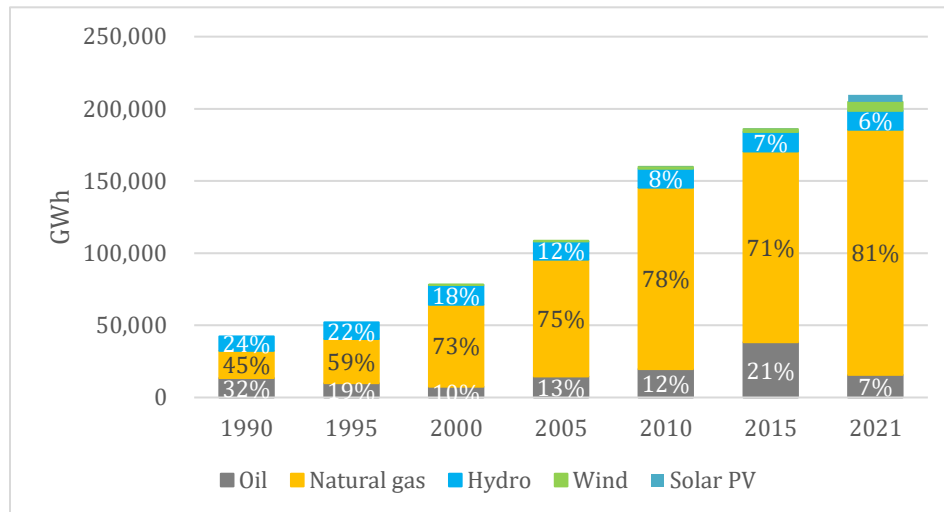
Developing a specific green hydrogen project in the Global South is also challenging for the investors, as it has to bundle infrastructure and industrial investments together, along with the management of power transmission and hydrogen transportation operations. It means that the risks of failure are considerably higher if any of these stages go wrong. Although in theory the project can be implemented via a partnership between a renewable energy developer and a hydrogen production developer, such a ‘dual developers’ arrangement is rare in reality. Normally the investor would prefer to assume full control of the complete project cycle. In this regard, a comprehensive and complex transactional and financial model governing different contractors, transporters, and off-takers became essential to the success of the investment. Conventional financial solutions for stand-alone infrastructure or industrial investment can be ineffective and insufficient in supporting such a complex project structure. Consequently, the financial model of green hydrogen projects requires innovative risk assessment instruments and solutions. The

question is, which types of investors and financiers are more capable of such experimentation? More specifically for this research, the question is whether the Chinese investors/financiers have the willingness and capacity to implement green hydrogen investments innovatively.

### 3. Governing the renewable energy and green hydrogen activities in Egypt

Egypt has achieved universal electricity access and has run a considerable energy surplus (over 25%) in recent years. However, its energy mix is heavily dependent on fossil fuels. Transition towards renewable energy sources was adopted in its national Sustainable Development Strategy (SDS) announced in 2016, also known as Egypt’s Vision 2030. The Egyptian government has set a target of generating 42% of its electricity from renewable sources by 2030, which represents a significant increase from the current level of around 12% (Figure 3). The ambition is based on Egypt’s vast wind and solar energy resources. Egypt enjoys an abundance of solar radiation across the country, with a potential of 74 billion MWh per year. It also possesses significant wind energy potential along its Mediterranean (from Alexandria to the Egyptian-Libyan border and along the Sinai Peninsula) and Red Sea coasts (particularly along the Gulf of Suez and Gulf of El Zayt).

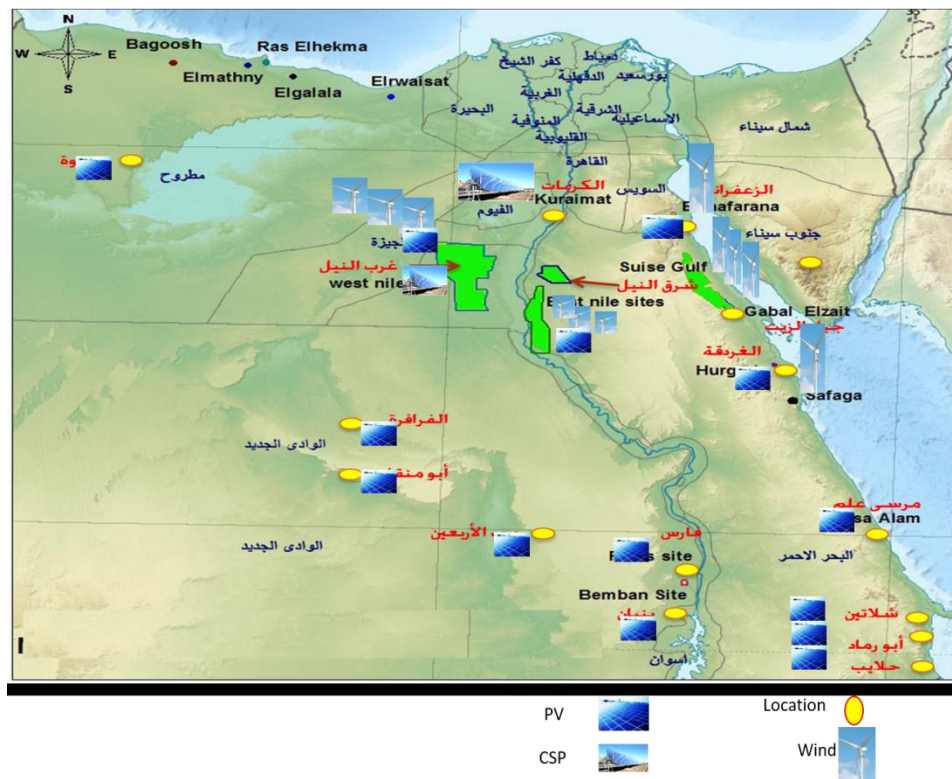
Figure 3. Egypt’s electricity generation by energy source



Source: Authors’ creation based on IEA (2020)

The regulatory and institutional frameworks to support renewable energy deployment have been evolving in Egypt, including new legislations, incentive mechanisms, policies, and government agencies. Egypt issued the Renewable Energy Law in 2014 and prescribed a comprehensive policy mix including competitive procurement, BOO/IPP development, and a feed-in tariff (FiT) system. It also opens up opportunities for distributive or self-supply solar systems, with a national cap of 1000 MW and a project cap of 25 MW. Under these new policies, several wind and solar energy projects have been operationalised in the past decade, including the massive Benban Solar Park (1650MW) in the Aswan Governorate (Figure 4 and Table 1). According to our interviews, the successful implementation of these large-scale projects has significantly boosted the confidence of international investors in developing further projects in the Egyptian markets.

Figure 4. Renewable energy projects in Egypt



Source: New and Renewable Energy Authority (NREA)

The recent decision of the Egyptian government to have an integrated approach to developing renewable energy and hydrogen production capacity opens a new transition pathway for the



country, as it provides more flexibility to utilize intermittent renewable energy capacities, particularly in a time of energy surplus and foreign exchange shortages. It should be noted that Egypt currently hosts a significant grey hydrogen capacity at home, with an estimation of over 1.8 million tons of annual consumption mainly for the fertilizer, steel, oil refineries, and methanol sectors (Habib and Ouki, 2021). The scaling up of green hydrogen investment would provide critical learning opportunities for the transformation of grey hydrogen capacities with more sustainable technologies. Therefore, the development of the green hydrogen sector is not confined just to achieving additional export revenue in the short run, but with long-term industrial ambitions.

*Table 1. Egypt renewable energy projects (current and under construction, in MW)*

	<b>Government-sponsored projects</b>	<b>Feed-in Tariff projects</b>	<b>Private sector projects (BOO)</b>	<b>Total</b>
Solar	196	1,650	1,400	3,246
Wind	570	2,258	1,770	4,598

*Source: NREA (2024)*

By September 2023, Egypt had signed 23 MoUs with major international companies, 10 of which have progressed to reach the framework agreement. The total value of these MOUs amounted to US\$83 billion, with an annual yield of up to 15 million tons of green ammonia and e-methane (Hydrogen Insight, 2023). Most of these projects are located at the Ain Sokhna port in the Suez Canal Economic Zone (SCZone), with a few exceptions near the Mediterranean Sea. The large number of MoUs indicates international enthusiasm but it is expected that not all of them could be eventually implemented into the operational stage. Only one pilot project was commissioned by the time of writing this article, which was developed by a joint venture between Norway’s Scatec, Egypt’s Orascom Construction, the UAE’s ADNOC, and the Sovereign Fund of Egypt (TSFE).

Egypt has established a regulatory and legislative framework in supporting the green hydrogen sector, including several decrees (Cabinet Decrees No. 20, 981, and 983) and a law (Law No. 2 of 2024), along with different incentive policies and measures. Currently, there are four government authorities in charge of Egypt’s green hydrogen development: The New and Renewable Energy Authority (NREA), The General Authority of SCZone, the Egyptian

Electricity Transmission Company (EETC), and The Sovereign Fund of Egypt (TSFE). Their different roles are briefly presented below:

- **NREA** is responsible for granting the lands needed for developing renewable energy infrastructures. It manages applications of green hydrogen project proposals and conducts pre-feasibility studies. NREA charges 2% of the annual renewable energy production revenue as the land use fee annually for renewable energy projects, which is to match the existing BOO projects that are in operation<sup>2</sup>.
- **EETC** as the national utility is in charge of providing transmission and distribution services and ensuring that green electricity is transmitted to the hydrogen production sites. EETC acts as the sole buyer of all electricity generated in Egypt. EETC charges 7% of electricity revenue as the wheeling fee for grid integration (EgyptERA, 2023), which raised developers' concerns over the increased costs of green hydrogen production, since electricity generation accounts for around 70% of total hydrogen production costs (H2GreenSteel, 2022).<sup>3</sup>
- **The General Authority of SCZone** is the managing and regulatory authority of the green hydrogen facilities, as most of them are to be located within the SCZone. It assists in accommodating prospective investors by providing necessary administrative services and infrastructure support.
- **The Sovereign Fund of Egypt** is the coordinator of all parties, indicated by an interviewee from a Chinese state-owned enterprise (SOE) in Egypt.<sup>4</sup> The Sovereign Fund of Egypt was established in 2018, with total assets of EGP77.5bn (US\$2.42 billion). It works closely with the Government of Egypt to manage investment deals related to specific state-owned assets. It takes part in green hydrogen projects as an equity partner and provides supports needed to sign green hydrogen MoU.

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<sup>2</sup> Interview with NREA, Cairo, 5 September 2023.

<sup>3</sup> Interview with practitioners, Cairo, 5 September 2023, and 10 September 2023; Online workshop with practitioners, Beijing, 26 December 2023.

<sup>4</sup> Interview, Cairo, 10 September 2023.



These four entities are led by Prime Minister Mostafa Madbouly and the Cabinet, as indicated by our interviewee from NREA.<sup>5</sup> Another interviewee from a Chinese SOE believe that the efficiency of these entities can be improved, and suggested that enhanced coordination among them is needed. Specifically, there needs to be a higher decision-making agency in coordinating the above-mentioned four entities, particularly regarding developing new policies and implementing existing contracts. The newly created National Green Hydrogen Council in September 2023 is designed to serve this role, which is chaired by the Prime Minister himself. In November 2023, Egypt's National Green Hydrogen Strategy was also approved by this newly established agency (Egypt Today, 2023).

The Egyptian government aims to increase domestic demand for green hydrogen after 2030. Our interviewees from NREA indicate that Egypt's strategy is to export all the green hydrogen before 2030.<sup>6</sup> After that the green hydrogen supply is expected to serve domestic demand primarily, such as for fertilizer production, transportation, and oil refinery facilities at home. More than 15% of global maritime trade passes through the Suez Canal, presenting an unmissable opportunity to develop hydrogen-based vessel refueling infrastructure in Egypt. Likewise, significant demand can emerge in the country's 'energy-intensive' industries in the foreseeable future (Hydrogen Insight, 2023).

The Egyptian government are making efforts to resolve various infrastructure challenges for its grand green hydrogen ambition, such as power transmission and water supply. For example, the Egyptian Green Corridor initiative was announced to accelerate the integration of renewable energy into the country's electricity grid by developing a dedicated transmission and distribution network (*Figure 5*). According to one interviewee, the project developers of green hydrogen will eventually share the cost of developing this green corridor. In December 2023, the Energy and Environment Committee of the House of Representatives approved a drafted bill regarding tax and non-tax incentives for investments in relation to the value chain of green hydrogen production, including green energy generation and desalination projects (Egypt State of Information Service, 2023). Egypt is the most vulnerable country to water scarcity on earth. To

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<sup>5</sup> Interview with an official from NREA, Cairo, 5 September 2023.

<sup>6</sup> Interview with NREA, Cairo, 5 September 2023.

tackle the challenge of water usage for green hydrogen production, Egypt has partnered with IFC and EBRD to reach its targeted desalination capacity of around 8.8 million m<sup>3</sup>/day by 2050, attracting prequalified 17 international consortia for participating in the first phase of this grand desalination program, including two proposals from Chinese companies (IFC, 2023).<sup>7</sup> The desalination facilities can also provide fresh water needed for other industries.

However, the key challenge is how these supportive infrastructures are to be delivered in time as the renewable energy and hydrogen production facilities usually take shorter periods to construct. In addition, as most of the green hydrogen projects will be clustered into the economic zones along the Suez Canal, maintaining safe working conditions also presents tremendous challenges. The SCZone as one of the key government agencies needs to work with other responsible entities to craft safety codes and standards before these projects are grounded.

Figure 5. Illustrative Map of Egypt Green Energy Corridor



Source: Hamilton (2022)

The Egyptian government provides incentive packages to entice both local and international investors. The income tax exemption is between 33% and 55% for green hydrogen projects commissioned before 2028. Additionally, imports of equipment, machinery, and raw materials

<sup>7</sup> The two Chinese companies prequalified in the desalination projects are Beijing Enterprises Water Group Ltd, Asia-Africa Green Energy Investment and Sinohydro Hong Kong Holding Ltd, Qingdao Desalination, SEPCO III Electric Power.

will be exempt from the value-added tax (General Authority of SCZone, 2023). It also allows 100% foreign ownership in green hydrogen investments. Egypt's Sustainable Financing Framework includes green hydrogen charging stations and facilities as qualified categories for green bonds and sustainability bond proceedings (Egypt Ministry of Finance, 2022). Egypt issued 'panda' bonds worth CNY 3.5bn in the Chinese market in October 2023, and 'samurai' bonds totaling JPY 75bn in the Japanese market. Egypt has secured approximately US\$1.5 billion in financing from international institutions, supporting the nation's climate change goals amid global economic challenges (Daily News Egypt, 2023). In October 2022, the Egypt General Authority for Investments (GAFI) launched the Golden License scheme, which is defined as a single consent on all aspects of establishing, operating, and managing an investment project. The Golden License will receive approval directly from the Egyptian Prime Minister, aiming to attract new sustainable investments into Egypt. Both renewable energy and green hydrogen projects are eligible to apply for such funding (Egypt Ministry of Finance, 2022).

Egypt has been relying heavily on international capital for the development of renewable electricity and hydrogen, particularly from Europe and the Middle East. For example, the Benban Solar Power Park Complex consists of 41 project units, with the majority of financiers and investors from Europe and MENA regions. Taking Norwegian company Scatec's six 65MW projects in Benban as an example, the equity and debt finance of these investments include the Islamic Development Bank and Islamic Corporation for the Development of the Private Sector (ICD). Saudi Arabia government holds the largest share in both IsDB and ICD (Fitch Ratings, 2023). At the same time, the EU and Japan are looking for low-cost renewable energy assets overseas. International and regional MDBs such as IFC, EIB, EBRD, and AfDB also played an important role in helping mega initiatives such as Benban take off. EIB announced its green transformation scheme in Egypt by mobilizing financing worth €1.3 billion including €300 million in concessional development financing for the government and €1 billion for the private sectors at commercial rates (Egypt Today, 2023).

#### **4. Chinese capacity in green hydrogen investments: from inside out**

China has been dominant in leading the wind and solar technologies, and more recently became the largest electrolysis developer too (Sinopec, 2023). In 2022, China had a production capacity

of 98 GW for on-shore and off-shore wind turbines, 552 GW for solar PV panels, and around 800 MW actual outputs for electrolyzers, taking the championship position in all three sectors. China's home market for green hydrogen has been growing dramatically in the past few years. According to the industrial association known as China Hydrogen Alliance, by the end of 2022, more than 300 green hydrogen pilot projects have been planned across the country, with 36 projects in operation, and a cumulative annual green hydrogen production capacity of 56,000 tons. The annual addition of nearly 33,000 tons in 2022 made a 140% year-on-year increase. Chinese researchers and practitioners have been experimenting with alternative seawater-based green hydrogen solutions around the fast-growing offshore wind farms (Xie, et al., 2022). However, it is still uncertain whether such technological supremacy can be applied as a competitive advantage in overseas markets. Comparably, it is noted that until recent years China's dominance in wind and solar energy technologies has yet to be fully applied to expanding capacities overseas (Shen, 2020). The situation is only gradually changing after Chinese President Xi Jinping announced the cessation of financing coal-fired power plants overseas in 2021 (Chen & Shen, 2022).

There are multiple explanations for why China's strong technological capacities in the wind and solar PV sectors at home have not yet been translated into massive overseas activities, as many would expect. At the outset, the Chinese SOEs and policy banks, as the major implementing agencies of Chinese overseas strategies, are increasingly cautious on the perceived high investment risks in developing countries. Secondly, most of the renewable energy projects are publicly procured and developed by Independent Power Producers (IPPs). Chinese companies are often less competitive than European and MENA investors in these open procurement opportunities.

These constraints have been further exacerbated by the COVID-19 pandemic and the following global economic disruptions, as many developing countries are facing significant difficulties in servicing their repayment obligations for the existing loans. Chinese financiers and SOEs are understandably becoming even more cautious and risk-averse. As a result, Chinese lending to Africa hit a record low, with less than US\$1 billion in 2022 (Moses, et al., 2023). Given the distinctive high risks around the green hydrogen investments as explained above, the borrowing cost from Chinese financiers could be high. Our interviewees from a Chinese company indicated

that they are actively considering international and even local financiers for more flexible solutions.

As for the green hydrogen projects in particular, Chinese investors face additional challenges in securing a long-term offtake agreement with the prospective green hydrogen end-users. Although this is a common problem that applies to all investors, Chinese actors are relatively disadvantaged, particularly in the MENA and SSA markets. The long transportation distance from China's home markets means that it is unrealistic to ship green hydrogen back home. Investors must identify and secure off-takers in adjacent markets, namely in Europe. A long-term green hydrogen or ammonia offtake agreement is often the precondition for the financiers to underwrite the project risks. Although Europe is the only region that has prescribed specific policy support to scale up the demand for green hydrogen, few buyers would be interested in arranging a long-term contract given the uncertain prospect of the market. In addition to the market disruptions, there are also concerns around policy changes and instability in both the buyers' and the suppliers' countries, which further impede reaching a long-term offtake agreement. For example, any adjustment or withdrawal of government subsidies or tax exemptions would significantly impact the outcome of the investments.

One Chinese expert explained to us:

*'Green hydrogen is a new commodity, and its prospect in the global market is with a lot of uncertainties. The long-term future price is difficult to predict. We have only started developing our forecasting model but with limited success so far'.<sup>8</sup>*

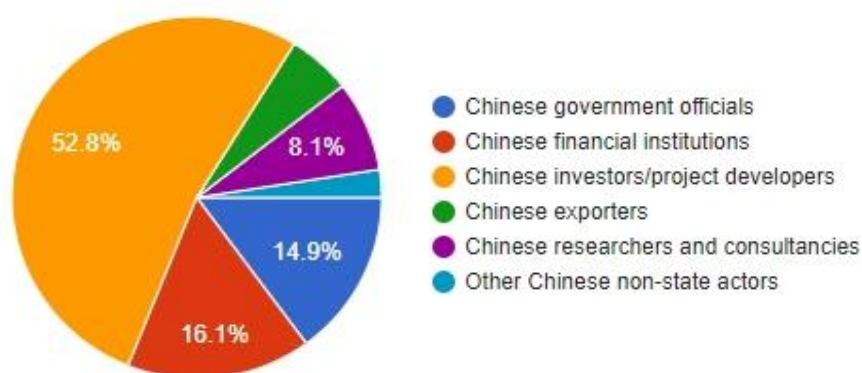
Chinese companies' comparative advantage, however, is their reputation for delivering large-scale infrastructure projects timely under harsh working conditions, with proper quality and cost control. The reputation is accumulated throughout years (if not decades) in the region. Most Chinese SOEs and private companies have sufficient in-house expertise to develop both renewable energy and hydrogen production facilities, which is another advantage. They also developed solid working relations with the relevant state and non-state stakeholders. Successful project implementation requires host governments to deliver supportive infrastructures such as

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<sup>8</sup> Interview at Cairo, 10 September 2023.

water, roads, and transmission lines. Previous collaboration between the investors and relevant government agencies appears to be an important determinant of success, as a certain level of mutual understanding and trust is needed between both parties (see Appendix). In our survey, when asked which type of Chinese actors are most required to engage in Egyptian renewable energy and green hydrogen markets, Chinese investors/contractors and financiers emerged as the most and second most important groups among local respondents (*Figure 6*).

*Figure 6. Survey: Who should be more active in Egyptian renewable energy and green hydrogen sector?*



*Source: Authors' creation*

As explained in the preceding sections, any green hydrogen project would involve four stages of activities, ranging from renewable energy generation, power transmission, hydrogen production, and transportation or sales of final gas products. The multi-location and inter-temporal feature of green hydrogen investments present significant challenges for governments, investors, and financiers alike. For the Chinese companies, the conservative risk perception of the state financiers in general and on long-term off-taking arrangement in particular appears to a significant challenge. In the following sections, these challenges and on-the-ground solutions will be further examined.

## **5. Chinese green energy and hydrogen projects in Egypt**

In this section, we are focusing on Chinese renewable energy and hydrogen projects via a comparative lens to the practices of developers and financiers from other regions.

### **5.1. Chinese renewable energy projects: beyond EPC and equipment supplier?**

In the Egyptian wind and solar energy market, Chinese companies have been active as EPC contractors and technology suppliers (See *Table 2 for the project list*). For example, when Egypt replaced its earlier plan on a 1GW coal-fired powerplant with the 500MW Kom Ombo solar park and the 500MW Amunet wind farm (located in Ras Ghareb), the MENA developers, namely AMEA Power and ACWA Power were awarded these projects. Yet they eventually contracted the Chinese EPCs, namely PowerChina and CEEC. In addition, Chinese companies Envision, Sungrow and LONGi are equipment suppliers for these two projects. Chinese renewable energy technologies are also gaining prominence in the markets. Leading solar panel suppliers such as CHINT, TEBA, JA Solar, and Longi plus leading wind turbine suppliers, such as Goldwind and Envision, are all building up their reputation in the market (*Table 2*). In some cases, Chinese companies are also involved in equity investment. For example, in the Benban solar park, two Chinese companies CHINT and TBEA performed as both EPC contractors and minor equity investors.



*Table 2. Chinese entities provide EPC services and equipment in Egypt's renewable energy projects under construction*

Project Name	Location	Energy Source	Capacity (MW)	Year of Commercial Operation	EPC Provider	Equipment Provider (Chinese Entities)	Project Cost, (US\$m)	Project Developer/Owner	Debt Investor
Amunet Wind Farm	Ras Ghareb	Wind	500	2025	Power China	Envision (China)	709	Amunet Wind Power: AMEA Power (60%); Sumitomo Corporation (40%)	IFC, Japan Bank for International Cooperation (JBIC), Sumitomo Mitsui Banking Corporation; Sumitomo Mitsui Trust Bank; Standard Chartered Bank; the Commercial International Bank of Egypt.
Gulf of Suez II Wind Farm	Ras Ghareb	Wind	500	2025	Orascom (Egypt), Siemens Gamesa Renewable Energy; Tractebel (France)	Goldwind (China)	660.061	Red Sea Wind Energy S.A.E.: ENGIE (France) (35%), Orascom Construction (Egypt) (25%), Toyota Tsusho Corporation (20%) and Eurus Energy Holdings Corporation (Japan) (20%)	EBRD; Japan Bank for International Cooperation (JBIC), Sumitomo Mitsui Banking Corporation (SMBC), the Norinchukin Bank, Société Générale S.A.; HSBC Bank Egypt S.A.E
Abydos Kom Ombo Solar PV Park	Kom Ombo, Aswan	Solar	500	2025	CEEC (China)	JA Solar (China)	305	Abydos Solar Power Company, a subsidiary of AMEA (100%)	IFC, Japan International Cooperation Agency (JICA), Dutch Entrepreneurial Development Bank (FMO)
Kom Ombo Solar PV Park	Kom Ombo, Aswan	Solar	200	2024	CEEC (China); Sterling and Wilson Solar (SWS) (India)	Sungrow (China), LONGi (China)	182	ACWA Power (100%)	EBRD; the OPEC Fund for International Development (the OPEC Fund), the African Development Bank (AfDB), the Green Climate Fund (GCF); Arab Bank; AfDB's Sustainable Energy Fund for Africa (SEFA); Arab Petroleum Investments Corporation (APICORP).
NA	Ras Gharib	Wind	200	2026	In Procurement Phase	Goldwind (China), Envision (China)	In Procurement Phase	Infinity Power: Masdar (UAE), Infinity (Egypt), Possibly Japanese financiers will be involved	EBRD; Possibly Japanese financiers will be involved

*Source: Authors' creation (based on public data and interviews with the Chinese companies)*

However, it is also noted that while Chinese EPCs and renewable energy equipment are prevalent in Egyptian markets, conventional Chinese financiers play a less dominant role in supporting these deals. Comparatively, during our field investigation, some interviewees believe Japanese financiers appear to be more active in supporting Egypt's green energy/hydrogen projects, even if there is limited Japanese equipment or technologies involved in the transactions.

One Chinese expert explained to us:

*'Japanese financial institutions such as JBIC and SMBC, and its export credit agency NEXI, believe that expanding Japan's international financial services is equally crucial as promoting*



*Japanese export of physical commodities or equipment... They can offer more favourable financial terms: such as longer credit period or lower risk premium'.<sup>9</sup>*

By contrast, the Chinese policy banks are abiding by the tenet of playing only a supportive role to the Chinese equipment exports or EPC contracts, and hence shun away from projects with no or minor Chinese ‘content’. Such a conservative strategy has limited their flexibility in supporting Chinese companies in a highly internationalised and competitive green hydrogen market. In addition, most private developers from MENA and European regions would be willing to arrange financing for the EPCs they choose, which is contrasted to the conventional government-sponsored projects in Africa where the EPCs have to arrange financing on behalf of the state developers. Consequently, the comparative advantage of China’s EPC+F model is less prominent in this particular context.

Japanese financiers are active in supporting international equity and debt investors in Egypt’s renewable energy projects. For example, the 500 MW Amunet Wind Farm project mentioned above is co-financed by Japan Bank for International Cooperation (JBIC), IFC, Sumitomo Mitsui Banking Corporation (SMBC), Sumitomo Mitsui Trust Bank (SMTB), and Standard Chartered Bank through a project financing scheme. Nippon Export and Investment Insurance (NEXI) provides Loan Insurance for Green Innovation and increased commercial risk coverage of 97.5%. Apart from providing loans, Japan’s Sumitomo Corporation is also an equity owner with 40% share. The other 60% is owned by AMEA Power (60%). JBIC and NEXI both signed MoUs with IFC and EBRD to promote private-sector development in emerging markets, showing much greater flexibility and collaborative capacity.

However, Chinese companies do possess a tremendous cost advantage for equipment and EPC contracts. For example, in wind energy projects, the cost of equipment accounts for the lion’s share of the total cost compared to the peripheral components such as concrete foundations, on-site electrical devices, transport and works on site-preparation. One Chinese expert explained to us:

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<sup>9</sup> Interview with a Chinese expert at Cairo, 5 September 2023.

*Wind turbines alone make up the single largest component of the CAPEX (capital expenditure) required for an onshore wind project, roughly 63% of total cost. Therefore, the cost advantage of Chinese enterprises is still significant.<sup>10</sup>*

In general, the Chinese companies have notable advantages in the technological capacity and cost-effectiveness, which were well recognized by local and international partners (see survey results in Appendix). These advantages have secured them a fair share of equipment supply and EPC contracts in the Egyptian RE market. However, the support from the Chinese financiers appears to be constrained, particularly in facing the rising demand of flexible or collaborative arrangement between Chinese and international partners. These unique features would also affect Chinese companies' overall appetite and strategies in engaging the emergent hydrogen opportunities, as explained below.

## **5.2. Comparing Chinese and Non-Chinese Green hydrogen projects in Egypt**

Among 23 announced green hydrogen MOUs, 10 of them are fairly large-scale transactions with annual production capacity above 1 million tons of green hydrogen/ammonia or equivalent.<sup>11</sup> Our interviews indicate that Chinese companies in particular prefer large-scale hydrogen projects from the perspective of economies of scale. However, many local green hydrogen experts advocate the case for small-scale projects for the reason of pragmatism and feasibility. Smaller projects may involve higher transaction cost, but they provide valuable learning by doing opportunities. Such projects would also be closely aligned to China's recent policy goal of promoting 'small and beautiful' activities along its flagship geo-economic programme, known as the BRI 2.0.<sup>12</sup>

One of the green hydrogen projects was launched in November 2023, with an increased cost of US\$ 6.75 billion compared with US\$ 5.1 in the initial MoU, largely due to increased production and uncertainties of the green hydrogen demand. As acknowledged by many Chinese companies in the market, green hydrogen projects are essentially industrial investments instead of public

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<sup>10</sup> Interview with a Chinese expert at Cairo, 5 September 2023.

<sup>11</sup> Authors calculation based on public data.

<sup>12</sup> 'Small and beautiful' is a phrase that President Xi Jinping announced in a 'Belt and Road' working group conference in 2021 to describe smaller-scale projects with quick impact and sound economic viability. [https://english.www.gov.cn/news/202310/11/content\\_WS6526825cc6d0868f4e8e023e.html](https://english.www.gov.cn/news/202310/11/content_WS6526825cc6d0868f4e8e023e.html).

infrastructures.<sup>13</sup> Traditionally, power infrastructures are developed to supply electricity as a public good, either via IPP or BOT arrangement, to be purchased by the state utilities (in this case the EETC). However, green hydrogen projects are commercial investments aiming for profit maximization, which involve international end-users as the ultimate off-takers. Combining two types of activities into one project would add another level of complexity. The green hydrogen developers need to manage green energy, power transmission, and water supply as major inputs, plus hydrogen/ammonia as major outputs.

It presents tremendous challenges for both the Chinese SOEs and state banks to manage these uncertainties. During the interviews it is clear that obtaining a long-term off-take agreement for green hydrogen/ammonia is the biggest challenge, due to the nascent stage of the market.

Traditional lenders often assess bankability purely based on the stable and robust revenue throughout the project life cycle, which can be hardly satisfactory for the green hydrogen case.

By comparing to the proposed Chinese projects, the only implemented piloting green hydrogen project in Egypt is developed by Scatec from Norway, which has partnered with Fertiglobe (UAE), the Sovereign Fund of Egypt and Egypt's Orascom Construction (as the EPC). It is a 100 MW green hydrogen production facility located in the Sokhna area. When the project is fully developed, the facility will be powered by 260 MW solar and wind energy facility. Fertiglobe also signed a 20-year offtake agreement for 100% of the gas volumes produced from the project. The green hydrogen will be used as feedstock for production of green ammonia. The key to the success of this piloting project is the involvement of an off-taker Fertiglobe as a joint equity investor, which secures a long-term and predictable revenue that improves the investment's bankability. Fertiglobe as both equity investor and off-taker means that any potential market turbulence is to be shared among different parties.

The comparison indicates that multilateral partnerships in the green hydrogen projects would open the doors for multilateral financing. Nurturing these partnerships takes time, but once established, they can be tremendously helpful to secure finance. It is noted that Scatec has established extensive networks back to its early involvement in developing the Benban solar park, which were then applied to develop its pilot green hydrogen project. In the Egyptian

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<sup>13</sup> Interview at Cairo, 10 September 2023.

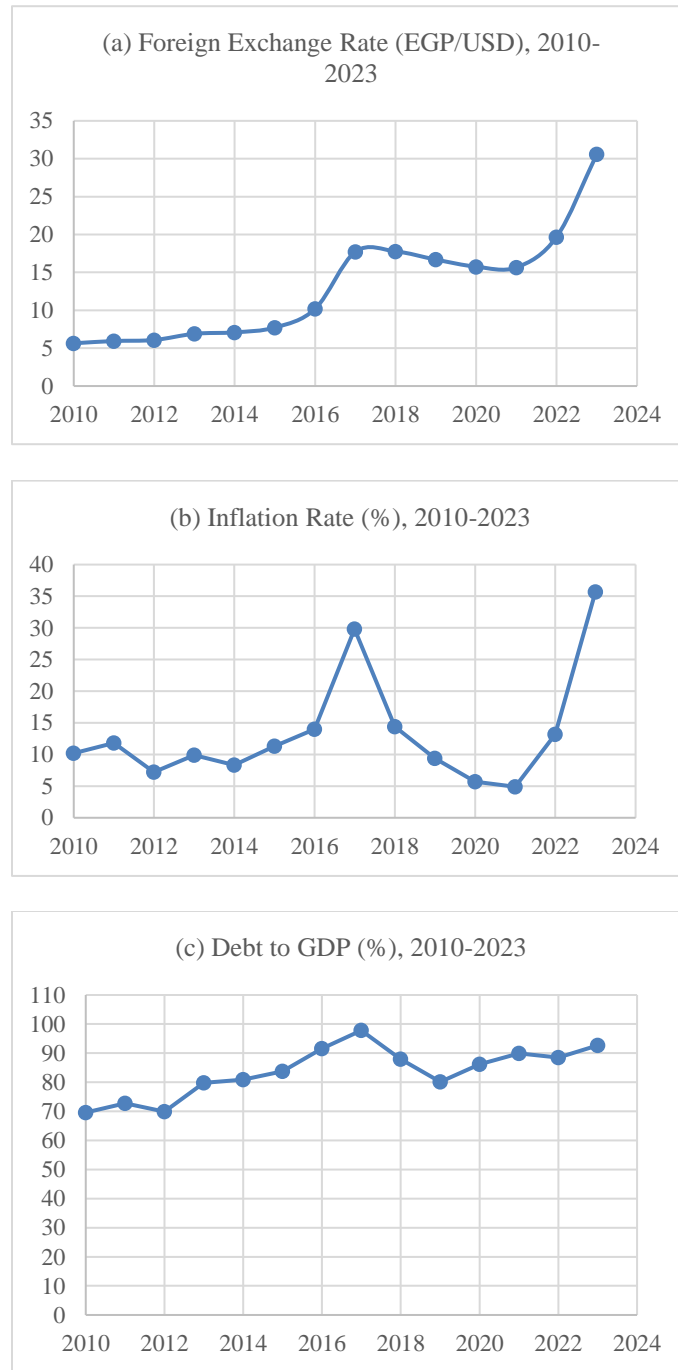
market, some Chinese companies have similar experience in nurturing networks due to their long engagement with the wind and solar energy sectors in the country. However, Chinese SOEs may face some particular constraints on establishing joint ventures with international partners, whereas Chinese policy banks and the export credit agency need to be more open to underwrite projects with minor Chinese equity investments. Only with such financial flexibilities, Chinese companies' superiority in technology and project management can be convened as a strategic advantage in the sector.

## **6. Key concerns and policy implications**

There are several broader concerns for the Chinese green hydrogen investors in Egypt. Among them, worsening sovereign default prospect, foreign currency shortage and convertibility, and rising security concerns are the most notable ones.

Egypt currently faces a constant shortage of foreign currency. The deficit of the current account reached US\$ 4.7 billion during FY 2022/23 (Central Bank of Egypt, 2023). It has prompted the Central Bank of Egypt to depreciate the exchange rate by 58.3% from September 2022 to November 2023 to stem the widening net exports deficit (*Figure 7(a)*), which caused inflation to an all-time high of 36% in November 2023 (*Figure 7(b)*). Egypt's debt-to-GDP ratio has increased significantly, from 69.6% in 2010 to 92.7% in 2023. Egypt needs more than US\$28 billion to meet repayments in 2024 alone (IMF, 2023) (*Figure 7(c)*). One interviewee indicated the difficulty of converting Egyptian pounds to U.S. dollar and the potential loss incurred by the depreciation of the Egyptian pounds. This is an increasingly prevalent challenge for the Chinese EPC contractors and prospect investors alike.

Figure 7. Foreign Exchange Rate, inflation rate, and debt to GDP ratio, 2010-2023



Source: Authors' creation based on IMF International Financial Statistics (IFS), World Bank, and Central Bank of Egypt

There are multiple reasons behind this round of economic challenges, among which the impacts of two ongoing conflicts in Ukraine and Gaza are particularly profound to Egypt's economic and security situations. Egypt is the world's largest wheat importer, with most of its imports previously coming from Ukraine and Russia. The Ukraine-Russia war has pushed Egypt's fragile food security to the very limit. The skyrocketing food prices are pushing up the inflation, which has been over 35% monthly throughout 2023.

The more recent and devastating war in neighboring Gaza Strip has further exacerbated the economic and security concerns in Egypt. The tourism and Suez Canal passage, as two major economic pillars of Egyptian economy, are severely impacted due to the on-going conflict. In addition, the potential influx of refugees, extra cost on border control, and additional efforts to prevent humanitarian catastrophes in the region would all bear extra burden on Egypt. Earlier 2023, Egypt already accommodated more than 317, 000 refugees from the conflict zones in neighboring Sudan. The worsening regional security situations around Egypt is taking a toll, which will certainly affect investors' risk perception, particularly for potential investments in most affected areas such as the Sinai Peninsula.

In general, the rising aspiration and potentials for the green hydrogen sector in Egypt provides considerable opportunities for the Chinese companies, particularly for those who have been cultivating the networks in the area of energy transition. However, it should be noted that the challenges of implementing specific green hydrogen investments on the ground can be significant, compared to conventional wind and solar energy projects. On the one hand, tremendous efforts having been exerted by the Egyptian government to address coordination and institutional challenges around the green hydrogen investments. On the other hand, there are several obstacles that Chinese companies and their financiers need to tackle to make further progress in the market. Below are some concrete policy implications for both parties based on our investigation.

Egyptian government has established a comprehensive regulatory and legislative framework in supporting the green hydrogen sector. However, several key issues need to be further clarified, including:

- Guaranteeing the completion of infrastructures, including green energy corridor and water supply, to the hydrogen/ammonia production sites. The contractual role and legal responsibility of the state utility and water suppliers need to be clarified within both standardized transactional arrangements and clear regulation, so that the uncertainties around supporting infrastructures can be minimized. At the piloting stage, this is not a big issue, but if there are multiple projects being implemented simultaneously, the stable and sufficient supply of these critical inputs can be a big concern among foreign investors. In addition, the reduction of the wheeling fee charged by EETC can help reduce the cost of green hydrogen production significantly.
- Regulating land access and safety standards. These regulations are not only for individual projects but for the economic zones who are expected to host most green hydrogen investments. Some re-planning and upgrading may be needed to coordinate hydrogen and non-hydrogen investments within the economic zones. The safety standards should ideally be in place before the actual project construction phase to avoid unnecessary rework in the future.
- Designing de-risking or risk-sharing mechanisms for the availability and convertibility of foreign exchange. The forex risks significantly reduce the expected profits and bankability of green hydrogen investments. Given green hydrogen's strategic value to the country's sustainable development, such de-risking or risk-sharing mechanisms should be put in place to attract more investors and financiers.
- Crafting industrial policies to nurture domestic production capacity and demand for green hydrogen/ammonia. Currently, Egypt is about to export all the production volumes before 2030, as the domestic demand and expertise in this sector is scarce.<sup>14</sup> <sup>15</sup>As the fifth largest producer of urea fertilizer and the second-largest producer of sponge iron in the world, Egypt has large potential demand at home for green hydrogen, such as producing green fertilizer (Egypt State Information Service, 2023).<sup>16</sup> The incoming EU Carbon Border

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<sup>14</sup> Interview with a free-lance consultant in the area of green hydrogen, Cairo, 5 September 2023.

<sup>15</sup> Interview with NREA, Cairo, 5 September 2023.

<sup>16</sup> Online workshop with experts, Beijing, 26 December 2023.

Adjustment Mechanism (CBAM) will impact on Egypt's grey hydrogen based products. Therefore, decarbonizing these sectors as much as, and as early as possible should on Egypt's policy agenda (UNIDO, FEI, and FPO, 2023). One local interviewee strongly support localization by arguing that domestic entrepreneurs should be encouraged to participate in the green hydrogen sector, but there is yet any supportive policies to nurture manufacturing capacities in electrolyzers and subsidizing home demand.

- Giving priority to the most implementable projects. Most interviewees believe that the majority of the MoUs would never be implemented given all the challenges mentioned above. The Egyptian government should focus on the most promising projects to avoid being over-stretched for its administrative capacities on projects that are unlikely to be accomplished.
- Establishing training programs and educational initiatives to address the significant expertise gap in the green hydrogen sector. Universities should be encouraged to open specialized courses and certification programmes on hydrogen technologies, safety protocols, and system maintenance. In addition, R&D and innovation initiative should be encouraged among local firms. One academic interviewee expressed the concern that the government grants are only interested in low-risk research but reluctant to support ground-breaking or 'high-risk, high-gain' research. Intellectual capacity building and learning opportunities are critical to drive technological progress and innovation at home. Alliances among private sectors, research institutions, and universities can foster knowledge transfer and co-creation to identify local solutions.

The Chinese companies have notable technological and cost advantages in both renewable energy and hydrogen projects. Yet, to scale up the Chinese investments in Egyptian market, the following issues need to be addressed:

- Nurturing capacity on project development and equity investments on top of the technological and EPC capabilities. Even though most of the Chinese companies are content with being the technology suppliers and EPC contractors at current stage, in the long-run more equity investment should be encouraged. This is particularly acute in the green hydrogen sector where industrial investment and infrastructure development are



inherently hooked. Nurturing the capacity for direct and equity investment on green hydrogen activities could provide tremendous long-term benefits for the Chinese companies, by accumulating critical know-how and expertise in managing the complex industrial-infrastructure nexus overseas.

- Cultivating partnerships with local and international entities, as it is nearly impossible for any individual investor to handle all four stages of green hydrogen activities alone (e.g. renewable energy production, power transmission, hydrogen/ammonia production, and gas transportation/sales). One of our interviewees strongly encourages Chinese companies to establish close partnerships with local industrial associations and companies, even though the local content requirement is currently absent.<sup>17</sup> Another possibility is to inviting the prospective green hydrogen off-takers as the equity investor. Local and international partnerships can help reduce uncertainties at the stage of project implementation, despite their high transactional cost initially, as indicated in the successful piloting project developed by Scatec.
- In the same vein, participating in collaborative financial consortium. Syndicated financing can be a more effective approach than any Chinese financier as the sole lender, due to its capacity for risk mitigating and sharing. Financial consortiums can also enhance the bankability of prospective investments. Chinese financial institutions are expected to work more actively with the regional and international MDBs and even commercial lenders for innovative and flexible financial solutions. In addition, alternative financial instruments, such as green bonds, carbon finance, and climate or development finance should be considered as complementary or alternative routes to the traditional project finance.
- Investing in domestic manufacturing capacity. Given China's unparalleled technological capacity in relation to the green hydrogen sector, investing host country's manufacturing facilities can be another route for Chinese companies to consolidate its position in the Egyptian market. Such investments, though often smaller in size, could provide valuable technology transfer and learning opportunities for the local partners. Additional support

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<sup>17</sup> Interview in Cairo, 5 September 2023 and online workshop in Beijing, 26 December 2023.

for technology transfer can be also considered via other bilateral cooperative schemes, such as South-South climate fund or bilateral development schemes.

## 7. Conclusion

Egypt is one of the developing countries that announced ambitious plans to become a leader in green hydrogen sector, given its superior wind and solar energy endowment and strategic location. Its previous success in attracting private investments in developing large-scale renewable energy capacities have boosted confidence among foreign investors and financiers to test the water of green hydrogen opportunities in the country. Chinese companies as major technology suppliers and EPC contractors in this market are also keen to explore these emerging opportunities.

Yet successful implementation of green hydrogen projects can be challenging for both hosting and investing parties. At the outset, each investment would be essentially an infrastructure-industrial complex (e.g. combining renewable energy infrastructures with hydrogen/ammonia production facilities), which include both public services and commercial activities. The complicated project structure requires tremendous coordination capacity among different host government entities governing different aspects of the projects. Egypt has established a comprehensive regulatory framework led by the National Green Hydrogen Council chaired by the prime minister, with four government agencies sharing the key responsibilities ranging from land acquisition, power access, financial investments, to other infrastructural support. However, there are notable issues that remain to be addressed to make the system more efficient. This is rather anticipated, as governing an emerging and cross-sectoral industry like green hydrogen is a typical learning by doing process.

The Chinese companies have unique advantages in the green hydrogen sector, given their strong technological and infrastructure development capacities. Some of them have been long engaging with Egyptian wind and solar markets, which helped to accumulate notable local knowledge, experiences and networks. However, compared to investors from other regions, Chinese companies and their financiers standing behind them, do need to enhance their flexibility in developing joint-ventures or adjustable financing packages. Without innovative solutions, there

can be significant constraint to further exploration of the green hydrogen opportunities in the Egyptian context.

There are broader uncertainties around the prospect of green hydrogen investments, including economic ones such as macro-economic instability and foreign currency shortages, and political risks due to the spillover effects of international and regional conflicts. These uncertainties need to be addressed and mitigated by both parties. Under such fast-changing situation, the Egypt government need to balance the short-term goal of generating foreign exchange revenues through the sales of green hydrogen overseas, and a long-term vision of nurturing domestic green industrial capacity as the basis for the successful transition out of the fossil-fuel based economy. The fast-changing situation in the region and dynamics of technological and market development requires further and constant analytical attention to this promising yet tentative sector.

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## Appendix: Survey results

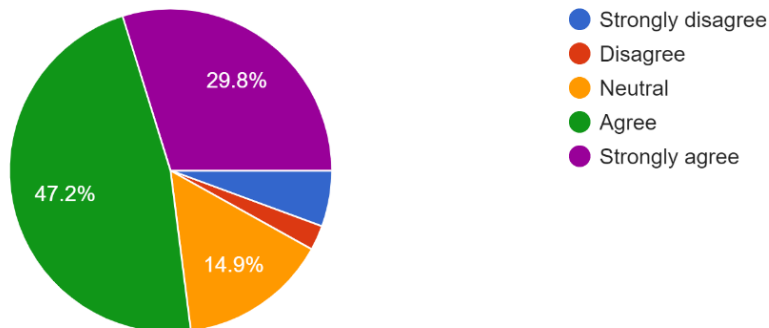
### Part 1. Demographics of respondents

Among 161 respondents, 94% of respondents' education level is Bachelor's degree or higher. 54% of the respondents work in the public sector, 31% of them work for the private sector, and 11% in non-profit organizations. More than half (59%) of the respondents work as managers (upper, middle, or junior management level) in their organizations.

### Part 2. Survey results on attitudes towards Chinese engagement in Egypt's renewable energy and green hydrogen sectors.

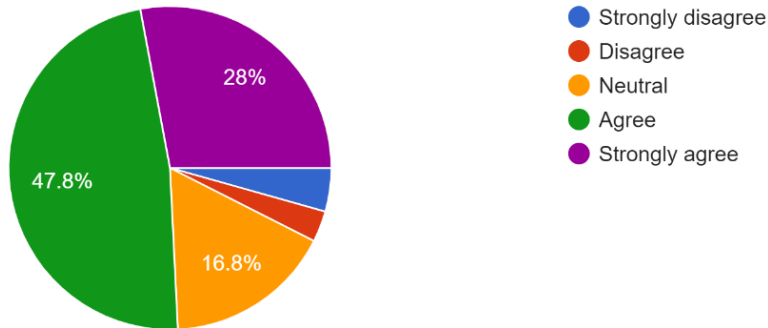
1. Chinese companies should play a bigger role in developing Egypt's renewable energy markets (such as wind and solar energy projects):

161 responses



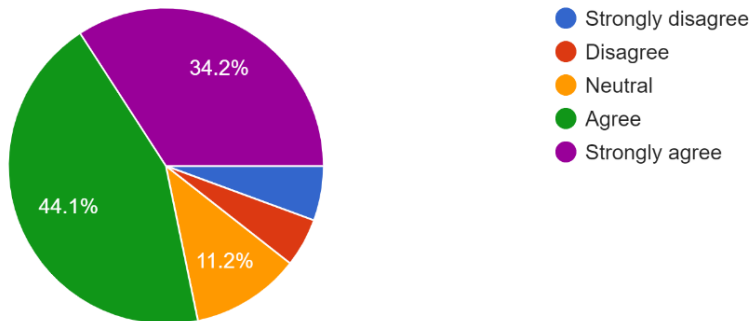
Survey result: 77% of the respondents agree or strongly agree that Chinese companies should play a bigger role in developing Egypt's renewable energy market.

2. Chinese companies should play a bigger role in developing Egypt's green hydrogen markets:  
161 responses



Survey result: 76% of the respondents agree or strongly agree that Chinese companies should play a bigger role in developing Egypt's green hydrogen market.

3. Egyptian government should encourage more Chinese companies to be involved in Egypt's green hydrogen markets.  
161 responses

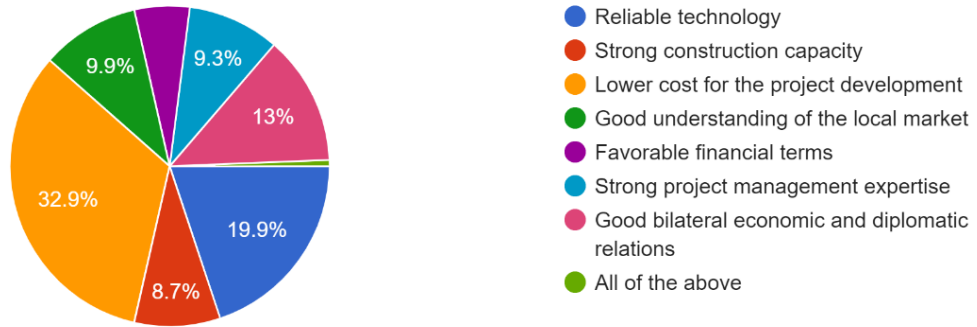


Survey result: 76% of the respondents agree or strongly agree that the Egyptian government should encourage more Chinese companies to be involved in Egypt's green hydrogen market.



4. What are the comparative advantages of Chinese companies to compete in Egypt’s renewable energy markets?

161 responses



Survey result: The top three comparative advantage of Chinese companies in Egypt’s renewable energy market are: Lower cost for the project development (33%), reliable technology (20%), and good bilateral economic and diplomatic relations (13%). 10% of responds believes that all above factors matter.

5. What are the comparative advantages of Chinese companies to compete in Egypt’s green hydrogen markets?

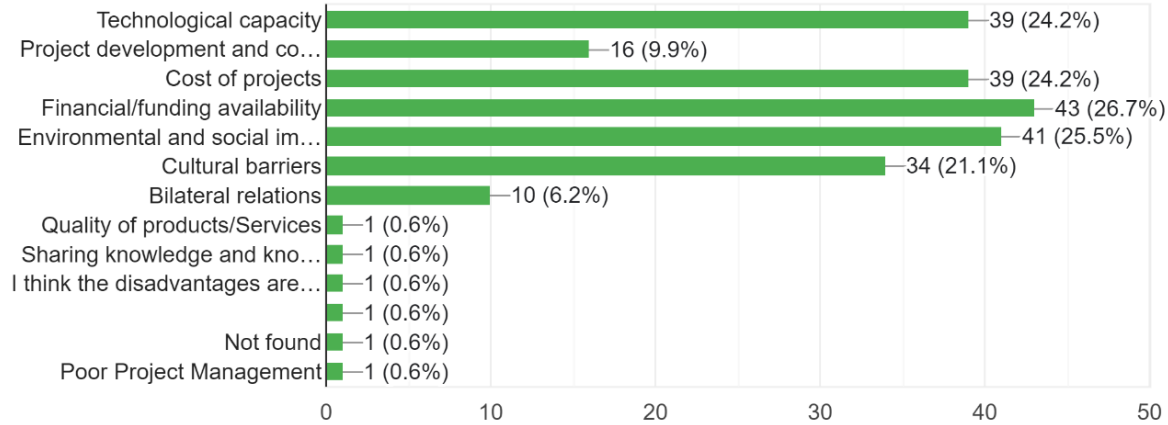
161 responses



Survey result: The top three comparative advantage of Chinese companies to complete in Egypt’s green hydrogen market are lower cost for project development (31%), reliable technology (22%), and good bilateral economic and diplomatic relations (15%).

6. What are the comparative disadvantages of Chinese companies to compete in Egypt's renewable energy markets?

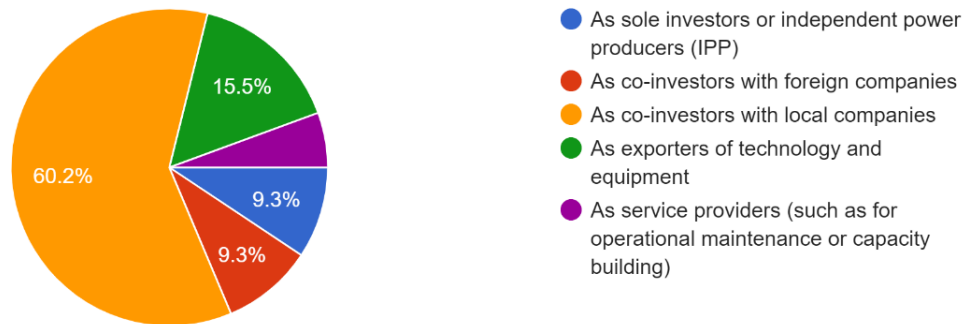
161 responses



Survey result: The top three disadvantage of Chinese companies to complete in Egypt's renewable energy market are: financial/funding availability (27%), environmental and social impacts (26%), and technological capacity (24%).

7. What can be the best role for Chinese companies to participate in Egypt's renewable energy projects?

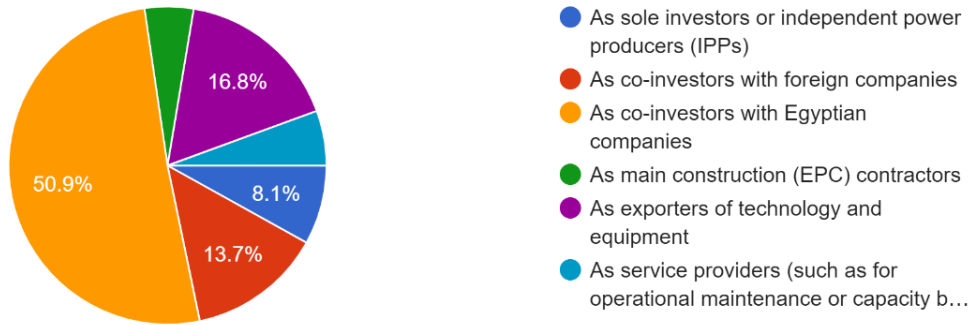
161 responses



Survey result: 70% of the respondents believe that the best role for Chinese companies to participate in Egypt's renewable energy projects are co-investors with local and with foreign companies and 16% are exporters of technology and equipment.

8. What can be the best role for Chinese companies to participate in Egypt's green hydrogen projects?

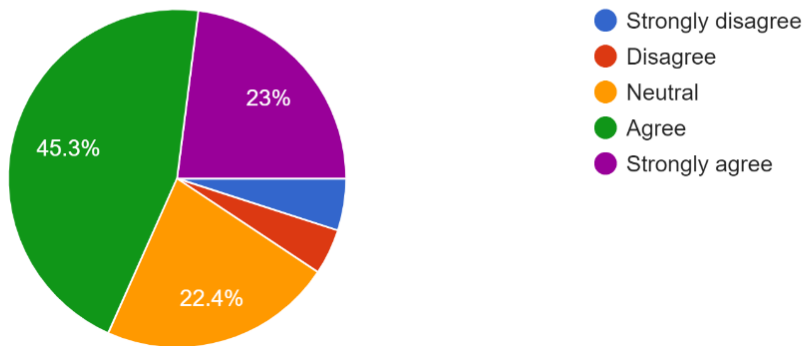
161 responses



Survey result: 65% of the respondents believe that the best role for Chinese companies to participate in Egypt's green hydrogen projects are co-investors with local and foreign companies 17% believe are exporters of technology and equipment.

9. Chinese financing is crucial for the project development in the renewable energy and green hydrogen sectors in Egypt

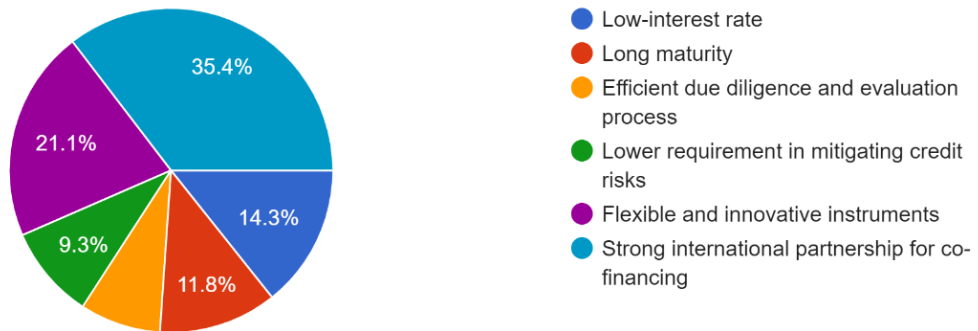
161 responses



Survey result: 68% of the respondents believe that Chinese financing is crucial for Egypt's renewable energy and green hydrogen sectors.

10. What are the comparative advantages of Chinese financing in supporting projects in the renewable energy and green hydrogen sectors in Egypt?

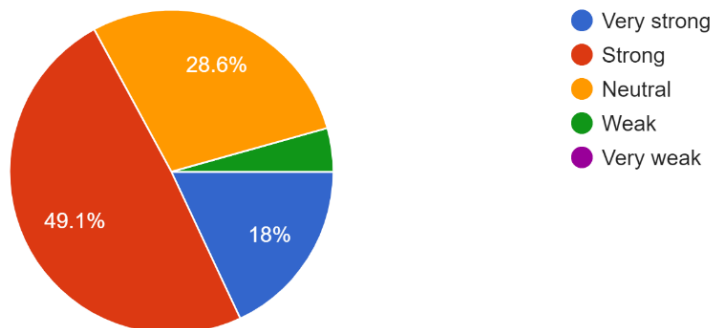
161 responses



Survey result: Respondents believe that the top three comparative advantages of Chinese financing in Egypt's renewable energy and green hydrogen sectors are Strong international partnership for co-financing (35%), flexible and innovative instruments (21%), and low interest rate (14%).

11. What's your overall impression of Chinese companies' competitiveness in developing/financing on-grid solar energy projects?

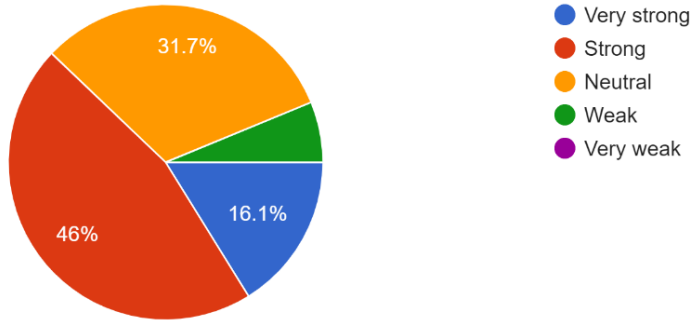
161 responses



Survey result: 67% of the respondents believe that Chinese companies are competitive in on-grid solar energy projects.

12. What's your overall impression of Chinese companies' competitiveness in developing/financing off-grid solar energy projects?

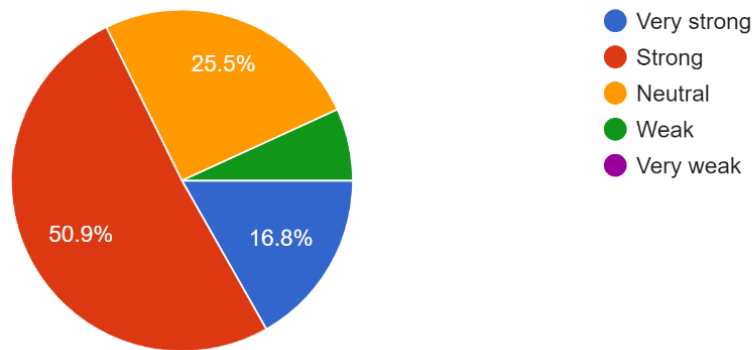
161 responses



Survey result: 62% of the respondents believe that Chinese companies are competitive in off-grid solar energy projects.

13. What's your overall impression of Chinese companies' competitiveness in developing/constructing/financing on-shore wind energy projects?

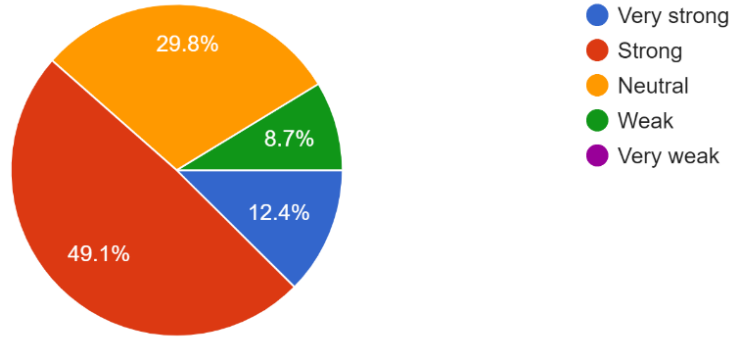
161 responses



Survey result: 68% of the respondents believe that Chinese companies are competitive in developing/constructing/financing onshore wind energy projects.

14. What's your overall impression of Chinese companies' competitiveness in developing/constructing/financing off-shore wind energy projects?

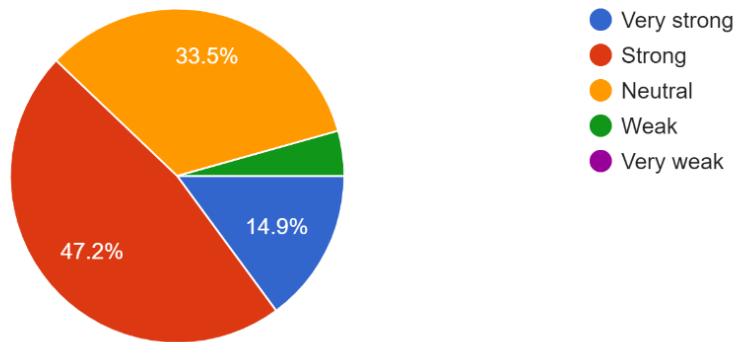
161 responses



Survey result: 62% of the respondents believe that Chinese companies are competitive in developing/constructing/financing offshore wind energy projects.

15. What's your overall impression of Chinese companies' competitiveness in developing/constructing/financing electrolyzer capacities?

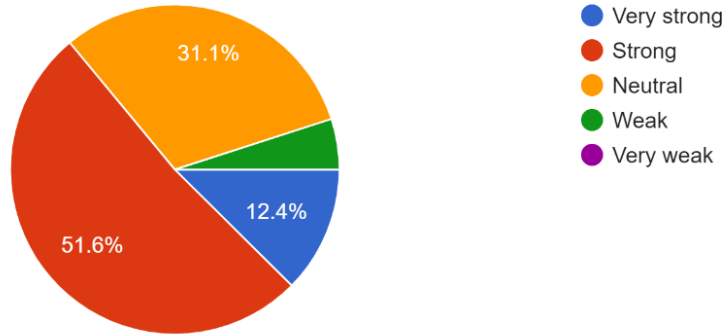
161 responses



Survey result: 62% of the respondents believe that Chinese companies are competitive in developing/constructing/financing electrolyzer capacities.

16. What's your overall impression of Chinese companies' competitiveness in developing/constructing/financing green hydrogen transportation/storage capacities?

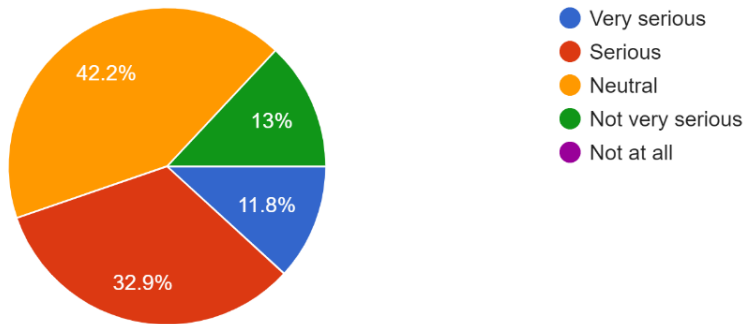
161 responses



Survey result: 62% of the respondents believe that Chinese companies are competitive in developing/constructing/financing green hydrogen transportation/storage capacities.

17. How much more concerning are Chinese projects' environmental or social impacts compared to investors from other regions?

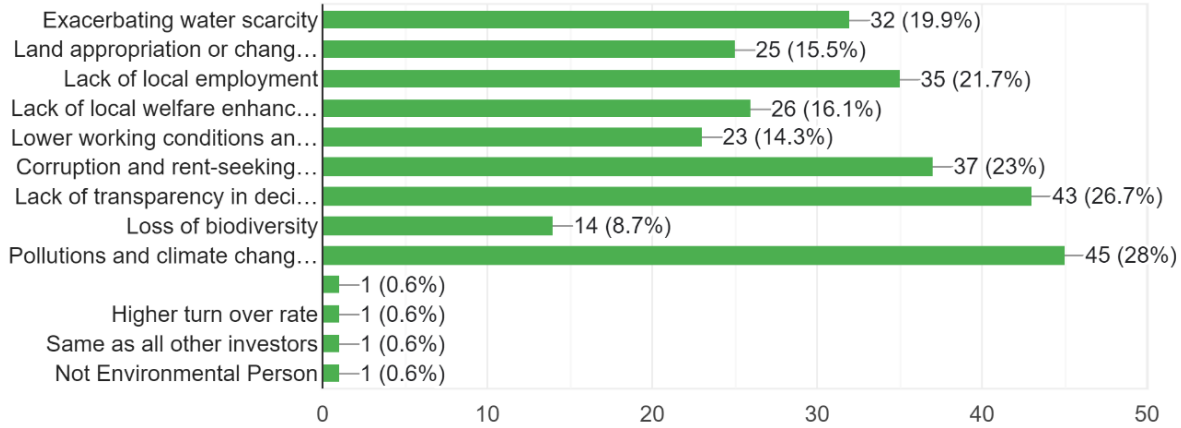
161 responses



Survey result: 45% of the respondents believe that Chinese projects' environmental or social impacts are more concerning compared to investors from other regions.

18. What can be the most concerning environmental and social impacts for the Chinese investment in the renewable energy sectors?

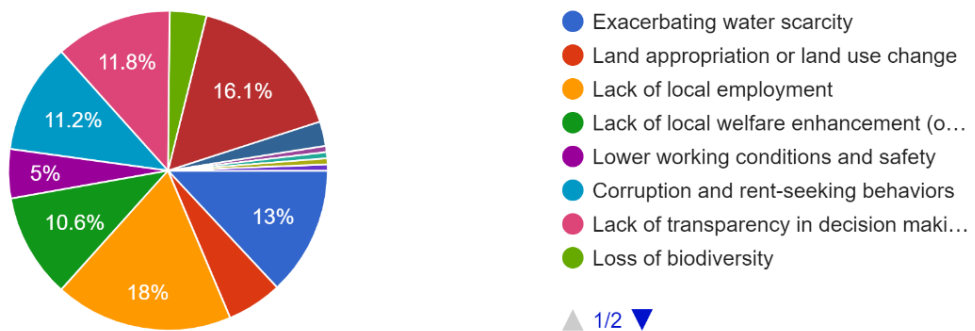
161 responses



Survey result: The top 3 most concerning environmental and social impacts for the Chinese investment in the renewable energy sector are: pollutions and climate change impacts (28%), lack of transparency in decision makings (27%), and corruption and rent-seeking behaviors (23%).

19. What can be the most concerning environmental and social impacts for the Chinese investment in the green hydrogen sector?

161 responses

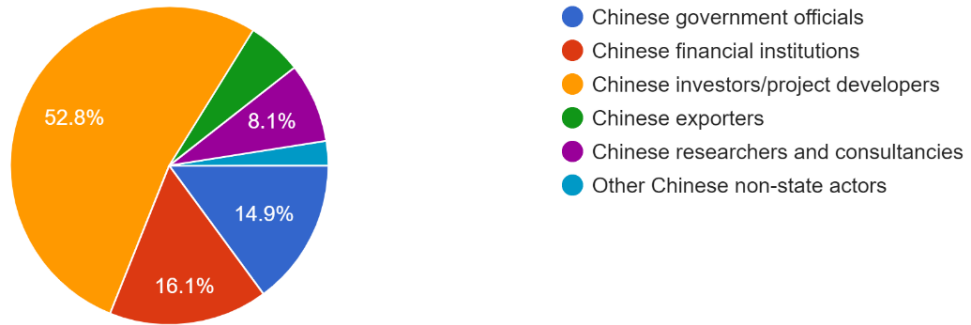


Survey result: The top 3 most concerning environmental and social impacts for the Chinese investment in the green hydrogen sector are: lack of local employment (18%), pollutions and climate change impacts (16%), and exacerbating water scarcity (13%)



20. Which type of Chinese actors do you think needs to be more actively engaged with the Egyptian renewable energy and green hydrogen sectors?

161 responses



Survey result: The top three Chinese actors that need to be more actively engaged with the Egyptian renewable energy and green hydrogen sectors are: Chinese investors/project developers (53%), Chinese financial institutions (16%), and Chinese government officials (15%).