LUISS

Institute for European
Analysis and Policy

Jean Monnet Centre of Excellence
on EU Inclusive Open Strategic Autonomy

Securing critical materials across the Mediterranean for the EU's renewable future

Leon Stille

Policy Brief 10/2024

July 29, 2024

Securing critical materials across the Mediterranean for the EU's renewable future

Leon Stille, New Energy Institute

Executive summary

The European Union's targets for renewable hydrogen production and broader renewable energy adoption face potential disruptions due to critical material supply challenges. This policy brief identifies the current issues related to material availability for electrolyzer and other renewable energy technologies.

- Strategies proposed to ensure a stable and diverse supply chain include:
  - Diversifying supply sources through international partnerships.
  - Investing in recycling and sustainable mining.
  - Creating strategic reserves.
  - Fostering technological innovation.
- Emphasis is placed on the strategic role and potential of the Mediterranean region, particularly the Middle East and North Africa (MENA).
- Engaging with the MENA region can:
  - Enhance economic diversification.
  - Create jobs.
  - Foster technological transfer.
  - Contribute to regional stability and economic growth.
- Innovations in materials science, as demonstrated by projects like HyTechCycling and REPLACE, are vital for developing alternatives to scarce materials and improving the sustainability of renewable energy technologies.
- Robust policy and regulatory frameworks are essential to support these efforts, ensuring that the EU's transition to a green economy is both sustainable and resilient.

Introduction

The EU aims to produce 40 GW of renewable hydrogen electrolyzers by 2030 as part of its broader strategy to achieve carbon neutrality by 2050 (EPRS, 2021). Electrolyzers, crucial for hydrogen production, rely on materials that are often scarce and geopolitically sensitive. The reliance on a limited number of countries for critical materials like iridium, platinum, and yttrium poses significant risks to the EU's energy security and sustainability goals. The Mediterranean region, especially the MENA area, offers significant potential to diversify and stabilize the supply of these critical materials.

Material availability challenges

Critical materials for electrolyzers

Electrolyzers, used for splitting water into hydrogen and oxygen, are vital for producing green hydrogen when powered by renewable electricity. The three main types of electrolyzers—Proton Exchange Membrane (PEM), Alkaline Water Electrolyzer (AWE), and Solid Oxide Electrolyzer Cell (SOEC)—each have specific material requirements:

1. **PEM Electrolyzers**: Require iridium and platinum, which are both rare and predominantly sourced from a few countries. Iridium is especially critical, with global production dominated by South Africa (Seck et al., 2023).
2. **AWE Electrolyzers**: Use nickel and cobalt, materials that also have supply chain vulnerabilities. Cobalt, for instance, is largely produced in the Democratic Republic of Congo, often under challenging ethical and environmental conditions (Elberry et al., 2021).
3. **SOEC Electrolyzers**: Depend on yttrium and zirconium, with significant portions of yttrium production concentrated in China (Arsad et al., 2023).

Broader renewable energy technologies

Other renewable energy technologies, such as wind turbines and solar panels, also depend on critical raw materials:

1. **Wind Turbines**: Require rare earth elements like neodymium and dysprosium for their permanent magnets.
2. **Solar Panels**: Use silicon, silver, and tellurium, each with varying degrees of supply risk and geopolitical concentration (IEA, 2023).

Potential challenges for the EU

Geopolitical risks

The EU's reliance on a few countries for critical materials poses significant geopolitical risks. For instance, the European Parliament's report highlights that China controls a substantial portion of the

supply chains for many critical raw materials, including rare earth elements, cobalt, and lithium (European Parliament, 2021). This concentration can lead to supply disruptions due to political tensions, trade restrictions, or other geopolitical events (DW, 2023). The recent Critical Raw Materials Act by the European Commission aims to address these vulnerabilities by promoting diversification of supply sources, enhancing recycling efforts, and fostering sustainable mining practices within the EU and its partner countries (European Commission, 2023). Additionally, the Act emphasizes the importance of strategic reserves to buffer against potential supply chain disruptions. By reducing dependency on a single supplier and developing a more resilient supply chain, the EU can mitigate the risks associated with geopolitical uncertainties and ensure a stable supply of critical materials essential for its renewable energy transition (IEA, 2023; IPCC, 2023).

Environmental and ethical concerns

Mining and processing of critical materials often have significant environmental impacts and can be associated with unethical labor practices. For example, cobalt mining in the Democratic Republic of Congo has been linked to child labor and severe environmental degradation (Elberry et al., 2021).

Economic vulnerabilities

Supply chain disruptions can lead to price volatility, which can increase the costs of renewable energy technologies and slow down the transition to a green economy. The limited availability of certain materials, like iridium, could severely constrain the scalability of PEM electrolyzers, as highlighted in recent studies (Seck et al., 2023).

The role and potential of the Mediterranean region

Resource availability in MENA

The Middle East and North Africa (MENA) region is rich in various minerals and resources that are critical for renewable energy technologies. Countries like Morocco, Algeria, and Egypt have significant reserves of phosphate, rare earth elements, and other minerals essential for the production of electrolyzers and other renewable energy components (European External Action Service, 2021).

Strategic partnerships

1. **Bilateral Agreements**: The EU can foster bilateral agreements with MENA countries to secure a stable supply of critical materials. These agreements should focus on sustainable and ethical mining practices, ensuring that environmental and social standards are upheld.

    - *Morocco and the EU*: In 2020, the EU and Morocco signed a partnership agreement to collaborate on renewable energy and critical raw materials, emphasizing sustainable mining practices and technological cooperation (European External Action Service, 2021).

- *Algeria and the EU*: The EU has been working with Algeria to develop its renewable energy sector, focusing on solar energy projects and the exploration of critical raw materials like rare earth elements (European External Action Service, 2021).

2. **Investment in Infrastructure**: Investing in the infrastructure of MENA countries to improve their mining capabilities can be mutually beneficial. It can provide the EU with a more stable supply of critical materials while boosting the economies of MENA countries.

    - *Tunisia and the EU*: The EU has invested in modernizing Tunisia's mining sector to improve the extraction and processing of phosphate and other minerals critical for renewable energy technologies. This initiative includes upgrading infrastructure and training the local workforce (European Investment Bank, 2021).
    - *Egypt and the EU*: The EU has partnered with Egypt to develop its infrastructure for mineral extraction, focusing on rare earth elements and other critical materials. This partnership includes funding for technological upgrades and environmental sustainability measures (European Bank for Reconstruction and Development, 2021)

3. **Joint Research and Development**: Collaborating on R&D initiatives can help develop more efficient mining and processing technologies, reducing environmental impacts and improving resource recovery rates.

    - *EU-MENA Renewable Energy Cooperation (RECASO):* This project focuses on joint research and technological innovation in renewable energy and critical material extraction, fostering collaboration between European and MENA universities and research institutions (European Commission, 2021).
    - *MASEN and EU Cooperation:* The Moroccan Agency for Sustainable Energy (MASEN) and the EU have been collaborating on R&D projects to improve the efficiency of solar technologies and explore the use of locally sourced materials for energy production (European External Action Service, 2021).

Geopolitical stability and economic growth

Engaging with the MENA region for critical materials can significantly enhance geopolitical stability and economic growth in these countries by providing multiple benefits for the EU as well. By providing economic opportunities and fostering development, the EU can help stabilize a region that has significant strategic importance for global energy markets (European External Action Service, 2021).

Firstly, economic diversification in MENA countries can reduce their dependency on oil and gas, making their economies more resilient to global market fluctuations. By investing in renewable energy and mining infrastructure, the EU can help these countries develop alternative revenue streams, which in turn can mitigate political and social unrest caused by economic volatility. For example, Morocco's focus on renewable energy projects, such as the Noor Ouarzazate Solar Complex, showcases how investment in renewables can drive economic growth and stability (IRENA, 2021).

Secondly, the creation of jobs through renewable energy projects and mining activities can alleviate high unemployment rates, contributing to social stability and overall economic prosperity. This is particularly important in countries with high unemployment rates, such as Egypt and Morocco.

According to the International Renewable Energy Agency (IRENA), the renewable energy sector in MENA has the potential to create millions of jobs by 2050 including for the MENA region (IRENA, 2021.

Additionally, technological transfer from the EU to MENA can elevate local expertise and innovation capacity, further fostering economic development. Some key initiatives include the EU-funded DESERTEC initiative, which aims to develop solar energy projects in the Sahara Desert, bringing advanced solar technologies and expertise to the region (DESERTEC Foundation, 2022).

Enhanced economic stability in the MENA region can lead to a more secure and predictable supply of critical materials for the EU, reducing the risks associated with geopolitical tensions and supply chain disruptions. Some key examples of these mechanisms in motion are:

Renewable energy projects

The MENA region is not only a potential supplier of raw materials but also a prime location for renewable energy projects. With abundant solar and wind resources, the region can become a hub for renewable energy production, contributing to global energy transition goals:

1. **Solar Energy**: The vast deserts of the MENA region offer ideal conditions for large-scale solar farms. Investments in solar energy projects can generate significant amounts of clean energy, which can be used locally or exported to Europe. A relevant examples is:
    - Desertec project: An initiative aimed at harnessing solar energy from the Sahara Desert to supply Europe and MENA with clean electricity. This project exemplifies the potential for large-scale solar energy collaboration between the EU and MENA (DESERTEC Foundation, 2022).
2. **Wind Energy**: Coastal areas in the MENA region have strong wind resources that can be harnessed for wind power projects. These projects can diversify the region's energy mix and reduce dependence on fossil fuels. A relevant example is:
    - Tarfaya wind farm: Located in Morocco, it is one of the largest wind farms in Africa and serves as a model for EU-MENA cooperation in wind energy (World Bank, 2020).

Strategies for ensuring stable and diverse supply

Diversification of Supply Sources

The EU must diversify its supply sources to reduce dependence on a few countries. This can be achieved through:

1. **International partnerships**: Establishing partnerships with resource-rich countries in the MENA and Mediterranean region that have stable political climates and strong environmental and labor standards. Countries such as Morocco, Algeria, and Egypt are rich in critical materials and can help secure a more stable supply of these materials. For example, the EU's partnership with Morocco on renewable energy and critical raw materials emphasizes sustainable mining practices and technological cooperation (European External Action Service, 2021).

2. **Recycling and circular economy**: Investing in recycling technologies and promoting a circular economy within the EU and its Mediterranean partners to recover materials from used products. This approach can reduce the demand for newly mined materials and enhance supply security. Collaborative efforts in recycling initiatives can leverage the technological expertise of the EU and the raw material availability in the MENA region.

3. **Exploration and sustainable mining**: Encouraging sustainable mining practices within Europe and in MENA partner countries to develop new sources of critical materials. For instance, EU investments in modernizing Tunisia's mining sector aim to improve the extraction and processing of phosphate and other minerals critical for renewable energy technologies (European Investment Bank, 2021). The EU could further support research and development in more sustainable extraction and processing technologies, fostering a mutually beneficial relationship with the MENA region.

Strategic Reserves and Stockpiling

The EU should consider creating strategic reserves of critical materials to buffer against supply disruptions. Stockpiling essential materials can provide a temporary supply during geopolitical or market shocks, ensuring continuity in the production of renewable energy technologies. Some key initiative examples of this within the EU and the US could serve as a basis for such a policy.

1. **European Raw Materials Initiative**: Launched in 2008, this initiative aims to secure sustainable supplies of raw materials by diversifying supply sources, fostering recycling, and creating reserves. The initiative has recently been updated to include a focus on critical materials for renewable energy technologies (European Commission, 2020).

2. **US Strategic Materials Stockpiling**: The United States maintains a National Defense Stockpile of strategic and critical materials to reduce dependence on foreign sources during emergencies. The EU can adopt a similar approach to build its strategic reserves for critical materials (US Geological Survey, 2021).

Engaging with the MENA region to develop local stockpiling strategies can further strengthen supply chain resilience. Collaborative stockpiling efforts, coupled with regional partnerships, can ensure that both the EU and MENA countries benefit from improved material security and economic stability.

Technological innovation

Investing in research and development to find alternatives to the most critical and scarce materials can reduce dependency on specific supply chains. Innovations in materials science can lead to the development of new materials or the more efficient use of existing ones. For instance, developing electrolyzers that require less or no iridium and platinum can significantly alleviate supply pressures. One such example is the HyTechCycling project under the EU's Horizon 2020 program, which focuses on improving the lifecycle of hydrogen technologies, including the development of alternative materials for electrolyzers (Horizon 2020, 2023). Additionally, projects like REPLACE, which aims to replace critical raw materials in clean energy technologies with more abundant and sustainable alternatives, highlight the EU's commitment to innovation (REPLACE Project, 2023). This focus on technological advancement is crucial as it can lead to breakthroughs that make renewable energy technologies more

cost-effective and sustainable, thereby accelerating the energy transition. Furthermore, such innovations can enhance the EU's competitiveness in the global market for renewable technologies, creating new economic opportunities and jobs within the region.

Conclusion

Ensuring a stable and diverse supply of critical materials is essential for the EU to achieve its renewable energy targets. By diversifying supply sources through international partnerships, investing in recycling and sustainable mining, creating strategic reserves, and fostering technological innovation the EU can mitigate the risks associated with material shortages. The Mediterranean region, particularly the MENA area, offers significant potential as a strategic partner in this effort. Engaging with MENA countries can enhance economic diversification, create jobs, and foster technological transfer, contributing to regional stability and economic growth. Additionally, innovations in materials science, as demonstrated by projects like HyTechCycling and REPLACE, are crucial for developing alternatives to scarce materials and improving the sustainability of renewable energy technologies. Robust policy and regulatory frameworks will further support these efforts, ensuring that the EU's transition to a green economy is both sustainable and resilient. By addressing these challenges proactively, the EU can secure its leadership in the global renewable energy market and achieve its long-term sustainability goals.

References

- Arsad, A. Z., Hannan, M. A., Al-Shetwi, A. Q., Begum, R. A., Hossain, M. J., & Ker, P. J. (2023). Hydrogen electrolyser technologies and their modelling for sustainable energy production: A comprehensive review and suggestions. International Journal of Hydrogen Energy, 48, 27841–27871.

- DESERTEC Foundation. (2022). The DESERTEC Concept. Available at: https://www.desertec.org/concept](https://www.desertec.org/concept

- DW Article on Diversifying Supply of Critical Raw Materials. (2023). Available at: https://www.dw.com/en/can-europe-diversify-its-supply-of-critical-raw-materials/a-69150065](https://www.dw.com/en/can-europe-diversify-its-supply-of-critical-raw-materials/a-69150065

- Elberry, A. M., Thakur, J., Santasalo-Aarnio, A., & Larmi, M. (2021). Large-scale compressed hydrogen storage as part of renewable electricity storage systems. International Journal of Hydrogen Energy, 46, 15671–15690.

- European Bank for Reconstruction and Development. (2021). EBRD Supports Egypt's Renewable Energy Sector with New Investments. Available at: https://www.ebrd.com/news/2021/ebrd-supports-egypts-renewable-energy-sector-with-new-investments.html](https://www.ebrd.com/news/2021/ebrd-supports-egypts-renewable-energy-sector-with-new-investments.html

- European Commission. (2020). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. Available at: https://ec.europa.eu/docsroom/documents/42849](https://ec.europa.eu/docsroom/documents/42849

- European Commission. (2021). Research and Innovation: Energy Research and Innovation. Available at: https://ec.europa.eu/info/research-and-innovation/research-area/energy-research-and-innovation_en](https://ec.europa.eu/info/research-and-innovation/research-area/energy-research-and-innovation_en

- European External Action Service (EEAS). (2021). Middle East and North Africa (MENA). Available at: https://www.eeas.europa.eu/eeas/middle-east-and-north-africa-mena_en](https://www.eeas.europa.eu/eeas/middle-east-and-north-africa-mena_en

- European External Action Service. (2021). EU and Morocco Enhance Cooperation in Renewable Energy and Sustainable Development. Available at: https://www.eeas.europa.eu/eeas/eu-and-morocco-enhance-cooperation-renewable-energy-and-sustainable-development_en](https://www.eeas.europa.eu/eeas/eu-and-morocco-enhance-cooperation-renewable-energy-and-sustainable-development_en

- European Investment Bank. (2021). EU Support for Modernisation of Tunisia's Mining Sector. Available at: https://www.eib.org/en/press/all/2021-102-eu-support-for-modernisation-of-tunisia-

s-mining-sector.htm](https://www.eib.org/en/press/all/2021-102-eu-support-for-modernisation-of-tunisia-s-mining-sector.htm

- European Parliament. (2021). Briefing on Critical Raw Materials. Available at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690606/EPRS_BRI(2021)690606_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690606/EPRS_BRI(2021)690606_EN.pdf

- European Commission. (2023). Critical Raw Materials Act. Available at: https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en

- Horizon 2020. (2023). HyTechCycling Project. Available at: https://www.hytechcycling.eu/](https://www.hytechcycling.eu/

- Intergovernmental Panel on Climate Change (IPCC). (2023). Climate Change and Land. Available at: https://www.ipcc.ch/srccl/](https://www.ipcc.ch/srccl/

- International Energy Agency (IEA). (2023). The Role of Critical Minerals in Clean Energy Transitions. Available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transition

- International Renewable Energy Agency (IRENA). (2021). Renewable Energy and Jobs – Annual Review 2021. Available at: https://www.irena.org/publications/2021/Oct/Renewable-Energy-and-Jobs-Annual-Review-2021

- REPLACE Project. (2023). REPLACE - Developing Sustainable Alternatives for Critical Raw Materials. Available at: https://www.replaceproject.eu/](https://www.replaceproject.eu/

- Seck, G. S., Hache, E., D'Herbemont, V., Guyot, M., & Malbec, L.-M. (2023). Hydrogen development in Europe: Estimating material consumption in net zero emissions scenarios. International Economics, 176, 100457.

- US Geological Survey (USGS). (2021). National Defense Stockpile. Available at: https://www.usgs.gov/centers/national-minerals-information-center/national-defense-stockpile

- World Bank. (2020). Morocco's Tarfaya Wind Farm Project. Available at: https://www.worldbank.org/en/news/feature/2020/02/10/morocco-tarfaya-wind-farm