July 2025

EcoPeace Middle East Desk Study of the Geo-political, Economic, and Environmental Feasibility of a Middle East - Europe Renewable Energy Corridor

RFQ-ECOPEACE-2024

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THE PROJECT

This project was carried out by EcoPeace Middle East. ECOPEACE MIDDLE EAST is a unique organisation at the forefront of the environmental peacebuilding movement. As a tri-lateral organisation that brings together Jordanian, Palestinian, and Israeli environmentalists, our primary objective is the promotion of cooperative efforts to protect our shared environmental heritage. In so doing, we seek to advance both sustainable regional development and the creation of necessary conditions for lasting peace in our region. EcoPeace has offices in Amman, Ramallah, and Tel-Aviv. For more information on EcoPeace or to download any of our publications please visit: www.ecopeaceme.org

Please reference this report:
EcoPeace Middle East, 2025, Desk Study of the Geo- political, Economic, and Environmental Feasibility of a Middle East - Europe Renewable Energy Corridor. Lead authors: Ezrahi, Ariel; Salman, Maryam and Mills, Robin.

ACKNOWLEDGMENTS

Ariel Ezrahi, Maryam Salman and Robin Mills were lead authors with contributions and review of EcoPeace Middle East staff including Gidon Bromberg, Nada Majdalani, Yana Abu Taleb, Bashar Al-Sorri, Ali Abdou, Olivia Basel, Abdel Rahman Sultan, Ahmad Jalal, Mohammad Ghnaimat, Sharon Bengio, Danni Reches and Peleg Gottdiener.

Our special thanks to Dr. Olaf Wientzek, Director of the Multinational Development Policy Dialogue (MDPD) of the Konrad-Adenauer-Stiftung (KAS) in Brussels, Nicole Linsenbold, Programme Manager - Development and Climate Policy, and Louis Bout, Programme Manager - Multinational Cooperation, Foreign and Security Affairs, for their support in facilitating and organising meetings and the stakeholder roundtable held in Brussels.

Data, feedback and suggestions on early stages of the research project were provided by a number of sources, including Ahmed Zaheer.

In addition, we would like to thank participants of roundtable discussions held in Amman, Tel Aviv, Ramallah and Brussels, and other experts and representatives of government ministries and agencies that shared with us their comments to earlier drafts of the report.

We benefitted greatly from earlier work carried out by the Sun Triangle consortium led by Dr. Noam Winer and by EcoPeace staff and consultants that worked on assembling a vast amount of background data, much of which served this report.

Finally, the content of this report and opinions expressed are the sole responsibility of the authors and do not necessarily reflect the opinion of KAS MDPD or the funders of EcoPeace Middle East.

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Executive Summary

- Clean energy is a crucial opportunity to foster sustainable development, economic reconstruction, and peace and reconciliation, between Israel, Palestine and the neighbouring countries of Jordan, Egypt and Saudi Arabia
- The **"**Sunrise Region**"** around North-Eastern Egypt, Jordan and North-Western Saudi Arabia has some of the world's best combined conditions for solar and wind power. The average daily output over a year of 1 kilowatt (kW) of installed solar panels in a typical part of the Sunrise Region is 5.1-5.6 kilowatt-hours (kWh), and with strong output even in winter, compared to 4.3 kWh in Greece, 4.2 kWh in Southern Italy, and 3.2 kWh in Southern Germany. Wind capacity factors in the best parts of the Sunrise Region average above 50% and are quite consistent through the year, while they may be around 21% in Italy, 22% in Germany and 25-30% in Greece with major seasonal variability
- Renewable electricity and hydrogen can be shared between these countries and exported to Europe via hubs in Gaza, Egypt and Israel
- This will create shared prosperity for the region, accelerate the rebuilding of Gaza by and for its inhabitants, provide economic returns, give the regional countries an incentive to work together and avoid a recurrence of armed conflict, and tie in key external stakeholders including the EU and US
- **This report proceeds** on the assumption that this initiative would be carried out as part of the pathway to a sustainable political solution between Israel, Palestine and their neighbours, in a reasonably collaborative atmosphere, accounting for all parties' legitimate security needs
- This analysis indicates that there is sufficient market, and that the technical conditions allow for economically viable electricity and hydrogen exports, via subsea cable for electricity and pipeline or ship for hydrogen, on a large scale, enough to supply up to 30% of demand in South-Eastern and Central Europe, via a series of phases (indicatively about 18 phases of 10 gigawatts (GW) each), delivered progressively over about 25 years
- This can improve Europe's energy security and accelerate its decarbonisation
- Next steps include:
    - More detailed techno-economic analysis and costing of a subset of defined concepts
    - Development of a phased plan synchronising technical, commercial and political steps
    - More detailed examination of potential environmental issues
    - Detailed stakeholder mapping and initial engagement

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o This report begins with a *Contextual Analysis* to lay out the broader political, economic, and environmental landscape relevant to a proposed Middle East-Europe Renewable Corridor ("corridor") and follows with a *Technical Feasibility Analysis* to assess its technical and economic viability within and from the "Sunrise Region[1]" to Europe via a hub in Israel and Palestine. It conducts also a *Geopolitical Analysis* to assess the benefits and opportunities for each key player involved, emphasising its contribution, including to the rebuilding of Gaza by and for its inhabitants, and realisation of shared objectives of security, stability, and an end to armed conflict. Lastly, it undertakes a high-level *Environmental Analysis* to assess potential environmental impacts of the proposed corridor and propose strategies to mitigate them.

o Core conclusions concur with the Sun Triangle's findings that renewable energy generated at the right sites around North-Eastern Egypt, Southern Jordan, and North-Western Saudi Arabia (the Sunrise Region), could, through electricity interconnectors, meet regional demand in Jordan, Israel, and Palestine, and supply up to 30% of Southeast and Central Europe's electricity needs via hubs in Gaza, Israel and Egypt. This would require approximately 135 GW of solar power and 35 GW of wind, or equivalent combination, distributed over about 10,000 km^2 of land (much of which, particularly that occupied by wind, could also accommodate continuing other usage). Additionally, it confirms the strong potential for cost-effective, large-scale exports of renewables-based ("green") hydrogen to Europe as part of the corridor to meet Europe's decarbonisation and energy needs, and support regional stability and reconstruction following the Gaza War.

[1] The Sunrise Region is the area of Southern Jordan, Neom in Saudi Arabia and Sinai in Egypt, for which a consortium of think tanks, civil society organisations, and academics proposed and supported a concept for the export of renewable energy from the Middle East to Europe

- We conclude **six key economic reasons** for exporting renewable electricity and green hydrogen through the corridor to South-East and Central Europe:
    1. All-in costs of delivered energy (generation plus conversion (if required) plus transport) may be lower than those of on-site generation in Europe
    2. The value of delivered electricity may be higher than indigenous generation because of the match of timing of renewable generation in the Sunrise Region to European demand patterns being potentially better
    3. Low or anti-correlation of renewable generation in the Sunrise Region to that in Europe is synergistic with European generation, reducing storage requirements and limiting the risk of periods of low renewable generation
    4. Large areas of suitable land for renewable installations are readily available in the Sunrise Region, while available or affordable land in Europe may be insufficient, not promptly accessible, or unsuitable to install required renewable capacity
    5. Delivered cost of low-carbon hydrogen or derivatives from the Sunrise Region to Europe could be cheaper than domestic production or imports from other areas, because of the high-quality renewable resources and geographic proximity
    6. Production of low-carbon hydrogen could develop local industry in the Sunrise Region with associated spin-offs, such as diversifying exports, and assisting Europe in the strategic diversification of fuels and feedstocks

- Hydrogen production could be employed to produce "green" materials such as ammonia, methanol, synthetic fuels, and steel which can be used domestically for purposes of reconstruction following the Gaza War or exported more readily while major exports of standalone hydrogen from the Sunrise Region to Europe are developed. The natural gas projects underway in Israel and Palestine (the Jenin Powerplant and Gas for Gaza (G4G)) can be ready for hydrogen blends, forming in the longer-term the backbone of a decarbonised system using some combination of hydrogen, low-carbon synthetic natural gas (SNG) and renewable natural gas (RNG)/biomethane

- Realising the renewable energy and hydrogen export potential of the corridor will create regional balance, ensure equitable access to energy, encourage infrastructure development in less resource-rich areas, promote stability and most importantly, contribute to bringing together Israel and Palestine, initially through projects and initiatives, and eventually it is hoped in other more politically challenging domains, with Jordan and Gulf states serving as key mediators and facilitators to progress regional reconstruction efforts. Jordan and Gulf states could play a central role in bridging divides to ensure the corridor's energy initiatives contribute effectively to long-term stability and peace in the region

- Collaborating with international partners like Europe, the US, and Gulf leaders like the UAE and Saudi Arabia to support Gaza's integration in the corridor can help prevent the strengthening of extremist forces in the region by creating economic opportunities, improving living conditions and fostering a sense of hope and regional cooperation. Recent political developments can allow the prospect of considering Syria and Lebanon as involved parties or at least recipients of energy from the Sunrise Region, helping their own stabilisation and reconstruction

- This report is a starting point for further research on the technical and socio-economic aspects of the proposed corridor. It emphasises the need for broader pre-feasibility and feasibility studies that assess in more detail the full social implications of the corridor, an environmental impact assessment, and a geopolitical risk assessment to analyse the potential of new relationships between different actors and effective engagement strategies between those prone to conflict

Introduction

The complex relationship between economic cooperation and regional stability in the Middle East has once again come into the limelight with the outbreak of the Israel-Gaza war in October 2023, and continuing military and political developments both in Israel and Palestine and across the wider region. Economic factors that long played a decisive role in shaping the foreign policy trajectories of Middle East states have now become pivotal in efforts to foster détente and reconciliation amid shared regional challenges.

The India-Middle East-Europe Economic Corridor (IMEC) can find a place at the centre of such efforts. Announced at the 2023 G20 New Delhi Summit, it signals a new momentum in global connectivity geopolitics that has the potential to advance collective peace and shared prosperity. Specifically, a **"Peace Triangle"**[2] of healthy interdependencies between Israel, Palestine, and Jordan – proposed by EcoPeace Middle East, an environmental peace-building organisation co-led by Israeli, Palestinian, and Jordanian members – is intended as an addition to the IMEC that can promote peace in the region via climate-smart interconnectivity initiatives. The Peace Triangle proposes three catalytic projects, a water energy exchange, a transport corridor and an export corridor of renewable energy from the Middle East to Europe, that builds on the IMEC platform to advance not only economic but also geopolitical, security, and economic gains for all sides.

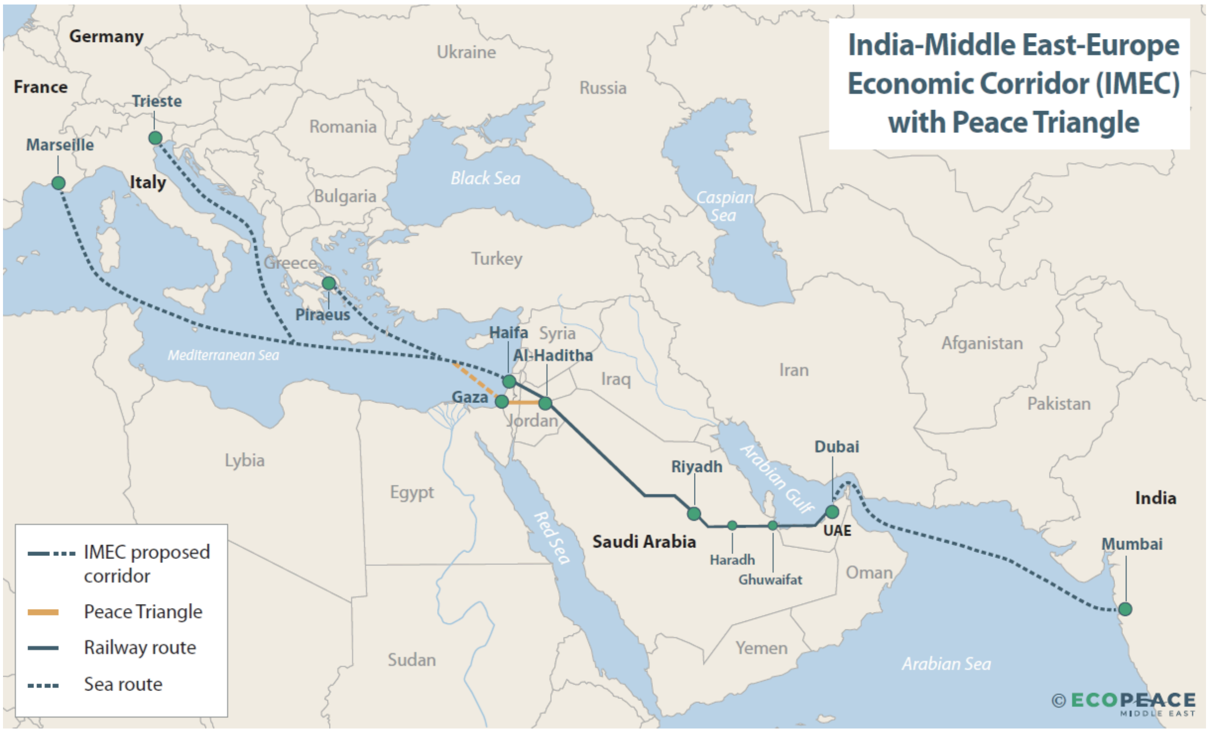


Figure 1 The India-Middle East-Europe Economic Corridor (IMEC) with The Peace Triangle Addition[3]

This desk study was commissioned by EcoPeace Middle East to specifically evaluate the geo-political, economic, and environmental feasibility of a Middle East - Europe renewable energy corridor. A consortium called the "Sun Triangle"[4] identified the southern part of Jordan, the North-West part of Saudi Arabia, and the Egyptian Sinai as the best area in the Mediterranean basin that can produce renewable energy combining sun and wind. The research identified that in a relatively small area, the combination of sun and wind can meet not only significant Middle East electricity needs, but through electricity interconnectors supply up to 30% of South and Central Europe's electricity needs. This concept is supported by recent progress in long-distance high-voltage cables, for instance from Western China and Inner Mongolia to Beijing and the Chinese coast, and other concepts for international subsea interconnectors, such as Iceland-UK, Morocco-UK and Australia-Singapore. EcoPeace has commissioned Qamar Energy, the Dubai-based strategic energy consultancy, to evaluate the initial findings of the Sun Triangle consortium, expanding the study to also include and compare the feasibility of producing green

[2] EcoPeace Middle East, "Our New Path to Sustainability: The IMEC Peace Triangle", January 2025, https://ecopeaceme.org/2025/01/28/the-imec-peace-triangle/
[3] Qamar Energy Research; background map from The Interpreter, "History repeats: A new (old) economic corridor emerges", November 2023, https://www.lowyinstitute.org/the-interpreter/history-repeats-new-old-economic-corridor-emerges (Elmurod Usubaliev / Anadolu Agency via Getty Images)
[4] The **Sun Triangle** is a concept proposed and supported by a consortium of think tanks, civil society organisations, and academics for the export of renewable energy from the Middle East to Europe

hydrogen and green hydrogen export pipelines in addition to electricity interconnectors. In line with the objectives of advancing the goals of the Peace Triangle, a cooperative framework involving Jordan, Palestine , and Israel, EcoPeace has prescribed that the study investigates the export nodes of renewable energy to focus on Egypt, Israel and Palestine (Gaza). This approach ensures that the benefits of renewable energy development are shared equitably among the Peace Triangle partners, fostering regional cooperation, stability, and sustainable growth.

The Sunrise Region is intended to support one of the Peace Triangle's catalytic aims, a Middle East-Europe Renewable Corridor, i.e. the production of renewable (solar and wind) electricity and renewables-based low-carbon hydrogen ("green" hydrogen) in IMEC-relevant countries with a renewables-rich resource base to supply Israel and Palestine, with onward export from coastal hubs in Egypt, Palestine (Gaza) and Israel via electricity cables and hydrogen pipelines to Southern and Central Europe. The main producers would be Jordan, the northern part of Saudi Arabia, and Egypt, while Israel and Palestine (Gaza) would be importers with the further intention of serving as export hubs towards Europe together with Egypt. Key investors, private and/or public, would ideally include the IMEC countries, including the Gulf Cooperation Council (GCC) with the EU, US and India.

An energy distribution plan of such scope could create regional balance by positioning key producers alongside importers and future re-exporters to Europe. This interdependence can foster regional cooperation, ensuring equitable access to energy, and encouraging infrastructure development in less resource-rich areas, promoting overall stability. In other words, the Peace Triangle aims to reduce reliance on any single country and strengthen regional energy security. Such an addition to the IMEC via a Peace Triangle would unlock a range of regional and international beneficiaries, including not just the three core partners involved in the Peace Triangle (i.e. Israel, Palestine, and Jordan), but also the Sunrise Region producers – Jordan, Saudi Arabia, and Egypt – as well as signatories to the IMEC (the UAE, India, the US, and the EU), the wider GCC countries[5], and potentially Turkey, Syria, Lebanon and Iraq.

For all these countries, it would promote regional political stability, diversify energy markets by providing new investment opportunities and routes to markets, reduce reliance on vulnerable marine chokepoints, strengthen economic relations, and promote the transition to low-carbon energy. Additionally, by supporting its renewable energy export aim, the corridor could unlock potential for support on other non-renewable energy-related aspirations of the Peace Triangle, such as fostering new regional dialogue as a new set of political dynamics emerge following the Israeli and US attacks on Iranian nuclear and military sites and personnel, the fall of the Assad regime in Syria, the election of a new Western-backed President in Lebanon – Joseph Aoun – who is expected to exert the Lebanese state's power over Hezbollah, the expectation of a US-led economic plan for post- war reconstruction. Renewable energy producer states such as Egypt and Jordan together with Israel and Palestine as export nodes could be advocated for inclusion in the IMEC as key facilitators of the renewable energy corridor.

Meanwhile, Donald Trump's inauguration speech on January 20 provided key insights into his administration's potential influence on the corridor, and more broadly, the Peace Triangle and IMEC. While he has committed to rolling back policies like the Green New Deal – a Congressional resolution under Biden that lays out the US's plans for tackling climate change – and the electric vehicle mandate, and separately signed an executive order to withdraw from the Paris Agreement, the US could support the Triangle's aims as long as they align with broader peace-making goals in the region including normalisation with Israel and Saudi Arabia as well as other Arab nations (also aligning with Trump's own agenda of being a global "peacemaker"). This could significantly enhance cross border conflict resolution, potentially advancing the Peace Triangle's clean energy initiatives despite his domestic pro-hydrocarbon – "drill, baby, drill" – agenda. President Trump is not against renewable energy per se; he has more of an issue with curbing limits on hydrocarbon production (a key driver of the US economy) and associates anything which refers to "climate" as related as being a left-wing agenda.

[5] Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE)

At Trump's meeting with Indian Prime Minister Narendra Modi in February 2025, the two leaders reaffirmed their commitment to IMEC[6].

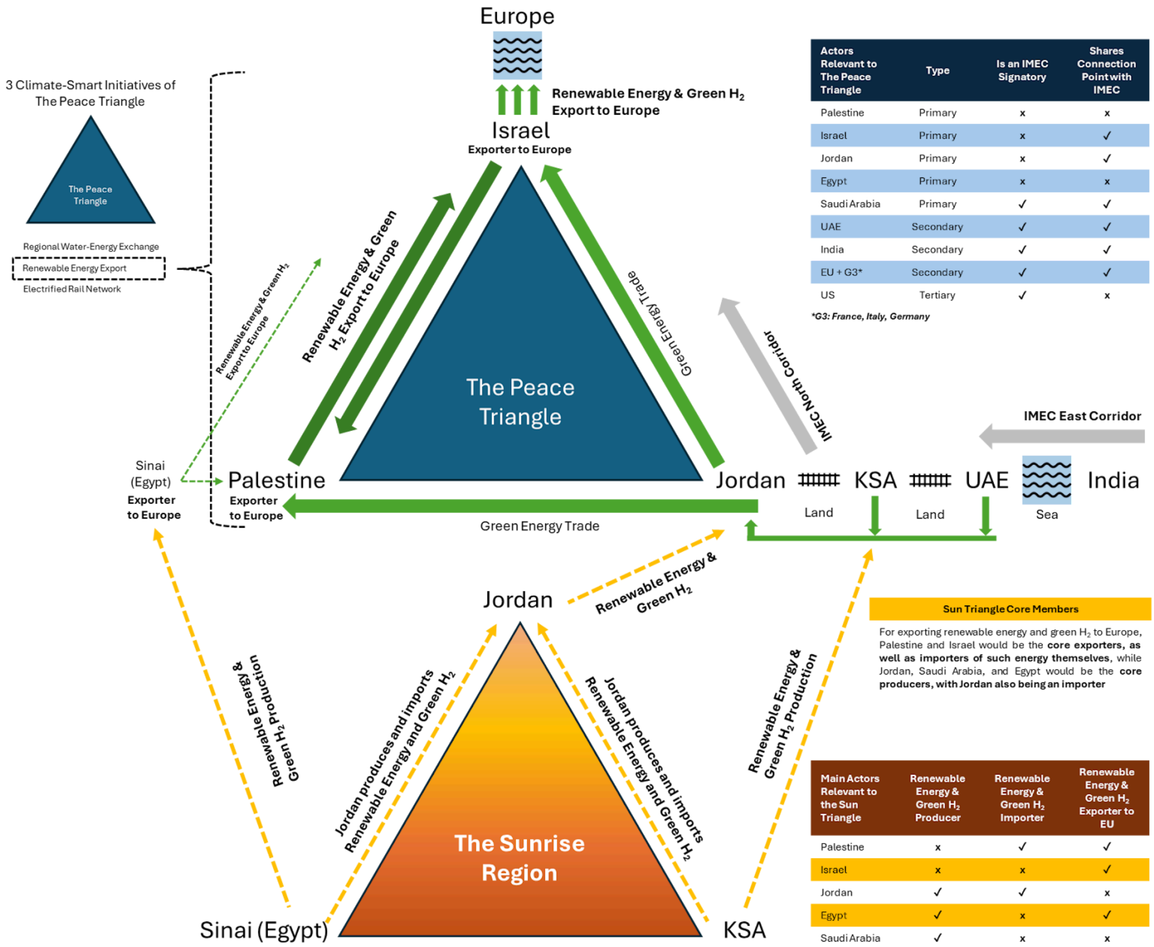
This report seeks to examine whether the energy export corridor concept of the Peace Triangle can drive enduring stability in the region of Israel, Palestine and their neighbours. It aims to understand if individual actors' geopolitical stances, economic strategies, and collaborative efforts can become the foundation for lasting peace and, if so, what forms of cooperation might be best leveraged as catalysts for further collaboration. By analysing the complex nexus of economic interests and stability, this report endeavours to highlight the potential of energy cooperation as a stabilising force, as well as the constraints and challenges that persist at this crucial policy intersection.

This report contributes to proposing how Middle East countries could collaborate on energy to improve stability and wellbeing, and reduce the risk and consequences of further regional conflict. It proceeds on the assumption that this initiative would be carried out as part of the pathway to a sustainable political solution between Israel, Palestine and their neighbours, in a reasonably collaborative atmosphere, accounting for all parties' legitimate security needs, and including effective intra-Palestinian cooperation and ability for institutions and infrastructure to function between Gaza and the West Bank.

[6] CNBC,14 February 2025, "How PM Modi and Trump plan to beat China's belt and road initiative" https://www.cnbctv18.com/world/pm-modi-trump-meeting-how-us-and-india-plan-to-beat-china-belt-and-road-initiative-19558677.htm

1. Contextual Analysis

1.1 Policy & Political Landscape



Actors Relevant to The Peace Triangle	Type	Is an IMEC Signatory	Shares Connection Point with IMEC
Palestine	Primary	x	x
Israel	Primary	x	✓
Jordan	Primary	x	✓
Egypt	Primary	x	x
Saudi Arabia	Primary	✓	✓
UAE	Secondary	✓	✓
India	Secondary	✓	✓
EU + G3*	Secondary	✓	✓
US	Tertiary	✓	x

***G3: France, Italy, Germany**

Main Actors Relevant to the Sun Triangle	Renewable Energy & Green H_2 Producer	Renewable Energy & Green H_2 Importer	Renewable Energy & Green H_2 Exporter to EU
Palestine	x	✓	✓
Israel	x	x	✓
Jordan	✓	✓	x
Egypt	✓	x	✓
Saudi Arabia	✓	x	x

Figure 2 The Peace Triangle's Renewable Energy Export Concept, supported by the Sunrise Region, as an Addition to the IMEC[7]

A Peace Triangle[8] for lasting Israeli-Palestinian peace, as proposed by EcoPeace Middle East, requires simultaneously satisfying geopolitical, security, economic, and climate interests. The IMEC Memorandum of Understanding (MoU) offers a unique political-economic coalition that has at its core enhancement of energy security, the establishment of competitive regional markets, coordinated resource – primarily energy – development, and promotion of diplomatic ties for socioeconomic growth and regional stability. It provides a rare and ambitious multilateral basis for dialogue and development, given its diverse line-up of signatories brought together by an eye-to-eye partnership. Including a Peace Triangle could help it more rapidly meet its aims, given that without overcoming current political and armed violence the IMEC concept could be abandoned, potentially disadvantageous to its members.

In other words, the Peace Triangle can become foundational to the aims of the IMEC by facilitating reliable access to energy for the purposes of energy security, economic stability, and social cohesion. Such facilitation is proposed to be carried out by the renewable energy corridor, a cooperative effort between three core renewable energy producers – the southern part of Jordan, the North-West part of Saudi Arabia, and the Egyptian Sinai and Red Sea coast – to supply renewable energy and green hydrogen to Palestine and Israel for own use and onward export to central and Southeast Europe, integrating Gaza as an additional export node to Europe, alongside Israel and Egypt for the purposes of regional peace-making and stability.

[7] Qamar Energy Research
[8] EcoPeace Middle East, "Our New Path to Sustainability: The IMEC Peace Triangle", January 2025, https://ecopeaceme.org/2025/01/28/the-imec-peace-triangle/

Energy security now emphasises collective action on climate change, promoting interdependencies and shared benefits to help economies flourish in a cooperative international framework, rather than pursuing traditional assertive and non-cooperative supply-focussed approaches that hindered environmental efforts. Some recent global developments have threatened a shift back to traditional zero-sum approaches, such as the aforementioned election of Donald Trump as US President, Russia's invasion of Ukraine, the China-US/EU trade disputes, and most directly, the Israeli-Palestinian conflict. Nevertheless, the general sentiment of each individual IMEC member has been to progress climate change mitigation and the transition to renewable and other low-carbon energy as quickly as possible, while at the same time committing to align these aims with economic stability, social cohesion, and regional peacebuilding efforts.

Table 1 Key energy objectives sought by actors relevant to the renewable energy corridor through the IMEC[9]

Core Actors Relevant to the Sunrise Region	Key Energy Objectives Sought through the IMEC	Energy Development as a Stabilising Force for the Region	Energy Cooperation Across Borders	Reducing Energy Poverty for Peacebuilding	Sustainable Energy for Economic Stability	Strengthened / Optimised Energy Supply Chains	Counter Monopolistic Trade Patterns
Palestine		●●●	●●●	●●●	●●●	●●	●●●
Israel		●●	●●●	●	●●●	●●●	●●
Jordan		●●	●●●	●●●	●●●	●●	●●
Egypt		●●	●●●	●●	●●●	●●	●
Saudi Arabia		●	●●	●	●●	●●●	●
Secondary Actors Relevant to the Sunrise Region		**Energy Development as a Stabilising Force for the Region**	**Energy Cooperation Across Borders**	**Reducing Energy Poverty for Peacebuilding**	**Sustainable Energy for Economic Stability**	**Strengthened / Optimised Energy Supply Chains**	**Counter Monopolistic Trade Patterns**
UAE		●●●	●●	●●●	●●●	●●●	●
India		●●	●	●●●	●●●	●●●	●●●
EU + G3*		●●●	●●●	●●●	●●●	●●●	●●●
US		●●●	●●	●●	●●	●●●	●●●
Legend / Key	● Low Emphasis ●● Significant Emphasis ●●● Priority Emphasis						

*G3: France, Italy, Germany

[9] Qamar Energy Research

Still, there are differences in their approaches towards climate change mitigation. Palestine requires urgent reconstruction efforts for Gaza following at least a sustainable interim political solution to the conflict with Israel before they can wholly embark on climate change mitigation efforts at a level similar to their counterparts. Securing energy access can act as a stabilising force for Gaza and will initially include hydrocarbon and electricity flows while the rest of the Sunrise Region works towards building renewable energy and other low-carbon energy-ready infrastructure that aligns with the Peace Triangle and IMEC's aims. This will be most strongly promoted *and* supported by the EU, Israel, the UAE, and Saudi Arabia, and others in the region who have set net-zero carbon target dates.

Egypt and Jordan have not yet set net-zero targets, but both remain intently focussed on expanding their renewables portfolio. In the case of Egypt, whose gas resources are declining, developing renewables and green hydrogen capabilities will help it secure not only its own energy security, but also enable export of surplus to the surrounding region and Europe, thanks to its rich resource base. For Jordan, developing clean energy interconnections with its neighbours could help relieve its overcommitment on high-priced power purchases, reducing the burden of incurring costs of contracted quantities that go unused. Both countries also intend to develop green hydrogen industries, for domestic use and export[10]Egypt being more advanced to date.

Table 2 Key climate action initiatives and targets of IMEC signatories

IMEC Signatory	Net-Zero Goal	Paris Agreement Signatory	Key Climate Action Initiatives / Targets	Importer / Exporter of Green Energy	Target Markets for Green Energy Trade
India	2070	✔	• 50% of cumulative installed capacity from non-fossil fuel-based sources by 2030 • Emissions intensity reduction from 33-35% to 45% by 2030 from 2005 levels • National Green Hydrogen Mission to produce 5 Mt/y of green hydrogen by 2030 • 500 GW of non-fossil energy capacity by 2030 • Reduce total projected carbon emissions by 1 Bt from now to 2050	Both	MENA, South Asia, Europe
UAE	2050	✔	• National Hydrogen Strategy to produce 15 Mt/y of low-carbon hydrogen by 2050 • UAE Green Agenda 2030 to reduce country emissions to <100 kWh • Reduce GHG emissions by 47% by 2035 from 2019 levels (i.e. from 196.3 $MtCO_2e$ in 2019 to 103.5 $MtCO_2e$ in 2035) • Reduce industry GHG emissions by 27%, in transport by 20%, in waste by 37%, in buildings by 79%, and in agriculture by 39% • Triple the contribution of renewable energy to the country's energy mix, by increasing installed clean energy capacity to 19.8 GW by 2030	Exporter	MENA, Asia, Europe
KSA	2060	✔	• Reduce carbon emissions by 278 $MtCO_2e$ annually by 2030 from 2019 levels • 50% of electricity from renewables by 2030, or the Saudi Green Initiative • Create 250 kt/y of green hydrogen by 2026 • Circular Carbon Economy National Program	Exporter	MENA, Asia, Europe
EU	2050	✔	• 55% emissions reduction target by 2030 below 1990 levels • European Green Deal and Fit for 55 Package • REPowerEU to fast forward the green transition and rapidly reduce dependence on Russian fossil fuels	Net Importer	MENA, North America

[10] Ministry of Energy and Mineral Resources, "Jordan is moving towards a green hydrogen economy with steady steps" https://www.memr.gov.jo/En/NewsDetails/AlKharabsheh_Jordan_is_moving_towards_a_green_hydrogen_economy_with_steady_steps

			• 10 Mt/y of renewable hydrogen production and 10 Mt/y of imported renewable hydrogen by 2030 • EU Global Gateway to boost smart, clean, and secure links in the digital, energy, and transport sectors		
France	2050	✔	• Reduce GHG emissions by 40% between 1990 and 2030 • 41.3% of renewables in final energy consumption in 2030 • Climate and Resilience Law • Energy Transition Law or the Energy Transition for Green Growth Law	Net Importer	MENA, North America
Germany	2045	✔	• Reduce GHG emissions by 65% until 2030 compared to 1990 levels • Reduce GHG emissions by 88% until 2040 compared to 1990 levels • 50% of heat in buildings produced in climate-neutral way by 2030 • Reach 80% renewables in the electricity mix by 2030 • Reach net-negative emissions in land use and forestry by 2030	Net Importer	MENA, North America
Italy	2050	✔	• Reduce GHG emissions by 33% by 2030 relative to 2005 levels • 72% of renewable electricity by 2030 • “Superbonus” Energy Efficiency Incentive Programme to provide tax breaks for energy-efficient building renovations • National Circular Economy Strategy	Net Importer	MENA, North America
US[11]	2050	✔	• Reduce GHG emissions by 50-52% by 2030 compared to 2005 levels • Reduce GHG emissions by 61-66% by 2035 compared to 2005 levels • Reach 100% carbon pollution-free electricity by 2035 • Inflation Reduction Act and 45Q and 45V credits for CCUS and hydrogen projects	Exporter	Europe

The climate action initiatives of the IMEC signatories also tie in with various multilateral goals, for example, wider regional connectivity by offering an additional option alongside the China-led Belt and Road Initiative (BRI). This is intended not only to address imbalances in trade patterns but also partner with impacted communities and environments for regional peacebuilding – a principle plainly absent from the BRI. Of note is that all of them have shown strong support for a viable two-state solution to the Israeli-Palestinian conflict, even actors that are yet to sign the Abraham Accords or more generally to normalise relations with Israel, such as Saudi Arabia.

As part of the Peace Triangle, the renewable energy corridor could serve as a transformative pathway towards a peaceful, prosperous Palestinian State, as envisioned by renewable energy producers like Saudi Arabia in the context of normalising relations with Israel. By fostering investment and collaborative reconstruction efforts in Gaza, this approach would generate significant economic and social benefits, not only enabling key IMEC aims but also helping to promote stability in Gaza and the broader region, while potentially countering the conditions that contribute to strengthening extremist forces. Depending on political developments, other conflict- and crisis-hit regional countries, notably Syria, Lebanon and Iraq, could also be included in future expansions of the initiative, as producers, importers and/or transit countries. All of these countries suffer currently from severe electricity shortages.

With Trump as President of the US, there will likely be a strengthening of relations between the US and Saudi Arabia. This could result in further steps towards normalization between Israel and the Gulf states (especially Saudi Arabia) which would promote US aims of bolstering cross-country investments in high-tech, artificial intelligence, and security, such as the Vision 2030 giga-projects that are a natural fit for US infrastructure

[11] These goals are expected to shift under the new US Administration, following Trump's rollback of climate policies and initiatives from the previous Administration under Biden

companies, and the Public Investment Fund's US$ 1 trillion war chest, which may target American investment managers. Saudi Arabia has consistently supported the two-state solution for Palestine and Israel, and has made it clear that normalisation of relations with Israel is dependent on meaningful progress towards a resolution.

For signatories like the EU, its foreign policy imperatives to preserve peace and international security, promote democracy, the rule of law, human rights and freedoms, are embedded into its external, climate-focussed partnerships in the region, which can act as a great support for the Peace Triangle concept, especially after being accused of inefficiency, disunity, and double standards in handling regional crises compared to Ukraine. The Triangle may present an opportunity for the EU to demonstrate unity and re-engage diplomatically and financially in its "Southern Neighbourhood" and the Mediterranean, improving its credibility and position in the region. The European Commission has set up a new Directorate-General for the Middle East, North Africa and the Gulf (DG MENA)[12]. The proposed new Pact for the Mediterranean has, as a key element, a Trans-Mediterranean Energy and Clean Tech Cooperation Initiative, with a focus on renewable energy trading and clean tech manufacturing[13]. The EU will have to balance the benefits (supply diversification, lower costs, regional economic development, political bridge-building, technological spin-offs) of importing large quantities of renewable electricity from the East Mediterranean, GCC and/or North Africa, with the potential supply risks of being more dependent on imports instead of being largely self-sufficient. Therefore, instead of sole reliance on any source, we believe a diversification of multiple sources (geographic and type) will provide the EU with better energy security. The EU is currently very dependent on oil and gas imports, so this does not represent a major change of paradigm. There is a wide benefit to all involved EU states, throughout South-East, South and Central Europe, so this initiative could help in forging consensus.

The GCC states could see the Peace Triangle's aims as a way to secure the IMEC, opening up additional routes to the Suez Canal (and potentially the Strait of Hormuz, at least for land transport of non-energy supplies towards Europe, rather than take the often unreliable sea routes through Hormuz and the Bab el Mandeb), making it a strategic asset that opens them up to a wide variety of new markets to expand their influence and have a more proactive say in regional security and geopolitics. It also helps them to expand independent, multi-aligned energy policies and leverage existing ties with all nations, including rivals, to shape the energy direction of the region. The Gulf states are involved in other regional interconnection initiatives, which might be complementary or competitive to IMEC. Most notably, Iraq, Turkey, Qatar and the UAE signed in April 2024 to cooperate on the Development Road, a plan to link Iraq's Gulf ports by rail and road to Turkey, and therefore to Europe and the Mediterranean. The UAE was represented at the signing by its energy minister, Suhail Al Mazrouei[14], illustrating the importance of energy in the IMEC concept. The Saudi Landbridge intends to connect the Gulf and Red Sea coasts of Saudi Arabia by rail, mostly intended for freight. It links to other current or planned rail projects, including the GCC Railway, and rail links to the Northwest of Saudi Arabia, near the Sunrise Region, and potentially connecting to Jordan[15].

For India, as the spearhead of the East Corridor of the IMEC, supporting the Peace Triangle would make it a leader among developing countries, offering it geopolitical prestige and stronger relations with the Gulf countries, Israel, Palestine, the US, and the EU. It would lend support to its own green hydrogen export plans by 2030, a target market for which is Europe. The Middle East-Europe Renewable Energy Corridor also fits with the India-led One Sun One World One Grid Initiative, which advocates the development of major electricity interconnections spanning Europe, Africa and South/Southeast Asia[16]. Early 2025 has seen new momentum on IMEC, with discussions between the Indian government and Greece, Israel, France, followed by Prime Minister Narendra Modi's visit to the White House in February 2025[17]. The UAE remains keen to move ahead on IMEC.

The US is an outlier when it comes to climate-focussed partnerships in the region, especially now that Trump has once again announced withdrawal of the US from the Paris Agreement, but, properly positioned, the Triangle could be positioned as a lucrative deal under the new administration to secure the unimpeded movement of

[12] European Commission, "One sea, three continents: a new Directorate General to strengthen Mediterranean and Gulf partnerships" 3 February 2025, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_395
[13] European Commission, "Speech by Commissioner Šuica at the Delphi Forum on Priorities and Challenges for the Mediterranean Region", 30 January 2025, https://ec.europa.eu/commission/presscorner/detail/en/speech_25_384
[14] Reuters, "Iraq, Turkey, Qatar, UAE sign preliminary deal to cooperate on Development Road project", 22 April 2024, https://www.reuters.com/world/middle-east/iraq-turkey-qatar-uae-sign-preliminary-deal-cooperate-development-road-project-2024-04-22/
[15] N. Webster, N. Al Taher, S. Al Shaibany, J. Langton and M. Nihal, The National, "Full steam ahead", https://thenational.shorthandstories.com/gulf-railway-gcc-uae-saudi-arabia-trains/
[16] Electra, "Road map for implementing 'ONE SUN ONE WORLD ONE GRID': an intercontinental power grid from Europe to South-East Asia", June 2024, https://electra.cigre.org/334-june-2024/global-connections/road-map-for-implementing-one-sun-one-world-one-grid-an-intercontinental-power-grid-from-europe-to-south-east-asia.html
[17] India's World, "The India-Middle East-Europe Economic Corridor", 25 February 2025, https://thenational.shorthandstories.com/gulf-railway-gcc-uae-saudi-arabia-trains/

energy, goods, and other shipments across oceans and through the Middle East, as well as to counter rising Chinese influence.

Despite his apparent disapproval of climate change mitigation efforts, Trump could support renewable supply chains originating from the Sunrise Region, benefiting American clean energy companies. As noted, the Trump Presidency is not necessarily against renewable energy per se, especially where US economic interests are present. Practically, Chinese companies would likely be leading suppliers of components of the wind, solar, battery, cable and hydrogen elements of the initiative. It would be desirable to maximise the contribution of US, EU, regional, GCC and Indian companies, to spread economic benefits and widen the supportive domestic coalitions.

1.2 Feasibility Review

Both renewable energy and green hydrogen are being pursued most actively in the Sunrise Region by Egypt, Saudi Arabia, and Jordan. These countries are surrounded by others in the region with similar large renewable resources but have important advantages in critical parts of the renewables and hydrogen value chain that position them ahead of others in meeting the purposes of the Peace Triangle.

Of note is that Saudi Arabia is one of the main signatories (or founders) of the IMEC while being identified alongside Egypt and Jordan as being the best situated to provide green energy to Israel and Palestine for own use and onward export to Central and South-East Europe, and integrate Gaza as an additional export node to Europe alongside Israel and Egypt for the purposes of regional peace-making and stability.

1. **Existing Energy Exporter Status**

   Saudi Arabia is the world's largest oil exporter, while Egypt is a significant gas producer (it also episodically re-exports imported gas). Jordan is the only country without significant domestic oil and gas production but is one of the most committed developers of renewables in the region, with over 25% of the country's electricity met by renewable energy sources[18]. The high prices of oil and gas in 2022-23 resulted in cash windfalls for energy exporters in the region, supporting the development of projects critical for the energy transition, such as green hydrogen and green electricity, which have become key inclusions in their respective energy strategies. For example, Saudi Arabia has plans to invest US$ 270 B to boost the share of renewable energy in its mix to 50% and bolster other low-carbon energy projects by 2030[19], with green hydrogen being one of the major takers.

2. **Low Levelised Costs of Electricity (LCOEs)**

   All three Sunrise Region countries have several times achieved world-record low bid prices for their renewable projects. This is based on excellent solar resources, the economies of scale from large areas of open, flat land, low costs of capital, and growing skills in project execution. The 600 MW Al Shuaiba PV IP Project in Saudi Arabia clocked-in at US¢ 1.04/kWh in 2021 and holds the global record for the lowest LCOE awarded[20]. Costs rose slightly in 2022-23 due to inflation and supply-chain bottlenecks, with the 1.1 GW Al Hinakiyah Solar PV Project receiving a winning bid of US¢ 1.68/kWh and the 400 MW Tabarjal Solar PV project US¢ 1.71/kWh[21], but were partly offset by efficiency gains, better design, and technology gains, notably the use of bifacial panels. A consortium of UAE clean energy company Masdar, China's GD Power, and Korea Electric Power Corporation won the 2 GW Al Sadawi Solar Project at a bid cost of US¢ 1.29/kWh in November 2024, the lowest in 2 years.

   Renewables in Egypt and Jordan are similarly cheap in capital and operating costs and output, but higher costs of capital for equity and debt makes their LCOEs slightly higher than their counterparts, although still attractive for pursuing green hydrogen. For example, a ground-mounted solar PV plant at Ma'an in Jordan with an annual capacity factor of 32.2% received a winning bid of US¢ 2.48/kWh as part of Jordan's Round 3

[18] Energy & Utilities, "Jordan a rising star in renewable power and exports", July 2023, https://energy-utilities.com/jordan-a-rising-star-in-renewable-power-and-news121608.html
[19] Fast Company, "Saudi Arabia to invest $ 270 billion to bolster clean energy sector", January 2023, https://fastcompanyme.com/news/saudi-arabia-to-invest-270-billion-to-bolster-clean-energy-sector/
[20] MEES, "Saudi 600 MW Solar: Commercial Ops", Issue 67/46, November 2024, https://www.mees.com/2024/11/15/news-in-brief/saudi-600mw-solar-commercial-ops/f1a13550-a358-11ef-b363-8bf2ad056855
[21] Saudi Gulf Projects, "Saudi Arabia Signs agreements for 1.5 GW Solar PV Projects", November 2023, https://www.saudigulfprojects.com/2023/11/saudi-arabia-signs-agreements-for-1-5gw-solar-pv-projects/

Solar PV Auction in 2018[22], while the 560 MW Aydos Solar PV Project in Egypt received a winning bid of only US¢ 2/kWh in November 2022[23]. The cost in Jordan could be expected to have dropped since 2018 given falling solar costs in general.

Both countries also have excellent wind resources in some locations, which can be blended with solar to achieve higher electrolyser load factors. The 505 MW Amunet Wind IPP Project in Egypt was priced at US¢ 3/kWh, among the least expensive rates globally[24]. In Jordan, wind farm projects offered as part of the country's renewable energy auction programmes have routinely received bids as low as US¢ 2.5/kWh[25].

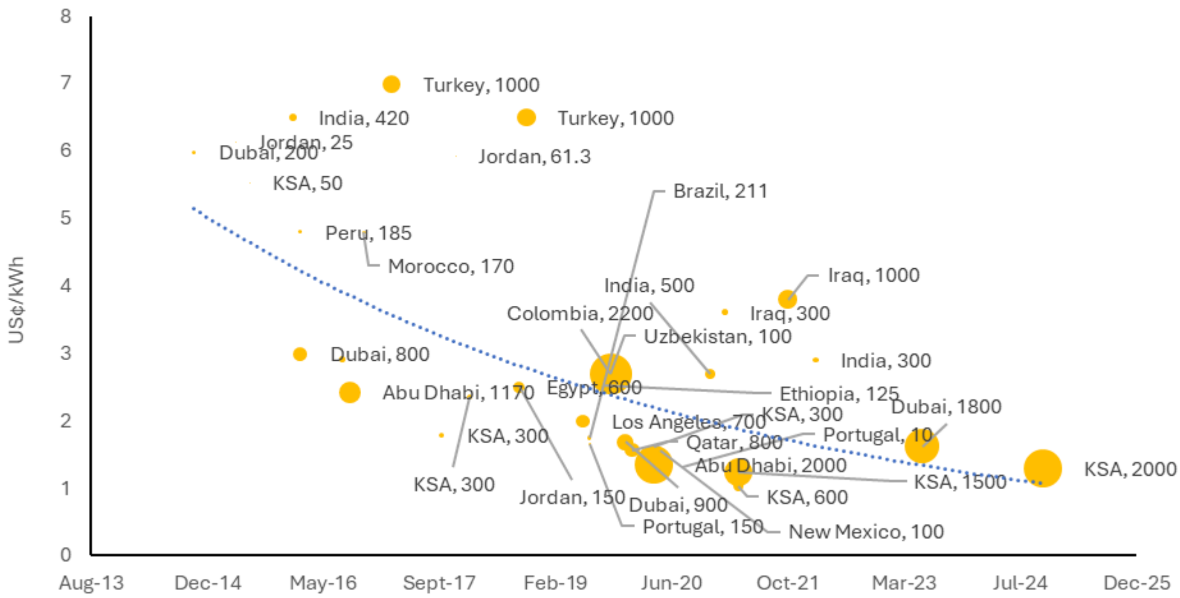


Figure 3 Historical Solar PV Bid Costs, project sizes in MW[26]

3. Significant Growth Opportunities

With a project pipeline spanning over 20 projects, Saudi Arabia, Egypt, and Jordan have close to 4 Mt/y of realistic medium-term green hydrogen potential, offering a number of opportunities across the clean energy value chain in the region. The increased deployment of renewable projects in these countries could easily support the export of renewable hydrogen *and* green electricity to South-East and Central Europe. Local use of hydrogen in green industries could support the development of low-carbon exports to support economic reconstruction. The export opportunity for green hydrogen or derivatives, though, is dependent on purchase commitments from European or other buyers who are willing to pay a premium for low-carbon supplies.

Exporting renewable energy to Palestine and Israel could be led by all three Sunrise Region core producers (Saudi Arabia, Egypt, and Jordan), with resultant renewable power used to meet electricity demand. The surplus would be exported as green electricity through South-East and Central Europe, and/or be converted to green hydrogen (or its derivatives, such as ammonia) to decarbonise hard-to-abate sectors domestically, and/or also exported to Europe. Longer-term, this would be a more cost-effective option for the EU than relying solely on its own renewable plants and would cement the renewable energy corridor as an integral aspect of the EU's overall energy transition programme.

As discussed later in the Technical Feasibility Assessment carried out in Section 2, the economics of supplying Greece and Italy to Germany with renewable electricity from the Sunrise Region area can complement similar supplies to the western side of Europe from North Africa (mainly Morocco). Previous

[22]Zawya, "Jordan's solar auction attracts lowest bid of $0.02488/kWh", September 2018, https://www.zawya.com/en/business/jordans-solar-auction-attracts-lowest-bid-of-002488-kwh-dbez6h6u
[23]IFC, "IFC and Partners Invest $1.1 Billion to Build the Largest Solar Plant and Wind Farm in Egypt", November 2022, https://www.ifc.org/en/pressroom/2022/ifc-and-partners-invest-11-billion-to-build-the-largest-solar-plant-and-wind-farm-in-egypt
[24]IFC, "IFC and Partners Invest $1.1 Billion to Build the Largest Solar Plant and Wind Farm in Egypt", November 2022, https://www.ifc.org/en/pressroom/2022/ifc-and-partners-invest-11-billion-to-build-the-largest-solar-plant-and-wind-farm-in-egypt
[25]MEED, "EXCLUSIVE: Jordan receives six bids for wind power projects", December 2018, https://www.meed.com/exclusive-jordan-receives-six-bids-wind-power-projects
[26]Qamar Energy Research

assessments of the potential of the Sunrise Region, including by EcoPeace[27], indicate that it could meet up to 30% of Europe's electricity demand, if the required infrastructure is established, specifically high voltage direct current (HVDC) lines and sub-Mediterranean transmission corridors.

Infrastructure is already being rapidly developed at locations close to the proposed Sunrise Region, such as in Egypt in the Suez Canal Economic Zone and on the Mediterranean Coast, and in Saudi Arabia at NEOM. This can be interlinked with IMEC-required infrastructure, including new and retrofit hydrogen pipelines and electricity export cables to send green energy to Europe via the Israeli interconnection at Haifa (and/or other Israeli ports such as Ashdod and Hadera on the Mediterranean Sea, and Eilat on the Red Sea), and a new interconnection at Gaza which could support reconstruction efforts by powering local industry with affordable energy from the Sunrise Region, while also enabling Gaza to serve as an export hub for surplus energy to Europe. One specific opportunity would be to develop data centres in the Israel - Palestine - Jordan area, using cheap renewable electricity firmed with batteries, that could be connected to intercontinental cables following the same route as the planned electricity lines.

The region has an existing network of gas pipelines, connecting Israel's offshore fields and domestic market, Jordan and Egypt, with potential rehabilitation of the continuation of the Arab Gas Pipeline to Syria and Lebanon. Recent progress has also been made on development of two of Cyprus's offshore gas discoveries, Aphrodite and Cronos, via tiebacks to Egyptian infrastructure. The planned Gas for Gaza pipeline (G4G) would be hydrogen-ready. Depending on the metallurgy and condition of existing natural gas pipelines, conversion to use for hydrogen or a hydrogen-natural gas blend is feasible and substantially cheaper than constructing dedicated hydrogen pipelines.

In July 2024, a project by the UAE-based Fertiglobe in Egypt was the sole winner of Germany's tender for the import of green ammonia. The project will supply 19,500 tonnes in 2027, increasing to at least 259,000 tonnes between 2027-33 and potentially up to 397,000 tonnes by 2033, with a maximum contract value of €397 million, and a contract price of €1000 per tonne including delivery to Europe, or a net price of €811 per tonne. Assuming energy efficiency of the hydrogen-ammonia conversion process of 67%, this is equivalent to €4.6/kg of input hydrogen.

By expanding the deployment of renewables in the short-term, regional actors could secure a strategic role in the future green energy business of the corridor. For example, they could benefit from optionality, allowing them to control the pace of development of these projects until green hydrogen production costs reduce further, while cementing their relationship with future green hydrogen-importing regions like the EU. In a first phase, exports of renewable energy would be likely to focus mostly on electricity, with some select green hydrogen-based projects to build experience and market scale. In a second phase, electricity exports would increase and would be accompanied by a major scale-up of green hydrogen exports, probably by pipeline, and the export of low-carbon products based on green hydrogen such as ammonia, methanol, synthetic aviation fuels (renewable fuels of non-biological origin (RFNBO), and steel.

[27] EcoPeace Middle East, "Our New Path to Sustainability: The IMEC Peace Triangle", January 2025, https://ecopeaceme.org/2025/01/28/the-imec-peace-triangle/

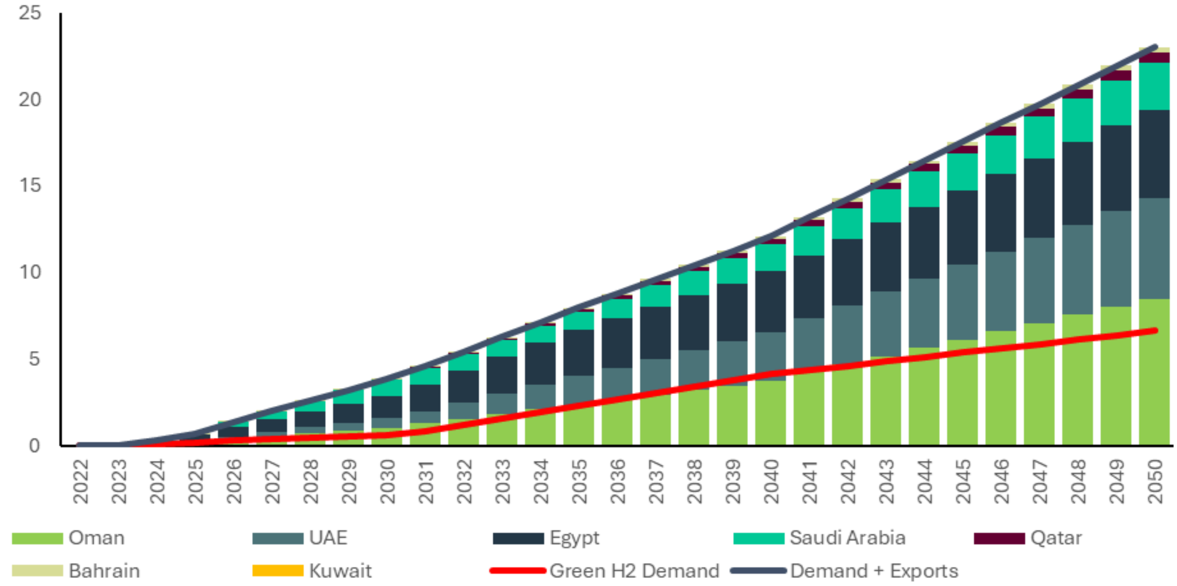


Figure 4 Green hydrogen production of the GCC countries plus Egypt to 2050, Mt/y[28]

The development of pipelines and/or liquefaction terminals at Israel and/or Palestine could support the development of a "hydrogen hub" for hydrogen into the region and Southern and Central Europe, and associated infrastructure that could support gas-to-power initiatives and surplus electricity export. This would require suitable cooperation from the Israeli authorities (and potential coordination with Egypt), with current Palestinian access to infrastructure and coastal areas extremely limited. Captured CO_2 from blue hydrogen could be used by exporter states in industry (Israel, Saudi Arabia, the UAE) offering permanent sequestration, for example CO_2-based cements, polymers or graphene, or underground storage or mineralisation. CO_2 takeback would make hydrocarbon exports from the region more favourable over those of competitors due to carbon neutrality.

Optimal strategies need to be decided on a per-country basis as well as part of the overall concept. Key issues for decision include:

- Would the production of both blue and green hydrogen and their blending be favourable for building scale for exports to Europe, bearing in mind Europe's general preference for green hydrogen only? The option of blue hydrogen mostly applies to Israel, since Egypt and Jordan do not have a surplus of natural gas, and the vast majority of Saudi Arabia's gas production is in the country's east, not near the Sunrise Region. Blue hydrogen can be used to support initial development of infrastructure and markets, given its current lower cost, but Europe's clear long-term preference is for green hydrogen.
- Will the export of hydrogen to Europe best be achieved by pipeline, as a derivative by ship (e.g. ammonia or methanol), or for producing "green" materials locally (e.g. steel, fertilisers, synthetic fuels) which are then exported? Egypt and Saudi Arabia have the largest industrial sectors of the countries considered, with Saudi Arabia developing its floating low-carbon industrial city, Oxagon, as part of NEOM, and local industrial production for export to Europe and other markets may be more appropriate there. Israel and Egypt have the advantage of more developed natural gas infrastructure, which could be converted to carry hydrogen, than Jordan or North-Western Saudi Arabia.
- Will the optimal export option be electricity, hydrogen, or both?
- To what extent will optimal hydrogen strategies vary between the countries considered, and particularly between the importing states (Israel, Palestine) and the producing states (Jordan, Saudi Arabia, Egypt)? How can complementary and synergistic strategies be developed, given also potential competitive tensions in a new industry?

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[28] Qamar Energy Research

4. Strategic Connectivity to End-Markets

Saudi Arabia, Egypt, Jordan, Israel, and Palestine are key strategically located countries. They control the route for export of East Mediterranean and Arabian Peninsula renewable electricity and hydrogen to Europe. This would reduce Europe's reliance for energy imports on existing routes that pass through geopolitical hotspots like the Bab Al Mandeb Strait and the Strait of Hormuz. Therefore, the development of the renewable energy corridor aligns with the EU's broader objectives of promoting stability in the Middle East, which is crucial to preserve its own security and economic interests.

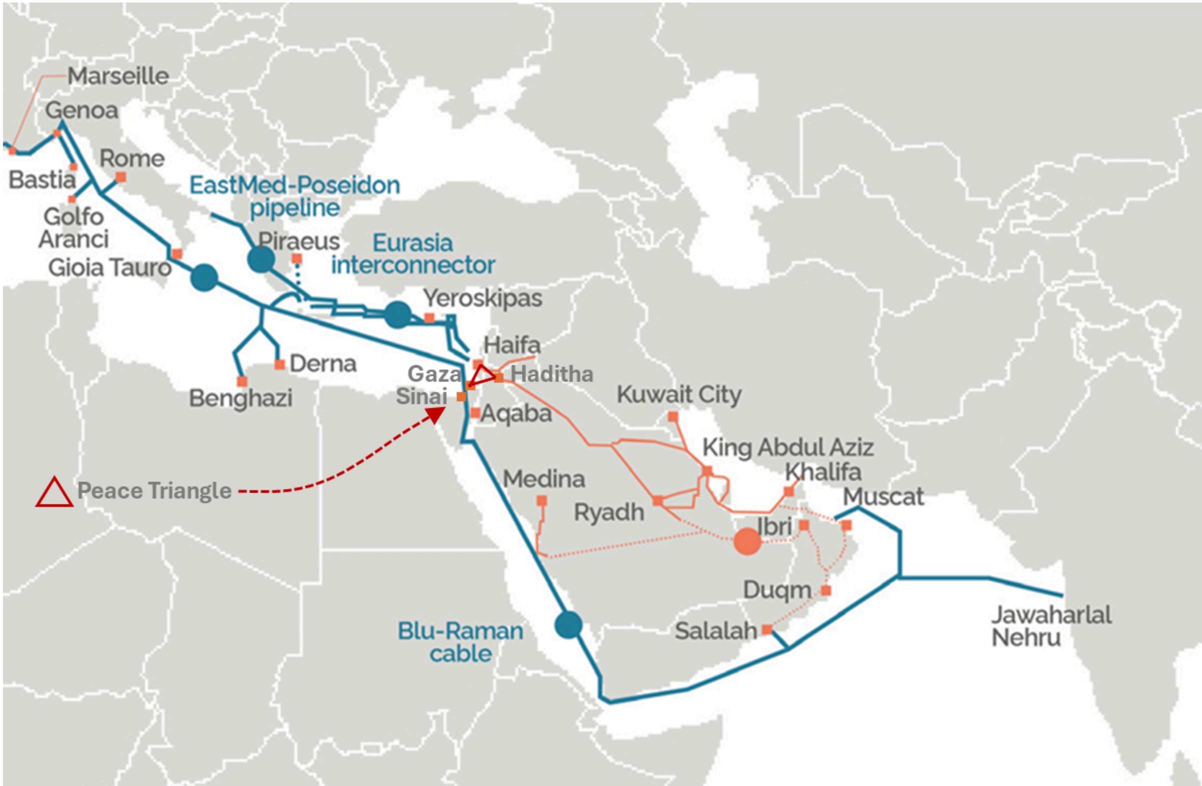

Figure 5 An expanded IMEC route involving Egypt, western Saudi Arabia, and Oman[29]

Additionally, renewable energy and green hydrogen export can also serve as the basis for deeper engagement of the IMEC countries on non-renewable energy-related aspirations for the region, such as reconstruction efforts in the wider Middle East and potentially involving Egypt as a partner of the IMEC. Cairo has been critical of the project due to the perceived shift of trade in the Middle East from the Suez to Israel. The IMEC is unlikely to divert a large share of Suez traffic, since companies might not see the value in transporting hydrocarbons and other energy in tankers or cheaper raw materials aboard bulk carriers, unloading them in the UAE, and then transferring them by rail to Haifa in Israel – particularly considering the handling costs. Even with containers, the freight transport system best suited to intramodality, the IMEC's railways would be unable to compete with the capacity of the Suez Canal. But it does give valuable optionality (making it complementary to the Canal), reducing risks of disruption, and could be important for non-energy goods, or other high-value or more time-sensitive goods.

This opens an opportunity for looping Egypt in as part of an IMEC "West Corridor", linking the western ports of Saudi Arabia through the Bab Al Mandeb to Sinai in Egypt, the western-most point of the Sunrise Region and the IMEC North Corridor onwards to Europe. This would also allow for incorporating Oman into the corridor, alleviating congestion at UAE ports by providing additional capacity by passing through Duqm – a major upcoming green hydrogen hub – and Salalah, which could serve as extra nodes in the network.

[29] Qamar Energy Research; background map from European Council on Foreign Relations

1.3 Regulatory Frameworks & Incentives

Despite the still-nascent nature of net zero-relevant policies in the region, policies specific to renewables, hydrogen, and clean energy uptake generally are developing rapidly. For example, all of the actors relevant to the Sunrise Region have ambitious National Hydrogen Strategies in place and are also developing business incentives to attract foreign investment into their clean energy sectors. These include direct tax rebates / credits, business incentives such as 100% foreign ownership, lower feedstock and utility prices, lower land costs etc., as well as direct budget spending in areas where fiscal incentives have not been employed – for example, to advance carbon capture, utilisation, and storage (CCUS) projects.

However, amidst this rapid development, regulatory challenges remain, particularly for Palestine. Its political and regulatory landscape, compounded by the devastating effects of the war, make it more difficult for it to engage fully in the emerging hydrogen economy, or at the least, at a level that matches its regional counterparts' abilities in the export of clean energy to Europe. International mediation and technical support, led by Israel and the EU, and supported by Sunrise Region producers like Saudi Arabia who insist on prosperous and stable Palestine as a condition for normalisation of ties with Israel will be crucial in addressing these barriers for Palestine. Such support could play an instrumental role in creating a cohesive, cross-border energy transport system, ensuring Palestine can actively participate in and benefit from the clean energy transition. Equally importantly, by helping to promote stability in Gaza and the broader region, it could counter the conditions that contribute to strengthening extremist forces, key security aims of both Israel and the EU.

There have also been strategic shifts in the direction of the Sunrise Region players' National Hydrogen Strategies. For example, both Egypt and Jordan are working hard to create investor value in parts of the hydrogen value chain other than pure production and export, which opens up a whole host of untapped opportunities in the midstream segment, i.e. logistics, transportation, storage, and distribution – a key imperative of the IMEC, and one which could add considerable strength to the renewable energy corridor if also focussed on by partner countries such as Saudi Arabia and Israel.

Egypt is the only country so far that is offering direct tax incentives, by allowing renewable hydrogen developers to access credit of up to 55% off the tax paid on their project if "local content" and "foreign financing requirements" are met. Meanwhile, Saudi Arabia offers developers extremely attractive land, utility, and feedstock rates if they demonstrate in-country value (ICV) addition and energy efficiency measures. For example, Saudi Arabia offers discounts on electricity prices to developers demonstrating innovative practices. Jordan is developing incentives for investment in hydrogen[30]. Palestine has a law on tax for renewable energy, and some incentives for renewable energy investment in the Investment Promotion Authority and its renewable energy strategy.

Table 3 Hydrogen sectoral readiness and maturity of Sunrise Region-relevant actors in the region[31]

Ranking Parameters	Jordan	Egypt	Saudi Arabia	Palestine	Israel
Does the country have a H_2 strategy?	✔ (not public)	✔ (not public)	✔	✘	✔
Maturity of the Oil & Gas Industry	2	4	4	1	4
Project Funding Structure for Domestic H_2 Projects	3	3	4	1	3
Programmes for Training Domestic Workforce in Operating H_2 Projects	1	2	2	1	2
Domestic H_2 Offtakers / Industrial Consumers	2	3	3	1	3
Enabling Infrastructure for H_2 Transport	2	2	3	1	3

[30] Jordan Times, "Jordan moves forward with green hydrogen strategy, eyes int'l clean energy role", 26 February 2025, https://www.jordantimes.com/news/local/jordan-moves-forward-green-hydrogen-strategy-eyes-intl-clean-energy-role
[31] Qamar Energy Research

Energy Self-Sufficiency	1	3	4	1	3
Key: 1 = Developing, 2 = Emerging, 3 = Mature, and 4 = Highly Mature					

Table 4 Renewables and Renewable Hydrogen Policy / Regulation and Tax Incentives provided by Sunrise Region-relevant actors in the region[32]

Ranking Parameters	Jordan	Egypt	Saudi Arabia	Palestine	Israel
Clear and Predictable Energy Regulation	✔	~	✔	✘**	~
Tax Rebates / Credits for Renewables and Renewable Hydrogen	✔	✔	✔*	✔	✔
Business Incentives for Renewables and Renewable Hydrogen	✔	✔	✔	✔	✔
Environmental Impact Assessments	✘	✘	✘	✘	~
Hydrogen Transport and Storage Regulation	✔	✘	✘	✘	~
CO_2 Capture Regulation	✘	✘	✘	✘	~
CO_2 Transport Regulation	✘	✘	✘	✘	~
CO_2 Liability (Post-Closure) Regulations	✘	✘	✘	✘	✘
Key: ✘ = No Development, ~ = Unclear / Lack of Visibility on Developments, ✔ = In Development / Exists					

*Hydrogen export projects are unlikely to be liable to the full extent of Saudi Arabia's recently introduced corporate tax, but may benefit from VAT reductions and/or exemptions on project parts, equipment, etc. for strategic projects or those situated in strategic areas (such as special economic zones)

** Reflects the current reality of Israeli control over borders, imports, permits and infrastructure construction, particularly for Gaza

Table 5 Strategic Shifts in Hydrogen Strategies of Sunrise Region-relevant actors in the region to encourage investment[33]

Country	Strategy Development	Shift	Export Focus
Jordan	• Duties and tax exemptions on all locally manufactured and imported renewable energy source equipment and systems • Direct proposal scheme (BOO competitive bidding) • Permit all investors to build, own and operate (BOO) power distribution and storage facilities for renewable hydrogen projects	***Tactical*** – New business incentives / tax breaks to increase investment	✔
Egypt	• Allow developers to access credit of up to 55% off the tax paid on the project if they meet "local content" and "foreign financing requirements" • Allow producers to export products and import materials through an intermediary, without licence or registration • 30% discount on use of seaports, 25% on value of industrial land rights, 20% on value of land rights for storage at ports	***Tactical*** – New business incentives / tax breaks to increase investment	✔✔✔
Saudi Arabia	• Cater to 10% of global hydrogen demand by 2030 • Ensure economic security in a post-oil future by diversifying exports, leveraging existing sectors' supply chains to increase local contents, and developing new industrial sectors	***Strategic*** – Ensure national strategic aims and capture future global hydrogen market	✔✔

[32] Qamar Energy Research
[33] Qamar Energy Research

Israel	• Large grants to kickstart hydrogen-related technology research and development initiatives • Specific grants from the Israel Innovation Authority and Ministry of Energy and Infrastructure, alongside complementary programmes such as the US BIRD Energy and EU Horizon	***Tactical*** – New business incentives / tax breaks to increase investment	✔

1.4 Financial and Security Considerations

Tables 3-5 provide a high-level overview of the regulatory frameworks and incentives in place for pursuing renewable hydrogen projects in the Sunrise Region-relevant countries. However, financial and security considerations exist. Most of these players have ambitious projects planned, which require continuous financial commitments and management of budgetary constraints. Despite a project pipeline of 35 Mt/y of low-carbon hydrogen by 2038 in the region[34]costs for green hydrogen still remain relatively high, as do costs for electrolysers and batteries. Only NEOM so far has taken FID in the region for a full-scale project, with first production anticipated by December 2026[35]. A smaller green hydrogen project in Egypt being developed by Norway's Scatec and the UAE's Fertiglobe also reached an offtake commitment with Germany in July 2024, but with important milestones still pending – such as selecting the electrolyser supplier and completing the project financing process – financial close is expected in H1 2025[36], or later. Slower-than-expected progress makes it unclear how the financing of these projects will be shared between partner countries.

While costs for renewable energy projects are expected to continue declining (despite a slight increase during 2022-2023 due to macroeconomic factors and the impact of geopolitical events on supply chains), costs for green hydrogen remain relatively high, as do the costs for electrolysers and batteries. These translate into higher costs across the value chain and ultimately higher delivered costs. Global estimates for green hydrogen costs have been revised since 2023 to now average US$ 3.74/kg by 2050, contrasted against just US$ 1.11/kg to US$ 2.35/kg for fossil fuel-based ("grey") hydrogen[37], and from previous estimates of prices reaching parity with grey hydrogen costs way before 2050. However, certain regions, including the Sunrise Region, will be able to enjoy cheaper costs for green hydrogen much sooner thanks to a renewables-rich resource base, as well as no formal directive from their governments on exercising trade limits with large, low-cost battery and electrolyser manufacturers like China, which can bring their project costs down further.

Still, large multibillion dollar gigawatt-scale projects, such as Saudi Arabia's NEOM mentioned above, have taken longer than anticipated to achieve FID, demonstrating the time needed for development costs, infrastructure investments and technological advancements to align properly. Returns on such projects will also depend on multiple factors, not least of which are component and equipment costs, global demand (which will rely on the urgency of the global system to decarbonise processes currently fuelled by carbon-intensive feedstocks), and ongoing technological breakthroughs that reduce costs. For the Sunrise Region, it can better realise the hydrogen export aim of the proposed corridor by securing offtake commitments from Europe who will be more willing to pay the price premium for green hydrogen compared to other locations who may not be pursuing the transition as aggressively. Locking in offtake will also help investors shoulder high upfront capex costs and attract equity or debt financing from the private sector or large sovereign wealth funds (SWFs) in the region who are pursuing hydrogen development internationally in North African and Central Asian markets as a matter of strategic vision and influence. Where such an option may not exist for a certain country in the region, for example for Egypt and Jordan, they may further develop incentives and tax rebates to attract investors, as well as various land allocation incentives.

The early-stage nature of the hydrogen market means it will take some time before hydrogen reaches a competitive pricing parity with fossil fuels. For hydrogen producers and exporters, a mix of long-term offtake agreements and potential market-based sales will generate income, but revenue-sharing models will need to be established carefully with a clear understanding of which parties will receive returns at various stages of the project lifecycle. Existing funding programmes from Europe (such as Horizon Europe, the European Investment Bank's Green Hydrogen Fund, etc.) could be leveraged to cover at least some portion of the initial investment required for a green hydrogen export project as part of the corridor in the form of blended finance that combines concessional funding with private capital to derisk investment. Governments in the region – such as the UAE –

[34] Qamar Energy Research
[35] Argaam, "NEOM green hydrogen facility to come online in December 2026: CEO", December 2024, https://www.argaam.com/en/article/articledetail/id/1774016
[36] Scatec, "Scatec's Egypt Green Hydrogen Project signed 20-year offtake agreement with Fertiglobe, based on H2Global award", July 2024, https://scatec.com/2024/07/11/scatecs-egypt-green-hydrogen-project-signed-20-year-offtake-agreement-with-fertiglobe-based-on-h2global-award/
[37] Hydrogen Central, "Green Hydrogen Costs Set to Stay Too High for Too Long", December 2024, https://hydrogen-central.com/green-hydrogen-costs-set-to-stay-too-high-for-too-long/#

are also considering the establishment of carbon credit systems like carbon pricing to incentivise the transition to hydrogen. The EU's introduction of the Carbon Border Adjustment Mechanism (CBAM) gives an incentive to countries exporting to the EU to introduce carbon pricing themselves. Development of renewable-specific and hydrogen-specific tax credits can help ensure revenue streams are optimised as the market matures and the cost of hydrogen production decreases.

An early kickstart to the renewable energy corridor's aims could be the extension of the GCC Interconnection Authority (GCCIA) electricity interconnection from Saudi Arabia to Jordan, from where it could connect to Israel and Palestine for supply of surplus renewable electricity generated. Current capacity is limited, and an expansion (private sector-led or public) could support supplies from Israel (and smaller volumes from Jordan – who already supplies 80 MW to Jericho in the West Bank) to Palestine. A more robust electricity interconnection could also be established with Egypt to expand capacity, offering the much-needed power supply, particularly to Gaza in Palestine, while working towards establishing export-ready and hydrogen-ready infrastructures for South-East and Central Europe. A Saudi-Egypt link of 3000 MW is under construction. Egypt also already has had an electricity connection with Jordan since 1999, with which it shares an inlet in the Gulf of Aqaba. If connected to the GCCIA link, it would require increasing its exchange capacity to much more than the current 550 MW[38].

Furthermore, the renewable energy corridor is situated in a currently volatile region, necessitating robust security frameworks and international cooperation to envisage and later safeguard the transit of these energy sources. The brutal terrorist invasion of Israel by Hamas and the following war in Gaza, with persistent violence in Israel-Palestine as well as Southern Lebanon (not far from the Haifa Port, a crucial hub of the corridor), has necessitated a renewed push towards a viable two-state solution and regional stability. However, no participating countries so far have shown signs of stepping away from the IMEC initiative, which could similarly mean support for the Peace Triangle concept will be sustained. In any case, it remains to be seen what the political future of Gaza will look like and who will control the strip after the war has ended.

Additionally, with the inclusion of Gaza as another export node of clean energy alongside Israel, it can support the realisation of Israeli security interests, as well as dedicated energy investments into Gaza supported by Saudi Arabia, Egypt, and Jordan as key renewable energy producers, and Europe, as the key consumer market. This ensures that both the Middle East states and Europe have core interests in advancing the corridor, as it boosts their economic welfare and national security (and also safeguards cross-border energy infrastructure), and also potentially prevents the rise of extremist forces in Gaza and the region in general. Mutual interests in realising IMEC aims have been more pressing than obstacles, with significant behind-the-scenes efforts and discussions among key stakeholders at various levels to keep the planning for the IMEC ongoing, signalling that it does remain on the agenda[39].

The Peace Triangle's unique advantage lies in its alignment with each participant's strategic agenda, regardless of regional relations. This suggests that each participant is likely willing to work for what may be a transformative project that is well conceived and has the potential to plant seeds of stability and dialogue in the region. Additionally, it could unlock several profitable opportunities for Middle Eastern, Mediterranean, European, and American businesses, and perhaps Indian.

[38] Africa Energy Portal, "Egypt: Cairo wants to export its renewable energy to Iraq via Jordan", May 2021, https://africa-energy-portal.org/news/egypt-cairo-wants-export-its-renewable-energy-iraq-jordan
[39] Chiara Lovotti, "Connecting the Middle East: IMEC and Beyond", published by ISPI, "Economic Cooperation: A Driver of Stability in the MENA Region?", November 2024, https://www.ispionline.it/wp-content/uploads/2024/12/ISPI-Report-2024-Talbot_Economic-Cooperation-web-1.pdf

Table 6 Opportunities for businesses participating in the renewable energy and hydrogen export arm of the Peace Triangle[40]

Sector	Business Opportunity	Best Suited For
Electricity / Green Power	• Grid-strengthening and expansions	Egypt, Jordan, Israel, Gaza / Palestine, KSA
	• Renewable projects (power-dedicated) with extremely low costs and high returns	Egypt, Jordan, Israel, KSA
	• Solar and wind parts (panels, turbines, inverters, mounting structures, conversion systems, transformers, monitoring systems, cabling and wiring)	Israel, Germany, Netherlands, India (?)
	• Novel, highly efficient energy storage technologies (thermal batteries (graphene hybrid), compressed-air storage)	Germany, Netherlands, US, Israel
	• T&D network improvements, electricity interconnections, sub-sea / land cabling	Egypt, Jordan, Israel, Greece, other Europe
	• HVDC for carbon-neutral power systems (sustainable transmission)	Greece, Germany, Italy, other Europe, Israel
Green Hydrogen Production	• Renewable projects (hydrogen-dedicated) with extremely low costs and high returns	Egypt, Jordan, Israel, KSA
	• Electrolysers parts and manufacture, development of alternative electrolyser sub-components that are low carbon	US, Germany, Netherlands, India (?)
	• Novel supply chain materials versus traditional alkaline which relies on volatile commodities like nickel	US, Europe, Israel
	• Pipeline expansion and construction, especially to hydrogen hubs	US, Egypt, Jordan, India (?)
	• Novel hydrogen production techniques / methods that require less water	Europe (Germany, other), Israel
Hydrogen Transport & Storage	• Pipeline retrofitting to support hydrogen blending in natural gas pipelines	US, GCC, Europe, Israel
	• Materials compatibility R&D, techno-economic analysis, life cycle analysis	US, Europe
	• Metallics and polymer materials for hydrogen service through pipelines	GCC, Egypt, Jordan, Israel
	• Connection of future off-takers with production facilities	GCC, Egypt, Jordan, Israel
	• Welding and high-quality steel tubes and pipes (construction)	GCC, India, Israel
	• High energy efficiency transport solutions to reduce costs and minimise leakages	Europe, Israel, US
	• Lower storage temperature technologies that can reduce safety risk from ammonia fuel	Europe, Israel, US
	• Manufacture of carbon fibre hydrogen storage solutions – carbon fibre-reinforced polymer (CFRP) for compact and lightweight storage	US, Europe (Germany, others)
Renewable Energy & Hydrogen Hubs	• Hydrogen-powered vehicles for long-haul travel and freight transport	GCC, Europe, US
	• Integration of refuelling stations in industrial and port areas to build connectivity with existing infrastructure	GCC, Israel, Egypt, Europe
	• Logistics management and solutions	GCC, India (?)
	• Roads, rails, civil engineering works	GCC, India (?), Egypt, Jordan
	• R&D and innovation centres, labs	GCC, Egypt, Jordan, Israel, Europe
	• Port connections, export jetties, buoys, docking and berthing, cargo handling, distribution centres, security infrastructure	GCC, Egypt, Jordan, Israel, India (?)
	• Environmental monitoring and inspection	Israel, Europe, Egypt

[40] Qamar Energy Research

2. Techno-Economic Feasibility

2.1 Regional Power Demand

Regional power demand and generation is dominated by Saudi Arabia, Egypt and Israel. Jordan is, however, already a significant player in renewable generation. Although Saudi renewable capacity given below for 2023 appears small, it is set to grow extremely quickly as major projects under construction and recently awarded are completed.

With the exclusion of Saudi Arabia, most of whose electricity market lies to the south and east of the immediate Peace Triangle area, regional power demand is relatively small compared to the nearest Southern European markets (Table 1). However, electricity demand in the Peace Triangle countries is likely to grow more rapidly than in Europe, because of faster economic and demographic growth; rising incomes allowing more use of air-conditioning; higher regional temperatures because of climate change, and greater need for desalination; and the connection of under-served demand in Palestine.

The potential markets for energy exports along the renewable energy corridor are shown below (Table 1). They are grouped into (1) the producing countries, (2) the immediate regional markets, (3) South-Eastern European countries reached by a connection through Cyprus and Greece, (4) Central European countries reached by a connection through Italy. It is assumed that western Mediterranean countries (Spain, Portugal, France) will more likely be served from Morocco. Central Mediterranean countries (Malta, Italy) could be served from central North Africa (Algeria, Tunisia, Libya) or from the Sunrise Region.

Table 7 Electricity markets to be served from the Eastern Mediterranean[41]

Country	Solar PV capacity	Wind capacity	Total renewable capacity[42]	Peak demand[43]	Renewable Power Generation[44]	Total Power generation[45]
Units	MW	MW	MW	MW	TWh	TWh
Producing Countries						
Egypt	1 836	1 890	6 709	37 000	26.5	200.8
Saudi Arabia	2 535	403	2 988	72 900	2.8	401.6
Jordan	1 990	614	2 621	4 050	5.7	19.1
Total	6361	2907	12 318		35.0	621.5
Transit Countries						
Israel	4 282	316	4 872	13 800	6.5	76.5
Palestine [46]	192	0	192	1 850	0.2	0.24
Total	4474	316	5064		6.7	76.74
Importing Countries – South-Eastern Europe						
Cyprus	606	158	778	1 290	0.88	5.4
Greece	7 030	5 220	15 805		22.4	49.8
(Crete)[47]				710		3

[41] International Renewable Energy Agency, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Renewable_Energy_Statistics_2024.pdf
[42] 2023; solar PV and CSP, wind, biomass, geothermal, hydropower (not pumped hydropower) and other renewables
[43] Not summed, as peaks are not necessarily coincident in time
[44] 2022
[45] Energy Institute, Statistical Review of World Energy 2024 (figures for 2023)
[46] Most demand is met by imports from Israel and Jordan, not by local generation. Demand is about 7 TWh, Palestinian Central Bureau of Statistics, https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Energy-Supply-2009-2020_E.html
[47] https://www.ej-geo.org/index.php/ejgeo/article/view/429.

Others[48]	7541	6088	35 072		73.0	149.9
Total	15 177	11 466	51 655		96.3	208.1
Importing Countries – Southern & Central Europe						
Italy	29 789	12 308	65 157	52 500	100.5	287.3
Germany	81 737	69 459	166 939	72 930	251.1	513.7
Others[49]	37 446	14 045	89 578		148.4	454.5
Total	148 972	81 767	321 674		500.0	1256

Before considering export projects, it would be necessary for socio-political acceptability and economic justice to meet regional electricity demand. Israel already has substantial renewable capacity, but its available land is limited by urban and agricultural use and military zones. This is even more the case for Palestine, where land-use restrictions have prevented major renewable installation despite urgent power needs. These countries have good renewable conditions, mostly for solar, but not as good as in the Sunrise Region. Their small geographic area also leads to little diversity of renewable output, exacerbating issues of intermittency. For all these reasons, substantial import of renewable-generated electricity from neighbours should lower costs and improve supply reliability. Previous initiatives, notably Project Prosperity, designed by EcoPeace, was intended to leverage such complementarity, facilitating the exchange of renewable electricity and desalinated water between Jordan, Israel and, ultimately, Palestine[50].

The Palestinian National Energy Strategy 2030, which has received government support, intends to reach 1,000 MW of installed capacity. There is technical potential for 3,000 MW of installed solar PV in the West Bank and several hundred MW in Gaza, and investment opportunities, particularly in Area C of the West Bank, could contribute to supplying both Gaza and the West Bank with clean energy. Development in Area C is currently heavily constrained by Israeli civil and military control, and that barrier would have to be addressed to allow significant expansion of renewable energy. This could be facilitated by the establishment of Designated Renewable Energy Zones with a fast-track permitting process, and no political designations[51]. Palestine does not yet have an officially established strategy for hydrogen. However, there is a working group, MED-GEM, collaborating with PENRA (Palestinian Energy and Natural Resources Authority) to assess green hydrogen opportunities. The outcomes of this assessment will help shape a national green hydrogen strategy in the near future. Gaza had three desalination plants pre-war, though they have reportedly suffered damage. The G4G project intended to unlock construction of more desalination facilities. The provision of more clean water for the territory could be integrated with the production of green hydrogen (for which most current technologies require desalinated, high-purity water).

The total renewable capacity in Jordan and Israel already approaches or exceeds half of peak demand. In the relatively near future, it's likely that generation will exceed demand at times, giving a surplus for storage or export. Jordan already has over-committed on power purchases and exports some electricity to Palestine and Iraq. Construction of dedicated renewable energy centres combined with storage can serve local and regional demand while allowing consistent exports, or the production of hydrogen and its derivatives for local use and export. Depending on political and economic developments, the severely under-served markets in Iraq, Syria and Lebanon are obvious early targets for electricity exports. Turkey is also a large nearby potential market, but reaching it requires either stability in Syria, or a modus vivendi over the disputed territories of Cyprus. The market need and political stability of Southern Europe may also facilitate large-scale electricity and hydrogen export projects.

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[48] Albania, Bosnia, Bulgaria, Croatia, Kosovo, Moldova, Montenegro, North Macedonia, Romania, Serbia, Slovenia
[49] Austria, Czechia, Hungary, Liechtenstein, Poland, San Marino, Slovakia, Switzerland
[50] P. Schwarzstein, Wilson Centre, "The Rise, Fall, and Possible Rise Again of the Middle East's Most Ambitious Environment Scheme", 1 November 2024, https://www.wilsoncenter.org/article/rise-fall-and-possible-rise-again-middle-easts-most-ambitious-environment-scheme
[51] Ariel Ezrahi, "An energy and sustainability road map for the Middle East", Atlantic Council, November 2024, https://www.atlanticcouncil.org/in-depth-research-reports/report/an-energy-and-sustainability-road-map-for-the-middle-east/

2.2 Renewable Generation

The Sunrise Region area has exceptional solar resources. These are much better than Southern Europe, even than Italy and Greece which have among the best solar conditions in the EU. Wind power is less evenly distributed (Figure 13) but there are good areas particularly along the Northern Red Sea (Gulf of Suez and Gulf of Aqaba).

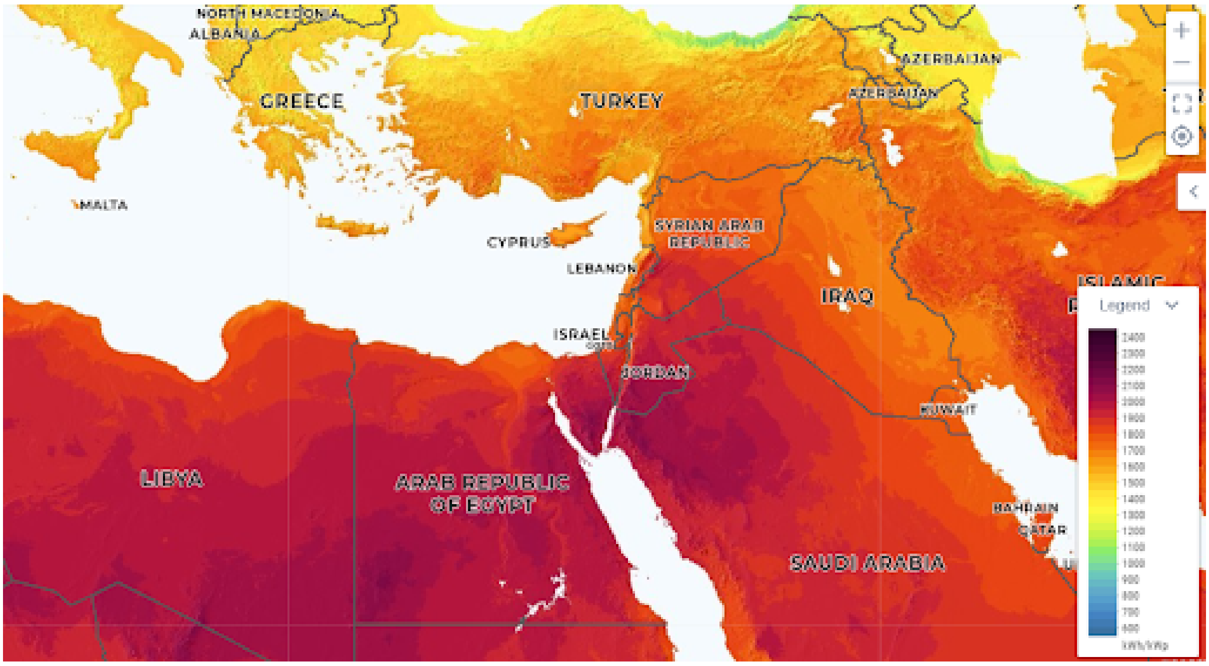

Figure 6 Solar insolation in the Sunrise Region area[52]

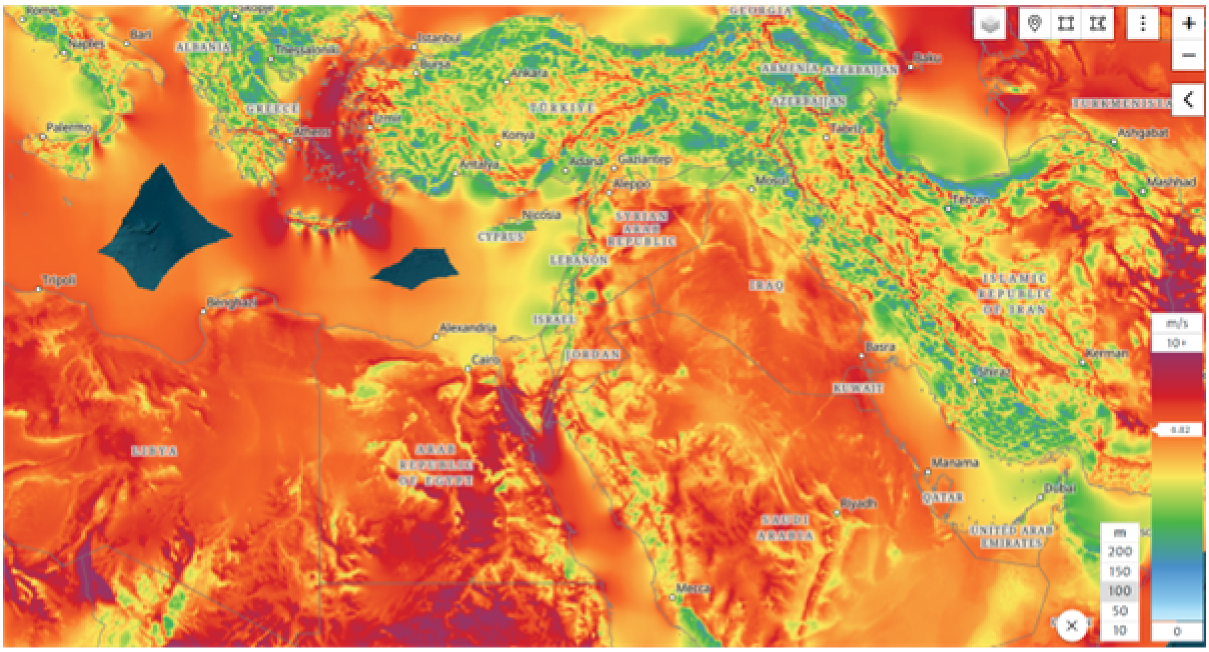

Figure 7 Wind speed in the Sunrise Region area[53]

[52] Global Solar Atlas, https://globalsolaratlas.info/

[53] Arcgis, based on Global Wind Atlas, https://www.arcgis.com/apps/mapviewer/index.html?layers=08be07c69cd4486995d1dc5d175156e3

The Sunrise Region concept aims at meeting regional demand plus 30% of the demand of the target European markets. At 2023 demand levels, this equates to:

- 100% of demand in Israel and Palestine[54]: 70 TWh (of which ~8.3 TWh was generated by existing domestic renewables in 2023)
- 30% of demand in Cyprus, Greece and the rest of South-Eastern Europe: 62 TWh
- 30% of demand in Italy, Germany and Central Europe: 377 TWh
- Total: 509 TWh

The estimated 509 TWh could be supplied on a gross basis by 35 GW of wind and 135 GW of solar PV (or an equivalent combination) located in the Sunrise Region area. As a comparison, Germany intends to have 374 GW of domestic renewables online by 2030, Italy 131 GW and Greece 19 GW, and the Sunrise Region concept would equate to about 32% of the renewable capacity of these three countries (output would be higher, given the better generation conditions in the Sunrise Region).

Note that this does not include any future demand growth, nor the domestic needs of Jordan, Egypt and Saudi Arabia. Extrapolating the last decade of electricity demand growth (about 2% annually) suggests demand in Israel and Palestine may rise by about 40 TWh by 2045. Electricity demand growth in the main European markets considered – Greece, Italy, Austria, Czechia and Germany – has been very low or negative over the last decade. However, it may accelerate given increased use of electricity for vehicles, home heating, electrified industry, and data centres. A further phase of this study should include a more detailed view of future demand in the target markets.

Despite these excellent solar conditions, solar installations in the Sunrise Region are relatively limited (Figure 14). The greater number of installations are in Israel, while they are also widely developed in Southern Italy and Greece. The Benban site in Southern Egypt and the Mohammed bin Rashid solar park in Dubai, UAE, are also clearly visible, as are a number of installations in Jordan. The pace of renewable installation will accelerate, with multi-gigawatt programmes in Saudi Arabia and Egypt underway; for now, though, abundant sites remain in the Sunrise Region.

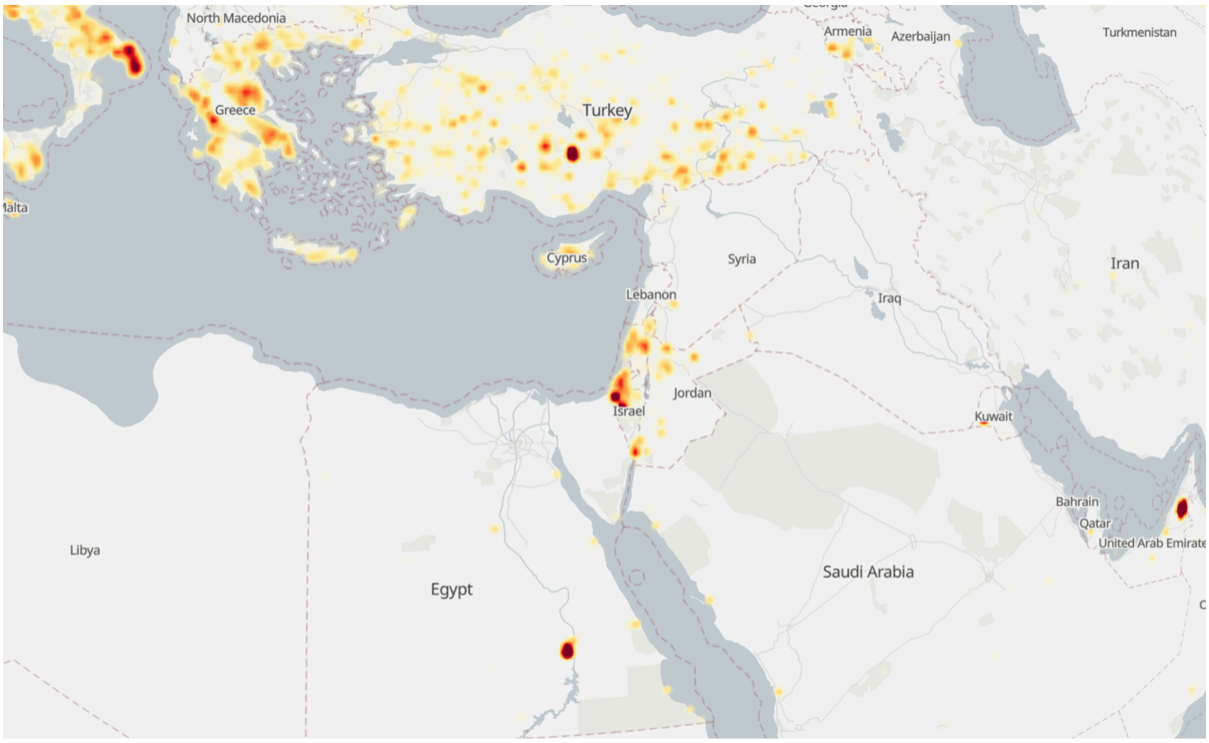

Figure 8 Solar power installations in the Sunrise Region and surrounding areas[55]

[54] Excluding renewable capacity already installed
[55] Open Infrastructure Map, https://openinframap.org/#4.33/31.79/27.91/L,S

2.3 Electricity Exports

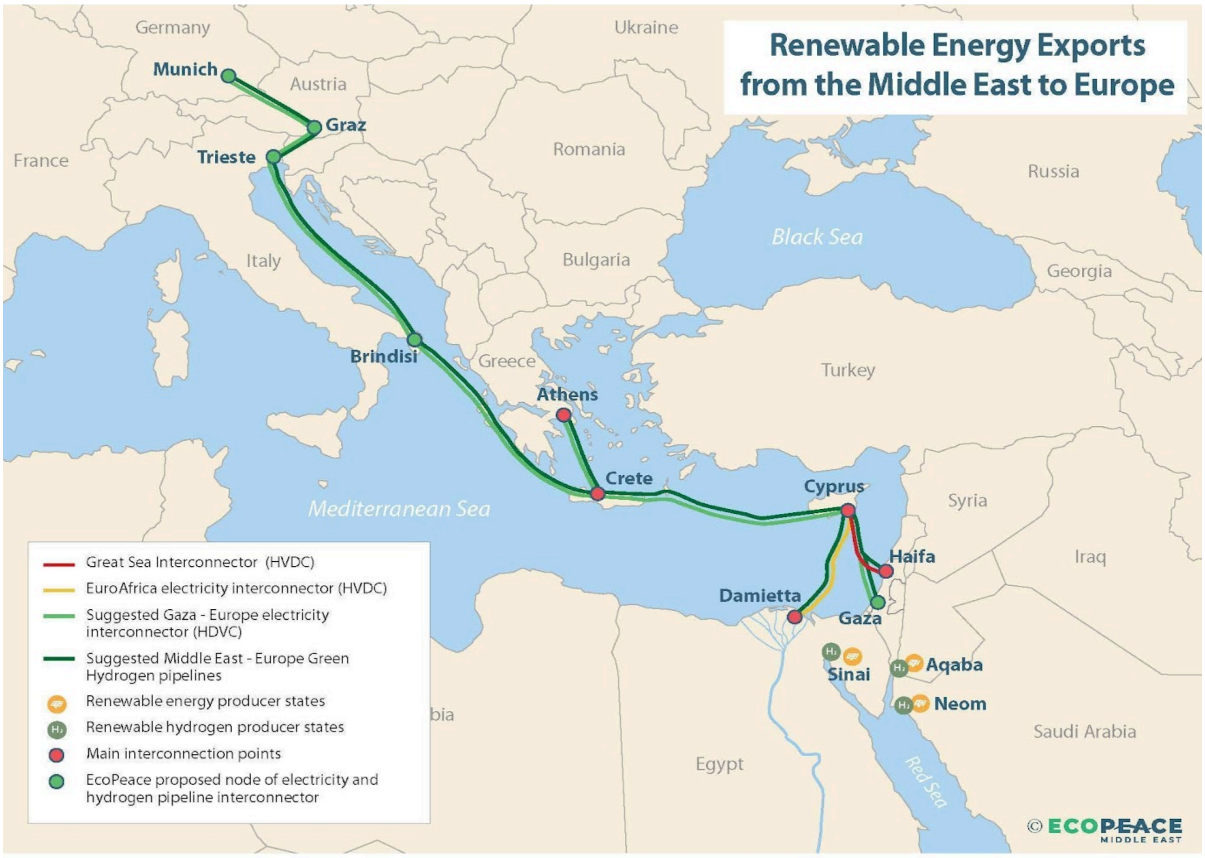

Figure 9 Renewable Energy and Green Hydrogen Interconnections from the Sunrise Region Area to Europe[56]

Renewable energy could be exported from the Sunrise Region area to Europe in four main ways:

- As electricity (via subsea high-voltage direct current (HVDC) cable)
- As hydrogen by subsea pipeline
- As hydrogen by ship (as liquid hydrogen, via a liquid organic hydrogen carrier (LOHC), ammonia with reconversion to hydrogen when delivered, or another carrier mechanism)
- As a derivative of hydrogen and/or electricity, by ship (ammonia, methanol, synthetic fuel, “green” steel, etc), intended to be used in its final form

There are four main economic reasons for exporting renewable energy from the Sunrise Region area to Europe:

- Costs of delivered energy (generation plus conversion (if required) plus transport) may be lower than those for on-site generation in Europe
- Match of timing (daily, seasonal) of delivered electricity to demand may be better than for indigenous generation
- Lower correlation of renewable generation in the Sunrise Region to that in Europe may reduce reserve/storage requirements or risks of extended period of low renewable generation
- Available or affordable land in Europe may be insufficient to install the required renewable capacity

[56] Qamar Energy Research

Five bidirectional HVDC links from the East Mediterranean to Europe are in various stages of development.

- The Great Sea (formerly EuroAsia) Interconnector will have 2000 MW of capacity and run from Hadera in Israel to Kofinou in Cyprus (310 km), then to Korakia in Crete (898 km), from where it connects to the mainland Greece system. It would run through a maximum water depth of 2200 metres between Israel and Cyprus, and 3000 metres between Cyprus and Crete[57]
- The EuroAfrica Interconnector, with bidirectional capacity of 2000 MW, would run from Burullus in Egypt to Kofinou in Cyprus (498 km) and then to Fodele in Crete (898 km), through water depths up to 3000 metres. Cables have been trialled in waters of 2150 m depth; 3000 metres therefore, though presenting some challenges, does not appear a major step beyond existing experience. For comparison, a hypothetical Egypt-Cyprus-Crete-Italy line would have a length of about 2000 km
- An earlier-stage project is the Green Aegean Interconnector, which is intended to bring solar and offshore wind power from Greece's Aegean Sea area, under the Adriatic Sea, to Slovenia, Austria and Germany[58]
- The Greece-Egypt interconnector (GREGY), with 3000-3500 MW capacity and intended to carry solely renewable electricity (75% wind and 25% solar), would run from Sidi Barrani on the North-Western Egyptian coast directly to Nea Makri in mainland Greece near Athens, through waters over 3000 metres deep, bypassing Crete and Cyprus[59]. Bids for project studies were received in February 2025
- Finally, Green Vein is intended to run 2800 km from West Sohag in Egypt to the Dolo Substation near Venice in Italy, traversing water depths up to 3000 metres, and with capacity of 3000 MW[60]

For the purposes of this analysis, the following comparison is made. Greece and Italy are considered as two representative and accessible electricity markets in Southern Europe. Their average solar and wind output over representative days in June and December is compared to their hourly electricity demand over the same period. This is then compared to the electricity output of solar and wind facilities located in representative locations in the Sunrise Region: Ras Gharib in Egypt, Makna near Neom in Saudi Arabia, Ma'an (solar) and Aqaba (wind) in Jordan. For comparison, output at Ashalim (solar) and Eilat (wind) in Israel, Deir Abu Mash'al (solar) and Hebron (wind) in Palestine are also shown. Solar PV plants are assumed to use double-axis tracking.

[57] entsoe "TR 219 – EuroAsia Interconnector", 29 July 2022, https://tyndp2022-project-platform.azurewebsites.net/projectsheets/transmission/219
[58] Three Seas, "Green Aegean Interconnector", https://projects.3seas.eu/projects/green-aegean-interconnector
[59] Copelouzos Group, ""GREGY" Interconnector", https://www.copelouzos.gr/en/service/gregy-interconnector/
[60] TERNA, "2025 Development Plan Overview", https://download.terna.it/terna/Terna_2025_Development_Plan_Overview_8dd62ef0043f220.pdf

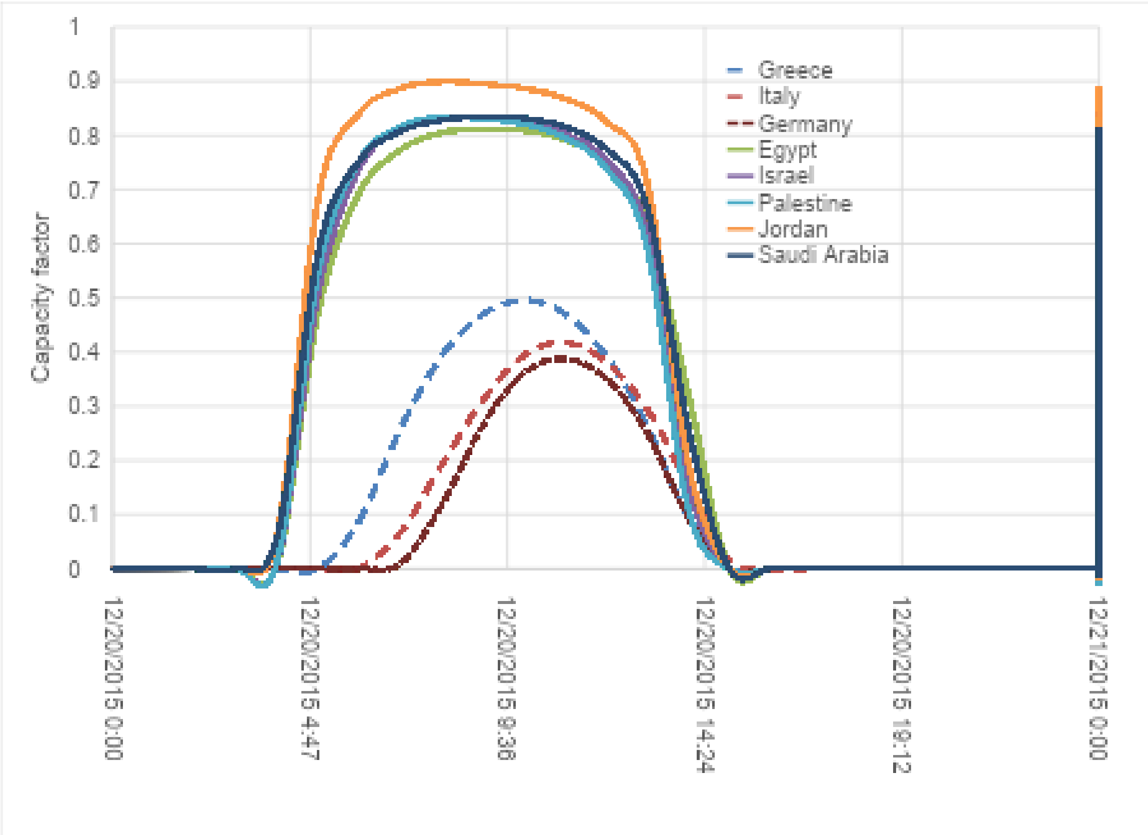

Figure 10 Capacity factor of solar in chosen locations, representative day in December (UTC)

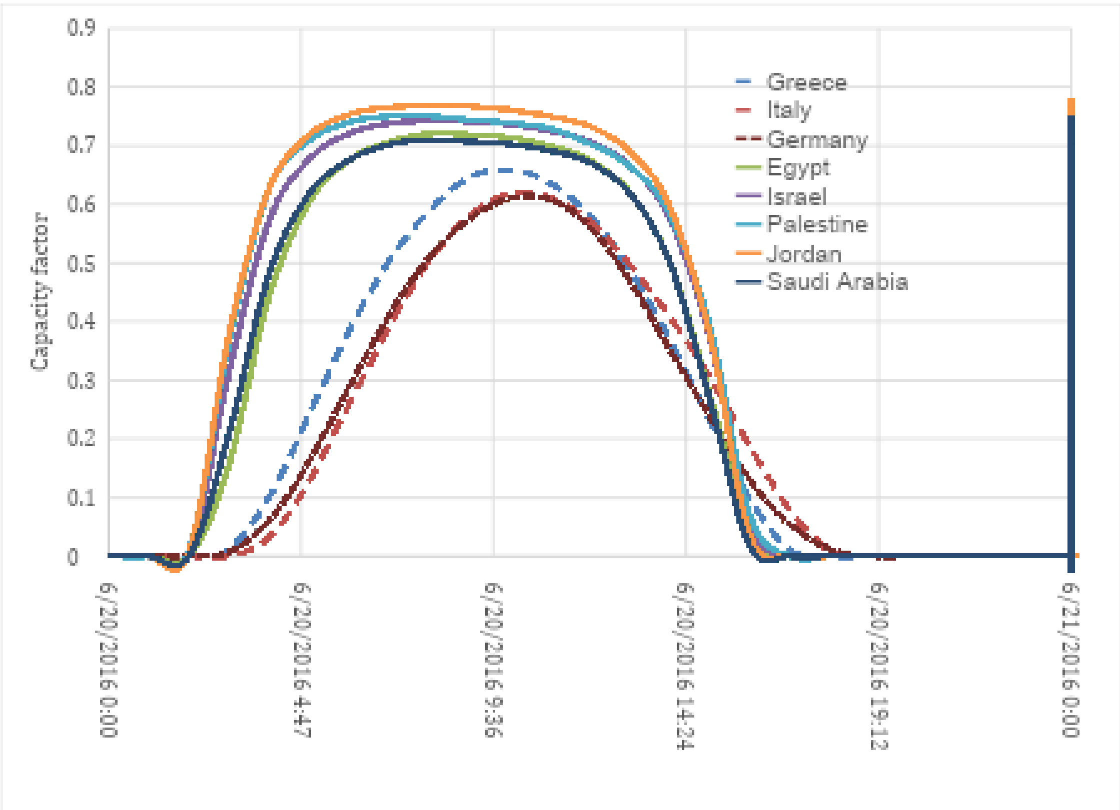

Figure 11 Capacity factor of solar in chosen locations, representative day in June (UTC)[61]

[61] Data from renewables.ninja

The solar power resources in the Sunrise Region area are much superior even to sunny European countries such as Greece and Italy (Table 2).

Table 8 Typical solar output by region

Area	**Typical a**verage daily solar output per 1 kW installed capacity (kWh)
Southern West Bank (Hebron)	5.1
Negev/Naqab Desert	5.3
Southern Jordan	5.5
Northern Sinai (Egypt)	5.3
North-West Saudi Arabia (Tabuk)	5.6
Attica (Greece)	4.3
Puglia (Southern Italy)	4.2
Bavaria (Southern Germany)	3.2

Solar output in June in Germany is similar to that in Italy, but output in December is significantly lower. Capacity factors from the Sunrise Region are in the range of 33-37% in a typical week in June and 20-29% in December, compared to 23% in Greece and 21% in Italy in June, and 12% for Greece and 8.5% for Italy in December. The solar output from the Sunrise Region is thus much superior to that in Europe, and more consistent, particularly in winter, the period of peak electricity demand in Central and Northern Europe.

In winter, sunrise is about two hours earlier in the Sunrise Region area than in Italy and three hours earlier than in Germany, while sunset is at about the same time in the Sunrise Region, Italy and Germany. The Sunrise Region therefore has advantages in meeting early morning demand in Europe, when overnight battery storage may have been depleted. Even in the final hour before sunset, solar generation in Egypt is about three times the level of Germany.

Average wind capacity factors in the selected locations in the Sunrise Region area range from 30-40% in December and up to 70% in the best locations in Egypt in June. For comparison, the average in June was 42% in Greece, 11% in Italy and 9% in Germany, and in December 62% in Greece, 7% in Italy and 25% in Germany. The best locations for onshore wind are in the coastal parts of the Northern Red Sea area, including the Gulf of Suez and Gulf of Aqaba, Sinai, the area around Neom in North-western Saudi Arabia, and Southern Jordan[62], as well as some interior parts of Egypt. Offshore wind has not been much investigated, but again the best potential is likely to be in the Northern Red Sea, with the Mediterranean having lower potential.

There is a negative correlation between wind in December in the Sunrise Region area versus in Greece, and a low or negative correlation in June; and there is an overall negative correlation between wind in the Sunrise Region and that in Germany, over the course of a year. This correlation is -0.15 on a monthly basis, and even higher, -0.53, on a weekly basis. That indicates that wind in the Sunrise Region would help to balance output in Greece and Germany, and vice versa. Wind in the Sunrise Region is also highly negatively correlated with solar (whereas in Greece it is positively correlated). The consistency of wind at the good sites in Egypt is also better; during a sample year (2016), the weekly output was never less than 26.5% of capacity, while in Germany, overall wind capacity factors ranged from 5% to 51%. Energy experts studying North-Western Europe are often concerned about the potential for a “Dunkelflaute”, a period of still conditions and heavy cloud cover during winter, with very low wind and solar generation. This coincides with the occurrence of high demand for heating. Dunkelflauten can occur simultaneously over large areas. But the occurrence of low wind conditions in Germany does not coincide with low wind in the Red Sea area of Egypt (Figure 18). Wind in Egypt can be relied on to generate at least 30% capacity factor even in times of very low wind output in North-Western Europe.

[62] S. Alsaqoor, A. Marashli, R. At-Tawarah, G. Borowski, A. Alahmer, N. Aljabarin and N. Beithou, “Evaluation of Wind Energy Potential in View of the Wind Speed Parameters – A Case Study for the Southern Jordan”, 1 December 2022, Advances in Science and Technology Research Journal 2022, 16(6), p275–285, https://www.astrj.com/pdf-156412-83368?filename=Evaluation%20of%20Wind%20Energy.pdf

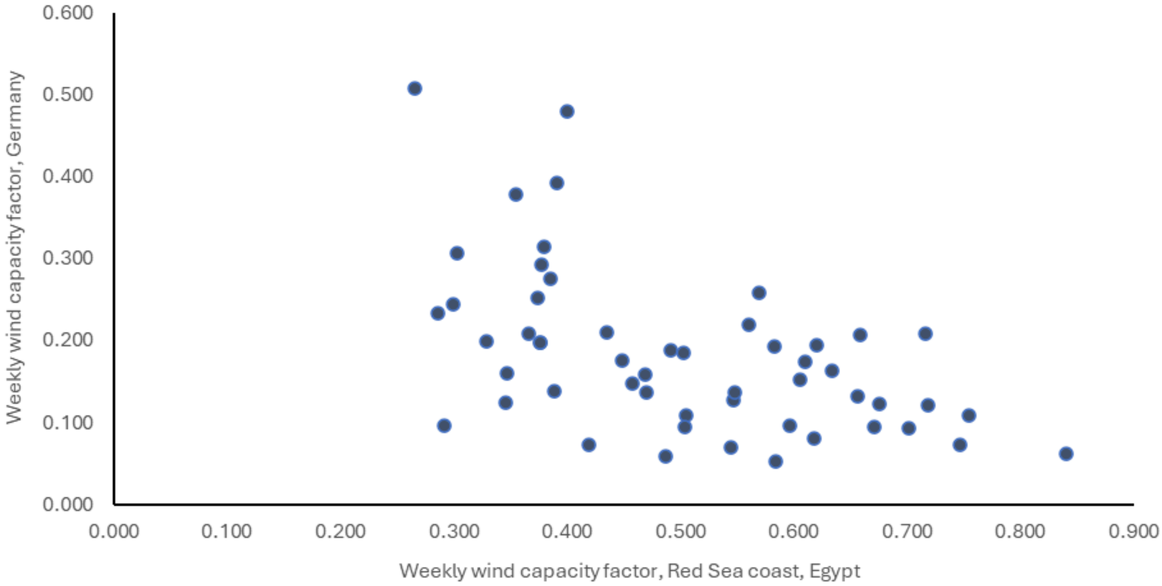

Figure 12 Weekly wind capacity factors, Germany and Egypt

A picture over the course of a year is shown in Figure 19. The wind capacity factor in a good location in Egypt is much higher, in every month, than the average generation in Germany, Greece or Italy. Even more importantly, it has a different seasonal pattern, being highest in summer, while wind generation in Germany and Italy (less so Greece) is highest in winter. This points to the utility of wind from the Sunrise Region in complementing wind power in Europe. Southern Jordan and North-Western Saudi Arabia also have good to excellent wind resources. Overall, these features of combined wind and solar supply from the Sunrise Region would reduce the cost of a European power system relying mostly on renewable generation, diminish the need for long-duration energy storage in Europe and improve the reliability of supply.

Electricity supply from the Maghreb in North Africa (Morocco, Tunisia, Algeria) can also help meet some of these objectives. Morocco is more likely to supply the Iberian Peninsula, France and the UK. Tunisia and Algeria are well-placed to serve Italy, but although their solar resources are excellent, their wind power resources are not as good as those of the Sunrise Region (the windiest areas in Algeria are in the far south). Being sited on about the same longitude as Italy, they also do not help with offsetting time zones. Both countries additionally have various political challenges. So the Maghreb and Sunrise Region should be seen as complementary sources of renewable electricity to Europe, helping further to diversify geography and political risks, not mutually-exclusive alternatives.

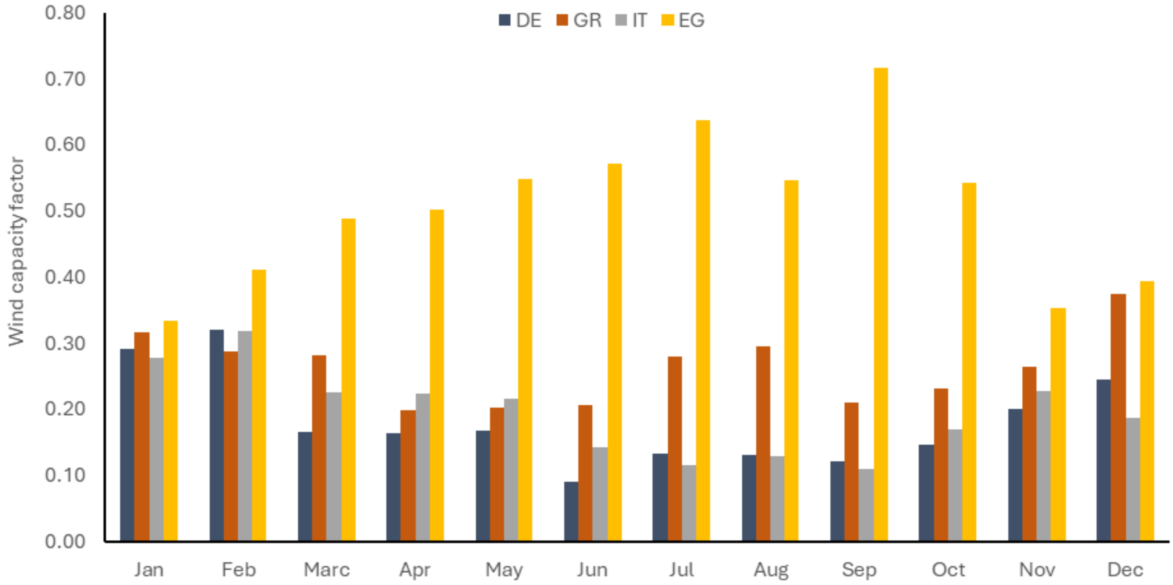

Figure 13 Wind capacity factors by location, monthly averages (2016)

These are indicative figures based on selected months and a few chosen locations. A deeper analysis would be required to examine numerous candidate sites, incorporate data over multiple years, and include realistic constraints on siting (mountains, urban areas, environmental reserves, military sites and so on). Nevertheless, they demonstrate that the solar and wind resources in the Sunrise Region area are superior to those in typical export destinations in Southern Europe, and that the daily and seasonal pattern of output would complement generation in Southern and, especially, Northern Europe, so reducing system costs and improving reliability.

Typical examples in the region for utility-scale plants in open land suggest capacity of about 5 MW of wind per km^2, and 44 MW of solar per km^2. The land under wind turbines can still host other uses such as agriculture; that around solar panels may be suitable for some cultivation or grazing. Use of bifacial panels, now becoming standard, would also raise the solar output per km^2. New panel sizes and technologies also show further gains in the available solar generation per unit area. Vertically oriented solar panels, intended to generate maximum in the early morning and late afternoon, can be used as windbreaks to shelter crops. Calculations here do not assume that solar and wind would be co-located, but that is also possible where favourable terrain and resource conditions overlap.

As a first phase, an indicative 10 GW project split equally between wind and solar would therefore require about 1100 km^2, assuming the wind and solar do not occupy overlapping areas. This is about 1.8% of the area of the Sinai, or 1.2% of the area of Jordan, and a very small fraction of the total area of Egypt or Saudi Arabia. The full project of 35 GW wind and 135 GW solar, to meet all the demand in the transit countries plus 30% of the target European demand, would require about 10 000 km^2 (7000 km^2 for wind and 3000 km^2 for solar PV). Indicatively, split evenly (2500 km^2 each), this could be accommodated in about 4% of the Sinai, 2.8% of Jordan, 0.3% of (non-Sinai) Egypt, and 1% of the Tabuk and Jawf provinces in North-Western Saudi Arabia. An additional, relatively minor, area would have to be allocated for substations, supporting infrastructure (e.g. road access) and transmission lines. In reality, with good design and future technological improvements, the required land area could probably be reduced.

If necessary, the available land area could be expanded by considering offshore wind, which may have good potential in the Northern Red Sea, and floating solar panels. Floating solar has already been implemented on some inland water bodies in Israel[63] and is being proposed for Lake Nasser in Egypt[64]. Marine deployment of floating solar would require a deeper study of metocean conditions but could also be promising. Therefore, land for a large renewable project should be readily available, even when excluding areas that are not suitable because of terrain, urban or agricultural use, environmental or cultural value, or military restrictions. Total peak demand in Israel, Palestine and Jordan is about 20 GW. Again, this could be readily supplied on a gross basis by available land in Jordan, Egypt and Saudi Arabia (as shown, Israel, Palestine and Jordan have already about 7.5

[63] https://www.pv-magazine.com/2024/05/21/israel-to-deploy-250-mw-of-floating-solar-agrivoltaics/
[64] https://taiyangnews.info/markets/egypt-planning-5-gw-floating-solar-power-plant

GW of domestic installed renewable capacity). The rest of demand in Egypt and Saudi Arabia could be met by renewable and other power generation located in other parts of the country, and both already have extensive renewable installations operating or under construction.

Given the short distances from the renewable generation sites to the local markets in Israel, Palestine and Jordan, it is likely that the generation would be split: one portion to the long-distance, HVDC cable for export, and one portion to conventional high-voltage (440 kV) AC transmission lines to connect to local grids. Egypt, Jordan, Israel and Palestine (and Iraq, Lebanon, and the GCC, other than Saudi Arabia) all run on 50 Hertz, while Saudi Arabia's grid is on 60 Hz, so a frequency converter would be required to connect to the Saudi grid. The EU, including Cyprus, runs on 50 Hz, but as it will be supplied with DC, the conversion to AC of the right frequency is handled by the converter station. It will need to be considered whether these connections should be isolated, or whether the Jordanian, Palestinian, Israeli and Egyptian grids would be synchronised. Also, to ensure the low-carbon certification of electricity and/or hydrogen produced, it would be necessary to avoid or limit the input of fossil-fuel based generation from the existing grid, or at least to ensure there is temporal matching of renewable output and energy exports (in accordance with emerging EU standards), if there is a connection permitting bidirectional flow.

2.4 Electricity Pricing

Renewable generation costs in the region are very low by global standards, given the high-quality solar and wind resources, the large scale of projects, the relative ease of obtaining permits, the availability of open and little-used land, and the experience gained in prior projects. For example, the 400 MW Al Henaiyah-2 solar PV project in Saudi Arabia was awarded in October 2024 at US$14 per megawatt hour (MWh), and the 600 MW Al Ghat wind project at $15.7/MWh[65]. Note that these were the prices bid for power purchase agreements, and are assumed to reflect the full cost to the developer over the contract length, typically 25 years for solar projects in Saudi Arabia and the UAE. Therefore, all costs quoted here include capital and operating costs plus return on capital (capital being a combination of debt and equity).

These projects have a very low cost of capital, due to the offtake being by Saudi state entities[66]. A cross-border project from a country with higher political and economic risk, and export to Europe, would incur a higher cost of capital, here assumed at 6%. Nevertheless, a levelised generation cost over project life of €30/MWh for solar PV and €35/MWh for onshore wind is probably reasonable for now. These costs will come down as technology and supply chains continue to improve, and experience and comfort is gained with these projects. Mechanisms to reduce the cost of capital, including institutional underpinning, long-term sale, purchase and pricing commitments (possibly via a contract-for-difference model), export credits and state guarantees, could allow a longer-term cost of €10-15/MWh.

Recent wind projects in Egypt have cost about $1-1.4 million (€0.96-1.3 million) per megawatt of installed capacity. Solar PV costs for large-scale Egyptian projects are around $0.9-1 million (€0.86-0.96) per megawatt. Saudi Arabia's large-scale solar programme has capital costs of about $0.6 million (€0.58 million) per megawatt. Battery costs, indicated by Masdar/EWEC's recent UAE project, and AMEA Power's Egypt project[67], are about $250/kWh and likely to fall substantially.

Solar PV plus battery storage is likely to be lower in cost than concentrated solar thermal (CSP) with thermal (e.g. molten salt) storage; however, the conditions in the Sunrise Region, with clear skies, are also very good for CSP and it could be considered as an auxiliary technology with the advantage of several hours of integrated storage. Dubai's Mohammed bin Rashid Solar Park Phase IV includes 700 MW of CSP with 15 hours of battery storage, and was awarded at $73/MWh[68]. This is more expensive than the likely cost of solar PV plus batteries, of about $60/MWh in the UAE, but close enough that cost reductions might make it a plausible complementary technology. There is also good geothermal potential along the Gulf of Aqaba and Gulf of Suez, and that could be considered as a further complement for providing dispatchable power. Both solar CSP and geothermal can also provide heat for local industries, cooling systems and desalination.

[65] KAPSARC, 22 May 2024, https://www.kapsarc.org/news/saudi-arabia-sets-new-world-record-in-producing-low-cost-electricity-from-wind-energy/
[66] H. Apostoleris, A. Al Ghaferi and M. Chiesa, "What is going on with Middle Eastern solar prices, and what does it mean for the rest of us?", 4 March 2021 https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3414
[67] https://www.thenationalnews.com/business/energy/2025/01/29/amea-egypt/
[68] C40 Cities, "Dubai's 'Mohammed Bin Rashid Al Maktoum' 5,000MW Solar Park Aims to Save 6.5 Million tCO2e Annually" April 2019, https://www.c40.org/case-studies/dubai-s-mohammed-bin-rashid-al-maktoum-5-000mw-solar-park-aims-to-save-6-5-million-tco2e-annually/

The cost of transmission through undersea cables depends on the cost of the cable and the utilisation rate. The Great Sea Interconnector's Stage 1, of 1000 MW, is estimated to cost €2.5 billion. The EuroAfrica Interconnector's Stage 1, of 1000 MW, is also quoted at €2.5 billion. Costs for the expansion to 2000 MW appear to be about €1 billion[69]. Unit capital costs for a much larger line would be lower.

Such lines are feasible; China has, for example, built onshore Ultra-High Voltage Direct Current (UHVDC) lines up to 12 GW, at voltages of 1100 kV, and up to 3324 kilometres long. Prysmian has successfully trialled a 500 kV HVDC cable in 2150 metres of water[70], which will be used for the Tyrrhenian Link between Sardinia, Sicily and mainland Italy. The proposed XLinks project would combine 11.5 GW of renewable energy generation in Morocco, 22.5 GWh of battery storage, and a 4000 km HVDC cable with 3.6 GW of capacity, running subsea from Morocco to the UK, at a maximum water depth of 700 metres[71]. A proposed Australia-Singapore interconnector would run for 5100 km (of which 4300 km subsea), with a capacity of 2 GW, traversing mostly shallow water but including sections up to 1900 metres deep. IceLink would connect Iceland's geothermal and hydroelectric power to the UK, with 0.8-1.2 GW of capacity and a length of 1000-1200 km, with a maximum water depth of 1100 metres, while the Atlantic SuperConnection between Iceland and the UK would have 1.8 GW capacity over 708 km[72], A more speculative project would connect Europe and North America[73]. Investment costs assumed here are taken from the literature and are consistent with the reported costs for the Great Sea and EuroAfrica connectors[74].

A direct connection under the Adriatic to Trieste would link into the Austrian and German markets and so the rest of Central Europe. This could follow a similar route to, or even be combined with, the Green Aegean Interconnector mentioned above. A connection running Gaza-Cyprus-Crete, then following the shallower water along the Greek coast and through the Adriatic to Trieste, would have a length of about 2400 km. A further 500 km onshore would take the cable from Trieste to Graz in Austria, then avoiding the higher part of the Alps, to join the German grid at Munich.

Table 9 Cost of Electricity Interconnections

Project	Capacity (MW)	Length (km)	Cost (million €)		
			Cable	DC converter stations	Total
EuroAfrica (Stage 1)	1000	1396			2500
EuroAfrica (expansion)	1000	1396			1000
Great Sea	1000	1208			2500
Green Aegean	3000	1400			8100
GREGY	3000-3500	954			4200
Sunrise Region to Greece	2000	1400	3102	320	3422
Sunrise Region to Greece	10 000	1400	15 512	1 600	17 112
Sunrise Region to Brindisi, Italy	10 000	2000	22 160	1 600	23 760
Sunrise Region to Trieste-Germany	10 000	2900	32 177	1 600	33 777

For this project, transmission would be required from the main generation sites to the maritime export points. Most likely, generation would be consolidated at nodes to link to the export project. The costs for the relatively short lengths of onshore transmission can be assumed to be included in the overall high-level costs given here, though the layout would require more detailed study once the main generation sites are selected.

[69] https://warwickhvdc.co.uk/uploads/1/1/3/3/113371609/warwick_hvdc_digest_-_august_2024_-_powerpoint_draft_-_hyperlinks.pdf
[70] Prysmian, https://www.prysmian.com/en/media/press-releases/record-breaking-submarine-cable-installation-at-2-150-m-water-depth
[71] J-B. Vaujour, "What Will Morocco Gain from XLinks UK Interconnector Project?", Energy Intelligence 11 December 2024, https://www.energyintel.com/00000193-9684-de9f-a1d3-bfec4b980000
[72] Offshore Energy, https://www.offshore-energy.biz/atlantic-superconnection-laying-the-fid-groundwork-for-subsea-interconnector-to-ply-uk-with-geothermal-and-hydroelectric-electricity-while-doling-out-wind-power-to-iceland/
[73] Ember Energy, https://ember-energy.org/app/uploads/2024/12/Analysis-Security-and-efficiency-The-case-for-connecting-Europe-and-North-America.pdf
[74] https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_UIC_indicators_table.pdf; https://www.sciencedirect.com/science/article/pii/S0959652622017346#bib48

Transmission losses are quoted at 3.5% per 1000 km for high-voltage direct current (DC), considerably less than for alternating current transmission, plus 0.7% in each conversion (AC to DC and DC to AC). Operating costs are based on a percentage of capital costs[75], including estimated cost of repairs as required. The lifetime of the cable is 50 years, but a conservative lifetime of 25 years is used here. Optimal cable size is around 2 GW, therefore a 10 GW phase would comprise five cables, which could have somewhat different starting and landing points, to minimise risks of single-point failures, and reduce the burden on the local grid at the arrival point[76].

For the indicative solar and wind plant located at Ras Gharib in Egypt, 2019 data show an average capacity factor of 29.5% for solar PV and 50.5% for wind. The output of the two is negatively correlated, hence the combination has a higher utilisation factor of the interconnector than either would separately. The economic return also depends on whether surplus generation, in excess of the capacity of the interconnector, can be sold locally, and if so at what price. Similarly, the use of batteries would allow higher utilisation factors; recent results in Abu Dhabi[77] would suggest that 24-hour steady power from solar is achievable at an added storage cost of about €50/MWh. The added storage cost for the wind-solar combination employed here would be lower; here, 2 hours of storage is assumed, as for the Xlinks project. In this study, an overall utilisation factor for the interconnector of 53.4% is assumed, though an optimisation exercise may indicate higher levels are achievable. Learning factors are assumed for wind, solar, battery and cable that reduce costs over time.

To show the effect of lower solar and battery costs in the longer term, Figure 21 indicates weekly average output over a year from 12 GW of wind and 15 GW of solar, evenly distributed between Egypt, Jordan and Saudi Arabia, with 33 GWh of battery, feeding a 10 GW cable. In this case, about 8% of generation exceeds the cable capacity and would have to be shed or sold locally. The cable utilisation is 83.5%, showing that a very high utilisation factor is achievable with a moderate amount of battery storage and a carefully-chosen balance of wind and solar PV. Exported electricity is somewhat lower in the winter since both wind and solar output are lower in the winter in the Sunset Region. However, since peak demand in the Sunset Region and the local importing countries is in summer, this could be balanced by building a larger renewable system overall and supplying more electricity locally in summer. It will also be noted that there were a few weeks in which wind output dipped significantly (weeks 4, 14, 33 and 50 in this dataset), and that could be overcome with longer-duration storage such as pumped hydro.

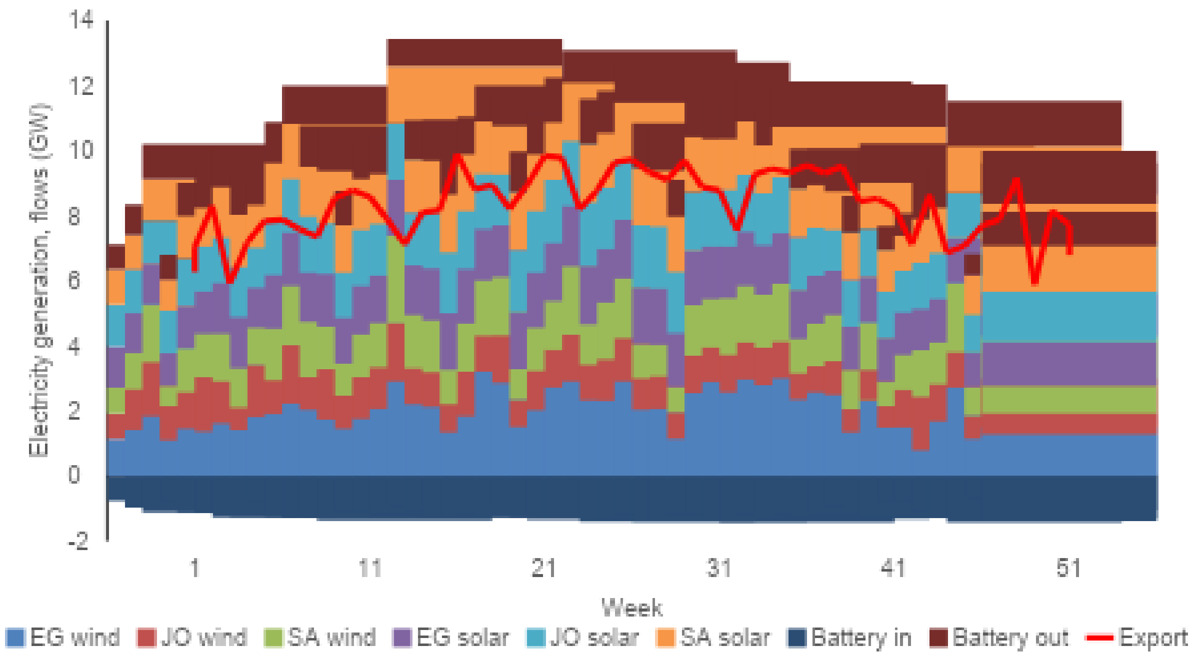

Figure 14 Weekly output from 10 GW system[78]

[75] https://www.sciencedirect.com/science/article/pii/S0959652619333360, https://www.sciencedirect.com/science/article/pii/S0959652622017346#bib48
[76] Ember Energy, https://ember-energy.org/app/uploads/2024/12/Analysis-Security-and-efficiency-The-case-for-connecting-Europe-and-North-America.pdf
[77] https://www.catl.com/en/news/6365.html
[78] Generation data from 2019, renewable.ninja; analysis by Qamar Energy

The breakdown of annual investment to reach the target of 30% of electricity supply in the target European markets is shown (Figure 10). This assumes one 10 GW phase with supporting solar and wind generation and battery backup is commissioned every two years from the starting year to Year 7, and one 10 GW project every year thereafter, to reach the full 30% capacity (135 GW solar, 35 GW wind and 170 GW of interconnection) by Year 25. Interconnection capacity is split equally between the route into Germany and Central Europe via Italy and Austria, and the route into South-Eastern Europe via Greece. Required investments are on the order of €10-15 billion annually initially, rising to €20-25 billion each year during the period of delivering a 10 GW phase each year.

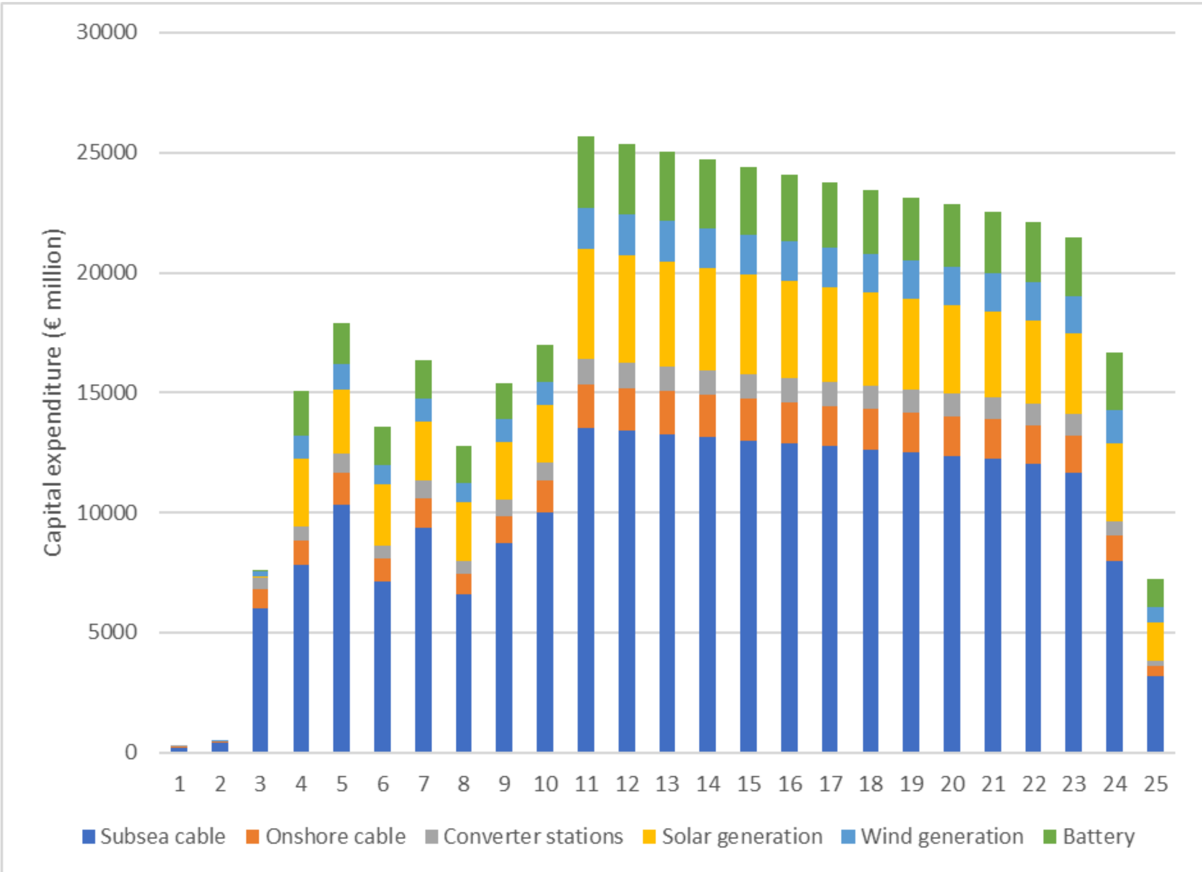

Figure 15 Annual investment from Year 1 to Year 25

The countries in the Sunrise Region do not have liberalised electricity markets in which electricity is freely traded, although Israel is in the process of opening up its market[79]. This is different from the situation in the EU, where the wholesale price in, for example, Greece and Italy, is reported hourly. It is therefore hard to determine *a priori* how much the interconnector would be used in export mode in the Sunrise Region (i.e. sending electricity to Europe), and how much, if at all, in import mode. For the purposes of this analysis, it is assumed that it operates purely in export mode.

These assumptions indicate that the Great Sea and EuroAfrica interconnectors would have a transmission cost of approximately €33 per MWh. The delivered cost of renewable electricity would therefore be in the range of € 63-68/MWh initially, falling towards €43-53/MWh as the renewable cost component of the project falls (mostly due to lower cost of capital).

[79] https://www.enerdata.net/publications/daily-energy-news/israel-unveils-new-reform-open-electricity-market-private-providers.html

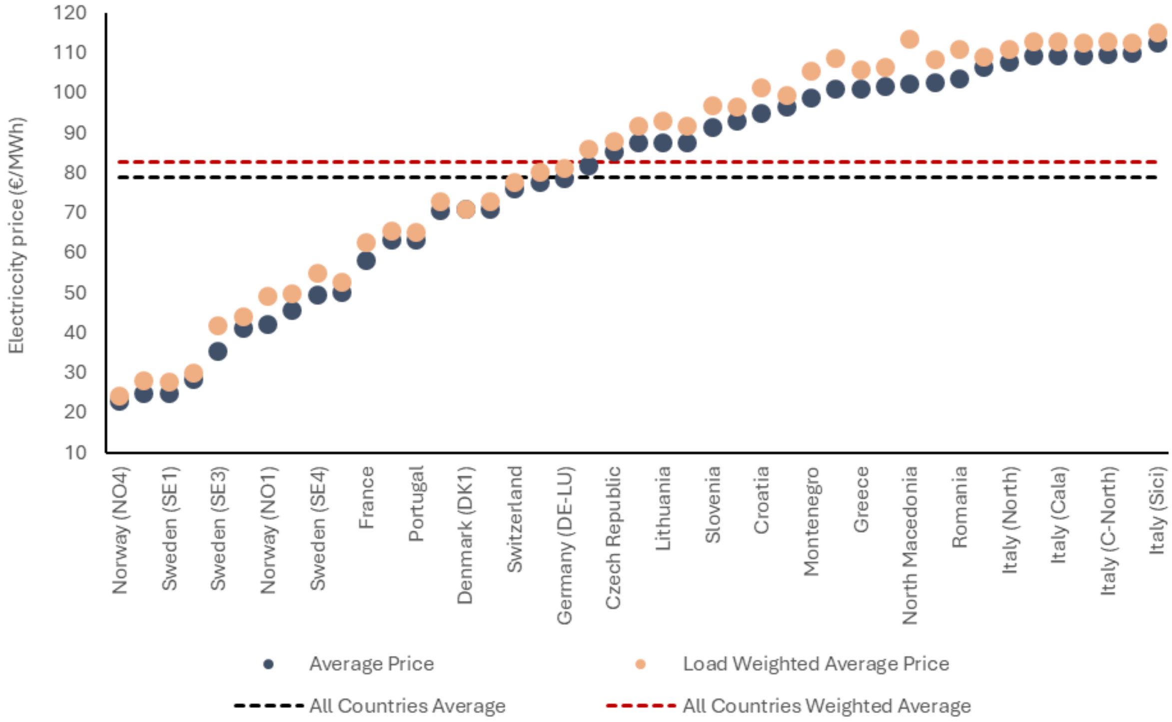

Figure 16 European electricity prices in 2024[80]

During the 2019-early 2025 period (Figure 23), the average wholesale price of electricity in Italy was €126/MWh (about US$ 131/MWh at current exchange rates), in Greece €121/MWh (US$ 126/MWh), and in Germany, €95.9/MWh ($99.9/MWh). Taking instead the 2023-early 2025 period, to exclude the impact of the Covid pandemic in 2020-21 and the Russian invasion of Ukraine in 2022, with the consequent European electricity and gas price crisis, the average prices are only slightly lower, €87/MWh in Germany, €118/MWh in Italy, and €110 / MWh in Greece.

These prices are clearly well-above the average delivered cost of power from this proposal. During the entire 2019-early 2025 period, the hourly wholesale price of electricity in Germany was above €66/MWh for 50% of the time, Italy 64% of the time, and in Greece 66% of the time. Increasing renewable generation in Germany, Greece or Italy is limited by the lack of suitable land, the high cost of land, the lengthy environmental and permitting procedures, and the relatively smaller sites which do not provide economies of scale and therefore raise costs compared to those in the Sunrise Region area. In Germany, wholesale prices were negative for significant periods, dragging down the overall average. Obviously an interconnector would not be used at such times, or would be used in reverse mode.

[80] Qamar Energy Research, with data from Entso-e

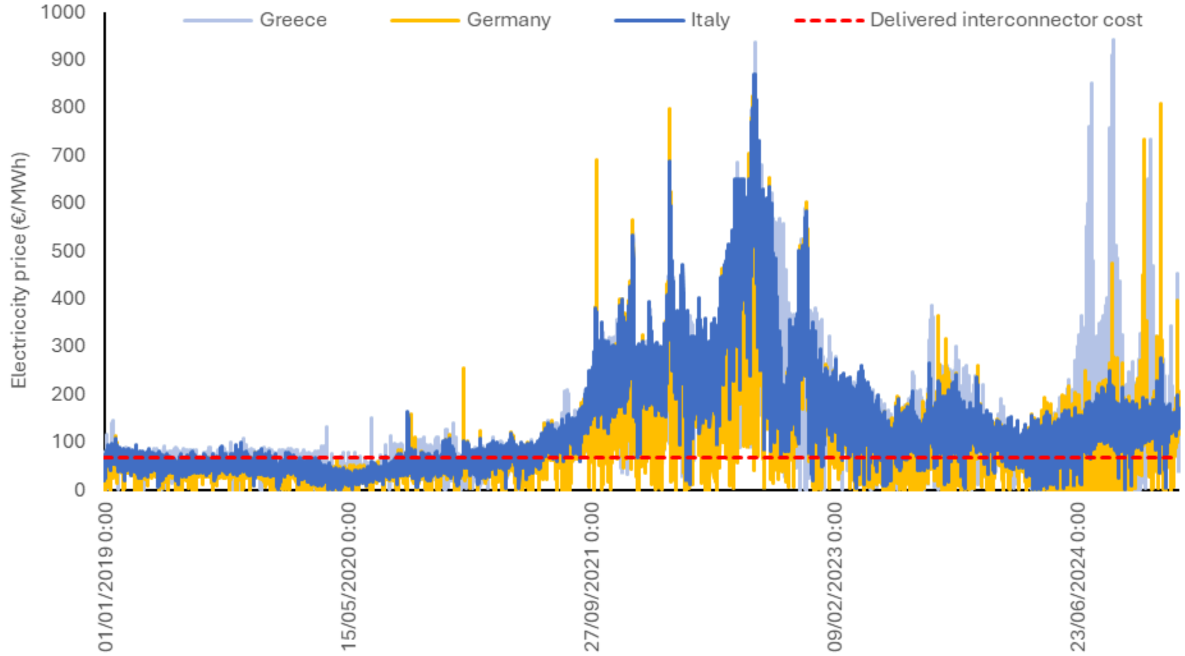

Figure 17 Hourly wholesale electricity prices in Germany, Greece and Italy and plausible delivered cost of Sunrise Region electricity, 2019-2025[81]

Such a project would not be built and financed on a merchant basis, but under a long-term contract. For instance, the planned XLinks project from Morocco to the UK is intended to be financed under a "contract-for-difference", effectively guaranteeing a fixed electricity price. However, the comparison of wholesale electricity prices indicates that a number of large renewable energy generation sites in the Sunrise Region area could be combined with one or more optimally sized high-voltage DC subsea cables to export large quantities of electricity to Southern Europe.

Though valuable, the Great Sea and EuroAfrica Interconnectors are too small to be transformative, either for their export or import markets. This would require a larger, more ambitious project spanning multiple countries. To meet the concept of supplying 30% of the gross demand in the targeted parts of Europe, plus 100% of the demand in the transit states, would require 35 GW of wind and 135 GW of solar PV, or an equivalent combination.

Indicatively, a phase one project of 10 GW of renewable energy (combining 5 lines with 2 GW capacity each, which could have somewhat different starting and landing points), with an average capacity factor of 53%, would produce 46.8 terawatt-hours (TWh) of electricity per year to be sent to Greece, Italy or Germany via a subsea HVDC cable. The indicative economics are shown in Table 4. It should be emphasised that these figures are simplistic and probably underestimate the value of the project. For example, they do not include the value of reverse flow when European power prices are low or negative; and the average price captured by the interconnector is likely higher given the noted negative correlation between renewable generation in the Sunrise Region versus Europe, especially Germany.

Nevertheless, this preliminary analysis suggests that electricity exports to Greece, especially, and Italy form a highly viable project. Exports on the much longer route to Germany would require a combination of lower renewable costs in the Sunrise Region, higher realised electricity prices in Germany, and other value creation (e.g. bidirectional flow, optionality to inject into the Italian, German or Austrian grid, higher utilisation factors via storage, etc.).

[81] https://www.raaey.gr/energeia/en/market-monitoring/greek-wholesale-electricity-markets/electricity-prices-statistics/resources/; https://dati.terna.it/en/download-center#/load/total-load

Table 10 Electricity export project economics

Market	Transmission cost (€/MWh)	Average electricity price 2023-25 (€/MWh)		Renewable generation €35/MWh			Renewable generation €15/MWh		
		All hours	Excluding hours <€15/MWh	IRR	NPV 6% (B€)	Annual cashflow (B€)	IRR	NPV 6% (B€)	Annual cashflow (B€)
Greece	32.8	110.4	114.6	17.7%	22.4	3.3	22.4%	33.0	4.3
Brindisi, Italy	46.5	118.4	118.9	12.8%	17.0	3.4	16.5%	27.7	4.3
Trieste / Germany	70.1	87.0	95.3	3.7%	-6.6	2.1	7.3%	4.0	3.1

For comparison to these cashflow figures, Egypt earned $9.4 billion in revenues from the Suez Canal in the 2022-23 fiscal year; Egyptian exports in total were $40.8 billion in 2024, those of Jordan about $12 billion, those of Israel $76.9 billion in 2022 (to exclude the impact of the war), and those of Palestine $1.58 billion. Such an electricity export project would therefore make a material contribution to the economies of the countries involved.

On a gross basis, such a 10 GW project would be sufficient to supply almost the entire current electricity demand of Cyprus and Greece. Therefore, allowing for seasonality and varying demand patterns, this is probably more than the Greek market could absorb and sales, transit or swaps into the wider European market would be required, via the interconnections of Greece with neighbours such as Bulgaria, Albania and, via a new planned sub—Adriatic cable, Italy. The much bigger Italian, German and wider Central European markets would be capable of absorbing a larger share of such exports. Tunisia and Algeria might, though, also compete to supply Italy in such a way. The Sunrise Region and Tunisia/Algeria corridors are not mutually exclusive and would help to diversify Europe's renewable imports.

The connection from Saudi Arabia would also facilitate wider electricity transfer to and from the GCC to Europe, as low-carbon generation in the GCC is expanding rapidly. Ultimately even wider transcontinental links are possible, for instance to India, which is already a core part of the IMEC concept, and Central Asia. The GCC has abundant little-used land with very good solar and wind resources, so export of power to Europe and India are not mutually exclusive. The timing differences can also allow for export of power to India in its early evening, switching to Europe in its early morning. Practically, the Eastern GCC states may focus on exports to India while Saudi Arabia exports to Europe from its North-Western areas.

Suitable commercial and institutional structures are also required to accommodate such a link and ensure its optimal usage. The connection of regulated with liberalised electricity markets is a complicated topic[82]. The GCC Interconnection Authority (GCCIA) links six regulated markets, while electricity transmission operators in Europe are represented by ENTSO-e[83]. Depending on the configuration of the interconnector, it would also allow electricity flow between the European grid and the GCCIA. Saudi Arabia is constructing connections to Jordan and Egypt, and Jordan is connected to Iraq, though the capacity of the Jordanian links is small. Liberalisation of markets, and the introduction of dynamic or at least time-varying pricing, would create value and enhance reliability, by allowing electricity to be generated, stored, exported and imported at the optimal times.

82 Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/01/EL57-Economics-of-Grid-Interconnections.pdf
83 https://www.entsoe.eu/

2.5 Hydrogen Production and Export

The other major option for the trade and export of renewable energy from the Sunrise Region area is "green" (renewable-derived) hydrogen. This is created by the electrolysis of water using renewable electricity. The water has to be fresh and pure, although methods of hydrogen production are under development that can use seawater.

The economics of hydrogen production are most strongly determined by the cost of the energy input. Secondarily, the cost of the electrolyser (capital, operating and lifetime), and its utilisation factor, are important. Utilisation factor can be increased by combining anti-correlated renewable inputs (solar and wind), incorporating batteries (at a cost), or using some additional electricity from non-solar or wind sources, for example nuclear, geothermal or grid power. Grid power will have a carbon footprint, depending on the nature of the generation attached to the grid, and therefore using it may prevent the hydrogen from being certified as "green".

The International Energy Agency (IEA) has assessed the cost of **green hydrogen production** in several key global locations in 2030 as follows: Chile $1.4/kg, Oman $1.6/kg, US $1.7/kg, Australia $1.9/kg, South Korea $2.6/kg, Central Europe $2.7/kg, Japan $3.8/kg[84]. For a typical configuration, capex accounts for $0.5/kg, operating costs for about $0.2/kg, and electricity input from $0.75-$1.7/kg (in a range of $15-35/MWh for the electricity cost). As noted, numerous solar and wind power projects in the GCC have achieved bid prices of $15/MWh or less, while in the Sunrise Region area, a cost of $30-35/MWh is reasonable. Note that more recent IEA analysis indicates somewhat higher costs, particularly with higher electrolyser costs and higher assumed cost of capital, but still indicate that Middle Eastern countries sit around the lowest end of the cost curve, with potential green hydrogen production costs in 2030 around $3/kg, compared to at least $4-5/kg for the best European projects[85]. Evidence from recent bids for the EU's inaugural Hydrogen Bank suggests production costs in the best EU locations (Greece, Spain, Sweden) at €5.3-5.8/kg ($5.8-6.3/kg)[86].

Achieving very low renewable input costs for hydrogen projects requires a commercial structure to deliver comparably low costs of capital to those for state-backed utility projects in the GCC. Under current circumstances, a hydrogen production cost in the GCC of more than $3 per kg is probably more realistic, although the GCC is still highly competitive with most other aspiring global producing regions.

The delivered cost of hydrogen depends strongly on transport costs. The sailing distance from Port Said in Egypt to Piraeus in Greece is about 1100 km, and from Port Said to Taranto in Italy, about 1740 km. Distances from Mediterranean ports in Israel would be similar: from Eilat, Aqaba or Saudi Red Sea ports somewhat longer, and with the requirement to pay Suez Canal tolls. Over these distances, transport cost by a dedicated hydrogen pipeline would be about $0.4-0.7 per kg, by ship as ammonia (as direct use, i.e. without reconversion to hydrogen) about $1.4-1.7/kg, as a liquid organic hydrocarbon carrier (LOHC) about $2.1-2.6/kg, and as liquefied hydrogen by ship $1.8-2.7/kg[87]. A 2023 study[88] estimated the costs of delivering 2.5 million tonnes of hydrogen annually from the Gulf to Europe by pipeline at €1.2/kg ($1.25/kg); the shorter distance from the Sunrise Region coast to Europe suggests a cost of about $0.35/kg.

If we assume that the IEA's perhaps optimistic production cost of $1.6/kg could be achieved, then the delivered cost to Southern Europe would be in the range of $2-2.3/kg by pipeline, $3-3.3/kg as ammonia by ship, and $3.7-4.2/kg by ship as LOHC. This suggests that delivery by pipeline could be competitive against local hydrogen production in Europe. "Green" ammonia would be marginal, and delivery of hydrogen directly by ship would not be economical. However, if production of hydrogen in Europe from renewables at the required scale is not possible, then imports could still be viable. A mix of delivery methods, routes and products also has attractions of improving energy security and resilience, particularly given Europe's recent energy security problems related to Russia. Export by ship from the Sunrise Region has the further advantage of being able to access other global markets, such as India. The GCC's choice between Europe and east Asia as its main export destinations for hydrogen depend on the incentive policies adopted in those importing regions, the location of the hydrogen

[84] International Energy Agency, https://iea.blob.core.windows.net/assets/338820b9-702a-48bd-b732-b0a43cda641b/RenewableHydrogenfromOman.pdf . These assume a plant lifetime of 25 years, electrolyser efficiency 69%, electrolyser capex $320/kWe, annual opex 3% of capex, and weighted average cost of capital 3.5-5% depending on the country.
[85] International Energy Agency, October 2024, "Global Hydrogen Review 2024", https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf
[86] Bruegel, "Lessons from the European Union's inaugural Hydrogen Bank auction", 23 May 2024, https://www.bruegel.org/analysis/lessons-european-unions-inaugural-hydrogen-bank-auction
[87] Agora Energiewende, https://www.agora-energiewende.org/fileadmin/AutomaticFiles/1466/abb-18.pdf
[88] Afry and Rina, https://afry.com/sites/default/files/2023-06/3355_afry_and_rina_joint_discussion_paper_hydrogen_pipeline_from_the_gulf_to_europe_use_case_and_feasibility_considerations_june_2023.pdf

production facilities, and the availability (or not) of hydrogen pipelines to Europe. But given the GCC's high potential for hydrogen production, the options of exports to Europe or East Asia are not mutually exclusive.

It may be possible to construct a "hydrogen-ready" pipeline from the Eastern Mediterranean to Southern Europe[89]. Natural gas pipelines exist over similar distances and water depths, and have been proposed from the East Mediterranean to Southern Europe. The principle of making natural gas pipelines hydrogen-ready has already been accepted, for instance in the case of the Gas for Gaza project. The construction or conversion of natural gas pipelines from the Maghreb to Southern Europe is also under consideration[90]. This pipeline would begin by transporting natural gas from the large fields discovered offshore Israel, Gaza and Cyprus (Egypt's gas is required domestically). It could then carry an increasing blend of green hydrogen, probably up to 20%, as it becomes available. Higher levels of hydrogen would then require a complete refit of the pipeline and compressors. A refitted pipeline has about 50% of the cost compared to construction of a new pipeline. This would be a possible way to export the region's natural gas to Europe in the short term, while remaining compatible with Europe's net-zero carbon plans in the longer term. If Israel and/or Cyprus instead opt for an LNG export solution for the gas discovered in their waters, this would lose the opportunity, as such a plant could not be converted for hydrogen exports.

Hydrogen exports by pipeline face competition from other proposals to supply Europe, such as the SoutH2 Corridor, which would run from Algeria and Tunisia to Italy, and supply Austria and Germany[91]. This has the advantage of potentially using repurposed gas infrastructure (Figure 24). The proposed hydrogen pipeline from the East Mediterranean can also connect to the Italian Hydrogen backbone as well as the Central European Hydrogen Corridor via Greece.

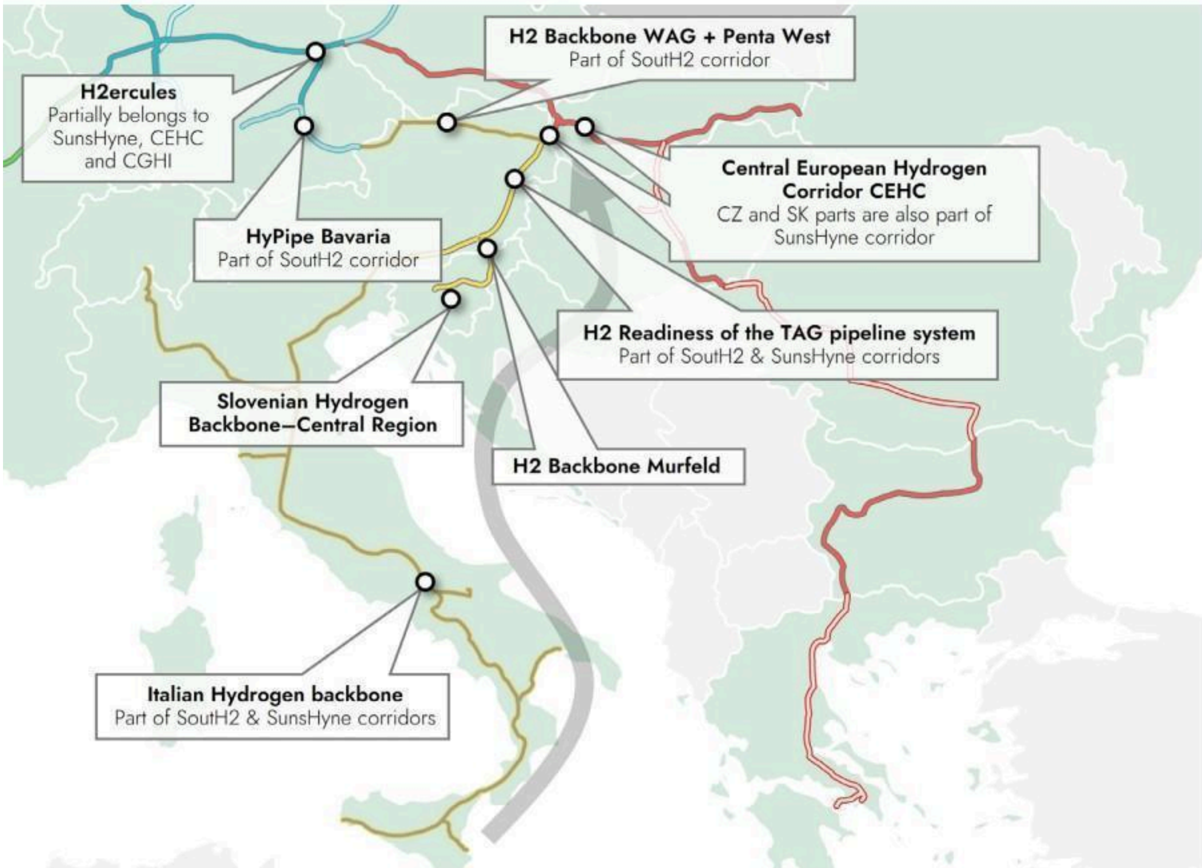

Figure 18 Proposed Southern European hydrogen pipelines

[89] e.g. Afry and Rina, https://afry.com/sites/default/files/2023-06/3355_afry_and_rina_joint_discussion_paper_hydrogen_pipeline_from_the_gulf_to_europe_use_case_and_feasibility_considerations_june_2023.pdf; A. Van Wijk, F. Wouters, "Hydrogen–the bridge between Africa and Europe", in M.P.C. Weijnen, Z. Lukszo, S. Farahani (Eds.), "Shaping an inclusive energy transition", Springer International Publishing, Cham (2021), pp. 91-119, 10.1007/978-3-030-74586-8_5

[90] e.g. European Bank for Reconstruction and Development, https://www.ebrd.com/content/dam/ebrd_dxp/assets/pdfs/green-economy-transition/EBRD_Policy_Academy._Low_Carbon_Hydrogen_Economy_in_Morocco.pdf

[91] https://enterprise.news/climate/en/news/story/551582df-445e-48c4-9e0e-b97a4ebee6cd/south2%25e2%2580%2599s-member-nations-sign-intent-agreement

The SouthH2 Corridor is intended to deliver up to 4 million tonnes of hydrogen annually, with an energy content of 133 TWh. The EU has a target of importing 10 million tonnes of hydrogen annually by 2030. The two most advanced projects to supply this are probably Neom in Saudi Arabia, with 0.2 Mt/y, and the contract between Germany's Hintco and Fertiglobe for up to 397,000 tonnes per year of green ammonia by 2033, or nearly 0.05 Mt/y of hydrogen. If the Sunrise Region targets a similar-sized project to SoutH2, it would require about 50 GW of solar PV and 15 GW of wind (or equivalent combination).

Export of hydrogen from the Sunrise Region area to Europe would probably be less economically attractive and more technically and commercially challenging than exporting electricity. However, it has the advantages of[92]:

- Developing a local hydrogen industry with associated spin-offs
- Diversifying the region's exports in product type and time (since hydrogen can be stored relatively easily)
- Diversifying the region's export markets, since, at least by ship, "green" hydrogen or ammonia could be exported anywhere, instead of being tied to a single market as by cable or pipeline
- Providing Europe with a more versatile product
- Assisting Europe in strategic diversification of fuels and feedstocks, thus helping to reduce dependence on imported oil and natural gas, not simply electrons which Europe does not import in major quantities

However, before developing major exports of hydrogen from the Sunrise Region area, it would be preferable to use it to produce "green" materials which can then be used domestically or exported more readily. These include:

- Ammonia – a fertiliser, feedstock and potential fuel for ships and power stations
- Methanol – with the addition of carbon dioxide from a biogenic or atmospheric source, "green" methanol can be used as a chemical feedstock, a precursor of olefins for the chemical industry, or a fuel for ships
- Synthetic hydrocarbons as a fuel for aircraft
- "Green" steel, using hydrogen as the reducing agent for iron ore in a direct reduced iron (DRI) plant

Producing any of these materials would contribute to local economic development and the creation of linked and downstream industries; support the aviation and maritime industries, particularly around the Suez Canal; and embed the Sunrise Region area in emerging global green supply chains. From the area of production, they can readily be exported by ship to Europe or Asia. Although per-tonne shipping costs for these materials are much lower than for hydrogen, they have a higher production cost versus traditional high-carbon methods and therefore require an end-buyer willing to pay a premium, or who is exposed to carbon pricing or tariffs. To ensure a low carbon footprint for these industries, their value chain would also have to be low-carbon, which could include, for example, the use of low- or zero-carbon shipping fuels such as green ammonia or green methanol for the tankers or carriers transporting the products.

The award of Germany's first government-backed green ammonia import contract was won by Fertiglobe, a subsidiary of Abu Dhabi National Oil Company (ADNOC)'s, in July 2024 at a delivered price of €1000/tonne (about $1050/tonne). Including conversion losses, this is equivalent to about $6.6/kg of hydrogen, of which production costs account for about $5.4/kg and transport therefore for $1.2/kg. The ammonia would be produced in Egypt. This demonstrates the competitiveness of renewable-based hydrogen from Egypt in the European market, under the current incentive schemes. For comparison, "grey" (high carbon) ammonia was selling at this time for about €400/tonne. To equal the cost of grey hydrogen, the green hydrogen production cost would have to fall to $1.4/kg, which is only likely to be achieved in the longer term (well beyond 2030). However, government subsidies and carbon prices may be able to bridge the gap in the medium term.

[92] See e.g. L. Ruseckas, "Europe and the Eastern Mediterranean: the Potential for Hydrogen Partnership", Stiftung Wissenschaft und Politik, https://www.swp-berlin.org/10.18449/2022C50v02/

3. Geopolitical Analysis

The Peace Triangle can be viewed as a helpful move to achieve "de-risking", whether political, economic, or both. For the EU, it could lend confidence to its ongoing efforts to strengthen geoeconomic and normative power in the region, while for the US, it could be an attractive deal to secure the unimpeded movement of energy, goods, and military shipments across oceans and through the Middle East. For the Gulf countries with rising influence in the region, it could offer dual benefits – helping them become an economic bridge between India and Europe and thereby becoming geopolitically relevant for the EU and the US; and, allowing them to expand independent, multi-aligned energy policies, leverage existing ties with all nations, including rivals, to shape the energy direction of the region. For India, as the spearhead of the East Corridor of the IMEC, supporting the Peace Triangle would make it a leader among developing countries, offering it geopolitical prestige and stronger relations with the Gulf countries, Israel, Palestine, the US, and the EU.

Key players relevant to the renewable energy corridor can be defined as in Table 8.

Table 11 Key players relevant to the Renewable Energy Corridor and their Classification as per Activity[93]

Classification	Main Activity for the Triangle	Key States Involved
Core Production States	Renewable Energy & Electricity Production	Jordan, Egypt, Saudi Arabia, Palestine, *Israel**
	Renewable Hydrogen Production	Egypt, Saudi Arabia
	Low-Carbon Hydrogen Production	Saudi Arabia, Egypt
Secondary Production States	Renewable Energy & Electricity Production	UAE, Oman, Palestine , Israel
	Renewable / Low-Carbon Hydrogen Production	UAE, Oman
Core Transit States	Import / Export Hubs for Renewable Energy & Electricity, and Renewable & Low-Carbon Hydrogen	Palestine , Israel, Egypt
Core Import States	Import of Renewable Energy & Electricity, and Renewable & Low-Carbon Hydrogen	EU (chiefly Greece and Cyprus initially)
Core Partner States	Peace Triangle Task Force Lead	UAE, US
Secondary Partner States	Support for the Sunrise Region	India, UK
Peripheral Focussed States	Less central but still significant focus on the Sunrise Region	Other GCC, Turkey, Iraq, China
Security Focussed States	Emergency Coordination for the Triangle	US, Lebanon, Syria

** Israel is developing renewable production capacity in the Negev desert, which could potentially connect to the Triangle as well*

For the Middle East countries, coalescing around shared goals in the form of the Peace Triangle has several reasons:

- A dissatisfaction with existing institutions such as some UN affiliated bodies in containing and resolving the ongoing multiple crises and projects on the ground
- The rising economic and political importance of non-Western powers, which seek to create their own institutions in the region, notably China and Russia, alongside the rise of "middle powers" like Turkey
- Recognition that rising to new energy and environmental challenges can benefit from new institutions, such as the International Renewable Energy Agency (IRENA), the Gas Exporting Countries Forum (GECF, who also conducts seminars dedicated to low-carbon hydrogen development), and the East Mediterranean Gas Forum (EMGF), and the Union for the Mediterranean (which includes all the relevant states other than Saudi Arabia[94])

[93] Qamar Energy Research
[94] Union for the Mediterranean, https://ufmsecretariat.org/who-we-are/member-states/

- The growing importance and awareness of energy and climate issues, and their complexity and global nature, requiring collaborative solutions. This means that existing institutions are tasked with new responsibilities. For example, the IMEC Secretariat, proposed in its Memorandum of Understanding, could take on the role related to energy connectivity and specifically to the Middle East-Europe Renewable Energy Corridor[95].

Various Middle East countries are already members of sometimes overlapping international organisations either focussed on energy or with some energy relevance, for example OPEC and the OPEC+ alliance, the Arab Energy Organisation (formerly OAPEC), IRENA, the GECF and the East Mediterranean Gas Forum. Other multinational bodies in which they are participants include the Shanghai Cooperation Agreement (Iran is a member; Bahrain, Kuwait, Qatar, Saudi Arabia and the UAE are dialogue partners); China's Belt and Road Initiative (all GCC countries are members); BRICS (the UAE and Saudi Arabia are members, as are Egypt and Iran); and now IMEC (the UAE and Saudi Arabia are founding members). Political and security cooperation are oftentimes the leading mandate of these larger multinational bodies, with energy security also rising up on the agenda recently for obvious reasons. The IMEC was largely proposed by Western countries as a counter to the BRI and BRICS, which are, if not overtly, designed to counter Western-dominated organisations, although Middle Eastern countries do not espouse this same view. Their involvement in the IMEC has no declared anti-Chinese stance and they (especially Saudi Arabia and the UAE) pursue multi-aligned foreign policies that ensure them greater autonomy and influence in international affairs.

As such, from the Middle Eastern countries' perspective, dual membership in both non-Western and Western-dominated fora places them in a unique position to leverage a rare opportunity for dialogue and development between rival partners in the region. It works away from "bloc thinking" towards more collaborative approaches. The realisation of a concept like the Peace Triangle could impact – more or less directly – almost 2 billion people in the Middle East, India, and the EU. This would also make it palatable to countries that are not directly linked to the Triangle, especially those bypassed by the IMEC route, such as Turkey, Iraq or China, among others, since it is a better prospect than perpetual war in the region. Moreover, the Triangle is at a conceptual stage for now, and even as an addition to the IMEC is not yet set in stone, meaning that an inclusive process remains very much possible.

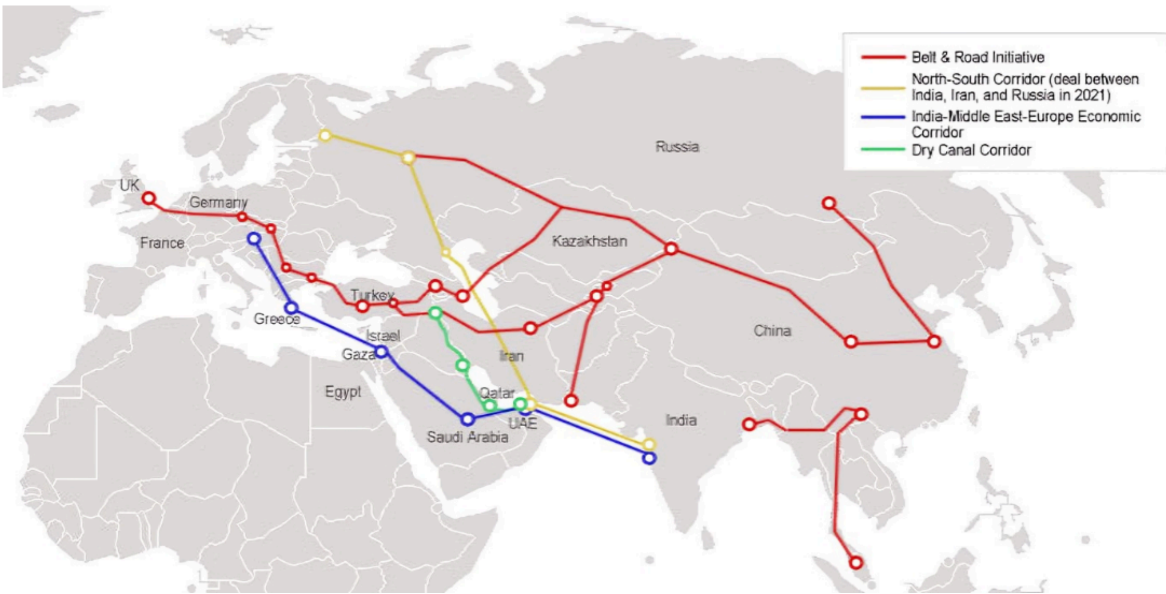

Figure 19 Selected geopolitical interconnectivity initiatives

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[95] King Abdullah Petroleum Studies and Research Centre, "India-Middle East-Europe Economic Corridor (IMEC)", 2 October 2023, https://www.kapsarc.org/wp-content/uploads/2023/10/KS-2023-II11-India-Middle-East-Europe-Economic-Corridor-IMEC-Bridging-Economic-and-Digital-Aspirations.pdf

Actors relevant to the Peace Triangle have a unique opportunity to make connectivity a vessel for sustainable peace in the region. They are more than the sum of their development banks and agencies, or that of their partner investors in the private sector. Collaborative efforts around renewable energy export call for the aggregation of participating countries' resources as an act of diplomacy, for the sake of shared geopolitical interests. These interests lie in the promise of resilient and efficient supply chains, safe from their potential weaponisation by rival powers. By reaching agreement on utilising energy resources for diplomacy, a conclusive solution to ending political and armed violence around the Peace Triangle will be within better reach. Redoing the diplomatic homework by utilising energy is therefore unavoidable. On the bright side, it is also an opportunity to make sounder plans.

As a practical matter, a large part of the required equipment – solar systems, wind turbines, HVDC cables and converter stations, batteries, and hydrogen electrolysers – will be sourced from China, at least in the short and medium term. This will be essential for delivering the project at reasonable cost, scale and timeline. This supply chain security, the impact of possible restrictive trade measures and disruptions, and the willingness of the EU and US to move closely with Chinese suppliers, has to be carefully considered. In the longer term, such a large project can be the catalyst for building out much more green manufacturing in the host countries and the EU.

3.1 Short-term Reconstruction and Confidence Building Opportunities

In the next three sections (3.1-3.3), a variety of projects and initiatives will be discussed which could provide the basis for opportunities for reconstruction as well as confidence building measures.

1. The resumption of electricity supply to Gaza as an initial first step could have a swift, positive impact by providing some stability to the region and helping address the severe desperation, poverty, and illness in the Gaza Strip. Israel could facilitate initial efforts to revive an energy supply, providing initial electricity and gas supply, after which it could support the rebuilding of the Gazan power sector by enabling grid expansions with the core production states of Egypt, Saudi Arabia, and Jordan. This could include the revival of Project Prosperity with the re-inclusion of Palestine. These countries are ideally situated for the building of connectivity that can enhance Palestinian energy resilience in the future by fostering closer cooperation between all involved parties – i.e. Israel, Palestine, Jordan, Egypt, and Saudi Arabia. Israel would be a prominent facilitator of any Gazan power sector reconstruction efforts, given the realities of geography, and the reliability of its past supply compared to countries like Egypt, who have often struggled to provide small amounts of electricity on time to Palestine due to their own power shortages. But in the longer term, Israel does not want to be responsible for the supply of energy to Gaza, so a mix of increased self-reliance (including all of Palestine), plus connectivity to the neighbouring states, is a preferable goal.

   Such reconstruction could involve direct Israeli efforts to rehabilitate the Palestinian power sector (for example on the Jenin Powerplant and Gas for Gaza (G4G) projects) through increased feedstock supply in the form of Israeli gas originally, and once developed, from the Gaza Marine project– which would go through Egypt or Israel to Gaza – to encourage Palestinian energy security. In any region, with or without war, an investment in connectivity that secures new and large volumes of energy can reshuffle the political, economic, and social status quo of the recipient, as well as its security climate.

2. Support for the renewable energy corridor's aims could also unlock potential for support on other non-renewable energy-related aspirations of the Peace Triangle by convening the Eastern Mediterranean's main gas producers and consumers, including Egypt, Cyprus, Israel, Jordan, and Palestine, as well as France, Greece, and Italy, with the US, the EU, and World Bank as observers. By bringing together conflict-prone actors such as Israel and Palestine, progressing regional reconstruction efforts on the basis of energy development will provide Israel and Palestine the opportunity to continue cooperating in the development of projects such as the Jenin Powerplant and the Gas for Gaza (G4G)[96] projects, supported conceptually and financially by the US and EU, and a MENA Task Force led by the US and the UAE[97]. These initiatives, focussed both on domestic consumption and exports, will connect Gaza and the West Bank to Israel's natural gas system, leveraging the Israel Natural Gas Lines' (INGL) current capabilities in hydrogen

[96] For more information on G4G contact the Palestinian Energy Authority in Ramallah or for a recent analysis (including illustrative maps) see: An energy and sustainability road map for the Middle East - Atlantic Council
Other relevant parties include Israel and international financial and/or political support to date came from the EU, Qatar, the Dutch Government and the US
[97] For more information and a recent analysis on the proposed structure for a Task Force platform to drive tangible cooperation on energy, climate and peace-related issues in the region, see: An energy and sustainability road map for the Middle East - Atlantic Council

delivery by creating opportunities for additional hydrogen-ready pipelines. The gas will likely come originally from Israeli offshore gas fields, but eventually from Gaza Marine field, once it is developed. Eventually, natural gas in these pipelines will be fully replaced by some combination of hydrogen, low-carbon synthetic natural gas (SNG) and renewable natural gas or biomethane (RNG).

The Arab Gas Pipeline was established in 2001 to facilitate gas supplies between Egypt, Jordan, Syria, and Lebanon, with the ultimate hope of connecting to Turkey. It currently operates between Egypt and Jordan, with work to revive the section through Syria to Lebanon. A 65 km, 36” pipeline is under construction from kibbutz Neve Ur on the Israel-Jordan border to connect to the Arab Gas Pipeline near Mafraq in Northern Jordan. Inside Israel the pipeline extends 23 km from the border with Jordan to near kibbutz Dovrat in the Jezreel Valley where it connects to the existing Israeli domestic natural gas distribution network. The Jenin Powerplant and G4G projects are planned to be connected to the Israeli network. These connections can provide additional supply options to Gaza for short- and medium-term needs. Utilising existing Arab Gas Pipeline infrastructure, even if not entirely used, could potentially lower costs by reducing required construction, compared to completely new gas pipeline infrastructure.

In the medium and longer-term, hydrogen could be supplied from Israel, and the core production states of Saudi Arabia and Egypt in the future, and possibly the UAE and Oman (as secondary production states), with surplus directed for export to Europe. The likely timeframe for this would be 2030+, although some hydrogen might be available from Saudi Arabia’s Neom project, and from Egyptian projects, earlier. Initial volumes would plug-in into the Israeli gas network retrofitted to carry hydrogen blends (for example, the gas pipeline to Jenin Powerplant and Gaza are designed to be hydrogen ready for up to 30% capacity) from Saudi Arabia and Egypt, while comprehensive terrestrial and underwater hydrogen infrastructure is constructed from Israel and Gaza towards South-East and Central Europe.

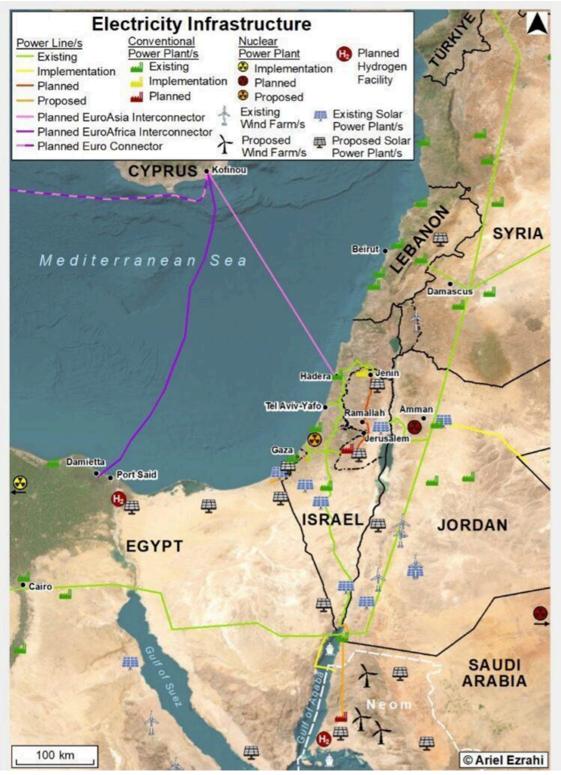


Figure 20 Electricity infrastructure in the Peace Triangle, including proposed infrastructure for low-carbon electricity cross-border trade[98]

Figure 21 Gas infrastructure in the Peace Triangle, including proposed infrastructure for the G4G project, and to enable low-carbon hydrogen cross-border transport[99]*. Please note this map has been adapted from the original map published by the Atlantic Council, in order to show Gaza as an additional possible* H_2 *export hub.*

[98] Ariel Ezrahi, “An energy and sustainability road map for the Middle East”, Atlantic Council, November 2024, https://www.atlanticcouncil.org/in-depth-research-reports/report/an-energy-and-sustainability-road-map-for-the-middle-east/
[99] Ariel Ezrahi, “An energy and sustainability road map for the Middle East”, Atlantic Council, November 2024, https://www.atlanticcouncil.org/in-depth-research-reports/report/an-energy-and-sustainability-road-map-for-the-middle-east/

3.2 Balancing Regional Powers in the Mediterranean and Beyond

1. Countries like Turkey and Lebanon might be eventually further down the line inclined to support the Peace Triangle, even if not directly connected to it. With the Lebanon-Israel maritime deal having been reached, it would make sense for Lebanon to participate, not least to foster energy cooperation across conflictual borders. The political position of post-war Syria remains unclear, but it is desperately short of energy and may be open to a constructive role in the concept. The Triangle could also support a more active role by the US in settling issues between both Israel and Lebanon, as well as with others in the region that do not have diplomatic relations. For example, finding a way to integrate Turkish support into the broader Peace Triangle would be an important step in resolving outstanding disputes in the Eastern Mediterranean, as well as improving Turkish relations with Israel. Turkey has already stated that the IMEC cannot exist without it [Turkey][100], so involving it in the Peace Triangle could play a significant role in driving forward and coordinating South Asia to Europe interconnection efforts, such as hydrogen pipelines from the Levant to Europe. Additionally, enhanced electricity connectivity could include Turkey. Onshore connections of electricity or hydrogen to Turkey would have to run through Syria (or Iraq), while offshore links would have to traverse maritime areas of the Republic of Cyprus (or, Lebanon and Syria).

2. Saudi Arabia and the UAE have the opportunity to be a balancing act between Western powers and China, Russia, and Iran in the region. While the US views Beijing's geoeconomic gains in the Middle East as a challenge to Western interests, the UAE and Saudi Arabia see their relationships with the West and China as "a positive-sum game". This difference in how Washington and the Arab states view China may offer opportunities to establish the renewable energy corridor as a bridge with other under-development corridors in the region like the BRI, whose entry point into Europe is Greece, similar to the IMEC. Additionally, China's state-owned China Ocean Shipping Company is the majority stakeholder in the Port of Piraeus, while the UAE's Masdar and ADNOC have several energy projects under development in Greece, which can encourage closer cooperation on building common energy infrastructure and supply chain resilience.

3.3 Progressing Sustainable Conflict Resolution

- The Peace Triangle provides the EU an opportunity to progress a sustainable conflict resolution along with partners like India, the UAE, and Saudi Arabia. It can reassert its geopolitical power, not just because of France, Italy, and Germany's compiled geopolitical clout, but because it can coordinate a proprietary approach. This approach could be value-based in practice, as has been the case for EU-supported conflict prevention and resolution, in Europe and around the world, making it once more the proactive face of peace, with benefits to both EU internal politics and the EU's external credibility.

  Through the Triangle, it could show unity and reinvest – both diplomatically and financially – in its "Southern Neighbourhood" and the Mediterranean through a project not limited to the sole purpose of sourcing energy flows. It could bring forward plans for shared infrastructure and networks embedded with EU foreign policy imperatives of promoting peace and international security, democracy, the rule of law, human rights and freedoms, and climate change mitigation, which are also among official key principles of the EU Global Gateway.

  This offer will have a role to play in the Triangle's design, governance and implementation – all while working together with several non-democratic partner governments. Moreover, efforts to resolve the Cyprus issue between Turkey and the Republic of Cyprus could create opportunities to commercialise Cypriot gas in the Turkish market, fostering energy infrastructure cooperation, including hydrogen-ready gas pipelines and electricity cables towards mainland Europe via Greece, while benefiting all parties involved.

[100] Nova News, "India-Middle East-Europe economic corridor, Erdogan: "It cannot exist without Turkey"", September 2023, https://www.agenzianova.com/en/news/economic-corridor-india-middle-east-europe-erdogan-cannot-exist-without-turkey/

- Meanwhile, Iran's longstanding geostrategic rivalry with the GCC states lingers despite the current détente between Tehran and Riyadh brokered by China in 2023. Still, the fall of Bashar al-Assad in Syria has cost Iran a long-time ally, often described as a lynchpin of Tehran's regional strategy, with its financial and military capacity significantly diminished to undertake further militant activity in the region. This has now been augmented by the recent conflict involving Israel and the US which has significantly weakened Iran militarily (although there are surfacing doubts as to the fate of their nuclear program) as well as politically. As such, this might open an opportunity for new dialogue with a weakened Iranian state – possibly brokered by the GCC states – and perhaps a new deal with the US. This can also ultimately apply once the bigger political / nuclear, the ballistic missiles program and proxy issues have been agreed to other domains such as support for the Peace Triangle's objectives. It is not contemplated that Iran would be part of this proposal, as that would require at the minimum a major diplomatic realignment. However, it is possible that a weakened Iran / and or following upcoming negotiations with the US, may reach an understanding with the GCC and the US so that it would at least not actively obstruct economic initiatives such as the IMEC or the Middle East-Europe Renewable Energy Corridor, and so that it would have deeper trade, including some energy cooperation, with the GCC and possibly India.

  Iran could lose large portions of trade that pass through the Strait of Hormuz chokepoint if it were to play a spoiler, given that the UAE is already rapidly expanding its Fujairah Terminal in the Gulf of Oman as an alternative. Additionally, India is investing in the Iranian Chabahar Port, one of the only few foreign investments remaining in the Islamic Republic, which it will be compelled to retain by remaining neutral to the objectives of the Triangle, given that India is the main origin point of the IMEC's East Corridor.

- Additionally, incorporating Gaza as an export node of clean energy in the **r**enewable energy corridor, alongside Israel, offers a unique opportunity to align regional security interests with economic development and stability-building, and achieve potentially full normalisation of ties between Arab countries and Israel. However, it also requires careful consideration of differing perspectives. From Saudi Arabia's perspective, any movement towards normalisation – particularly through initiatives like the Peace Triangle – will be contingent upon ensuring Palestine's stability and the realisation of a two-state solution.

  If Gaza is integrated into the clean energy network, supported by investments from Saudi Arabia, Egypt, Jordan, and the EU, it would create a sense of regional cooperation. However, this must be done in a way that ensures Palestinian stability and prosperity while also taking Israeli security concerns into account. Renewable energy and hydrogen investments could serve as a cornerstone of the wider reconstruction and development process in Gaza, enabling the territory to prosper while contributing to not only regional needs, but also European needs. These investments need to be framed within the larger context of a viable two-state solution and a long-term peace agreement.

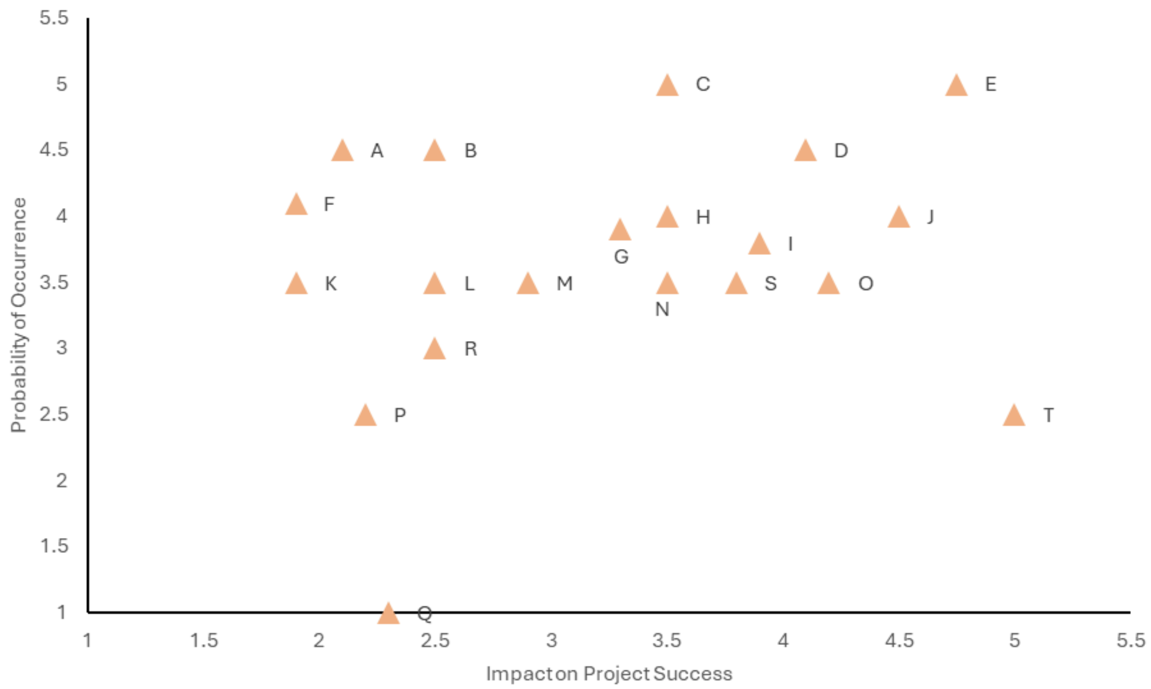
  From a practical standpoint, both the Middle Eastern states and European countries will want to have core economic and security interests at stake to ensure the success of such a plan. Europe, as the key consumer market for renewable energy, would have a vested interest in ensuring the success of clean energy exports, for economic and environmental reasons and to safeguard critical cross-border energy infrastructure. The involvement of European countries helps create a sense of mutual responsibility, making it more likely that all parties will work together toward lasting stability.

  Furthermore, the collaboration between Middle Eastern countries and Europe to support Gaza's integration into the renewable energy corridor could help prevent the rise of extremist forces in the region. By creating economic opportunities, improving living conditions, and fostering a sense of hope and regional cooperation, this energy initiative could mitigate some of the conditions that fuel extremism. Securing this political foundation will therefore be essential for ensuring that the corridor's energy initiatives can contribute effectively to long-term stability and peace in the region.

Table 12 Benefits and Interests for Each Participatory State in the Corridors

Opportunity **(Benefits / Interests)**	Main Beneficiaries **(Participatory States)**
Restored Energy Access	Palestine (Gaza)
Renewable Resource Development	Palestine, Israel, Jordan, Egypt, Saudi Arabia
Natural Gas Resource Development	Palestine (Gaza), Israel, potentially Lebanon
Investments in Renewable Project Infrastructure	Palestine, Israel, Jordan, Egypt, Saudi Arabia
Investments in Hydrogen Project Infrastructure	Palestine, Israel, Jordan, Egypt, Saudi Arabia
Investments in Infrastructure	Palestine, Israel, Jordan, Egypt, Saudi Arabia
Energy Security and Stability	Palestine, Israel, potentially Mediterranean States, Levant
Regional Integration	Palestine, Israel, Syria, Lebanon, Iran (?)
Transmission / Transport Tariffs	Palestine (Gaza), Israel, Jordan
Energy Supply Chain Development	Palestine (Gaza), Israel, Jordan, Egypt
Economic diversification	Saudi Arabia, potentially other GCC (UAE?)
Diplomatic Prestige	Saudi Arabia, UAE, Egypt, Jordan, Israel, US, EUI

Figure 17 provides a political risk assessment of the factors that could impact the realisation of the renewable energy corridor and Peace Triangle concepts.



A	Fluctuations in energy prices drive up energy costs
B	Israeli military presence beyond its borders in Palestine, Syria, and Lebanon
C	Multilateral peace plans take longer-than-expected to materialise
D	EU focus distracted by Ukraine reconstruction
E	Limited progress on IMEC casts shadow on project realisation
F	Houthi attacks / skirmishes continue in Red Sea
G	Israel-Saudi relations not normalised
H	Project financial burden not equitably balanced between partners
I	EU capability to lead project undermined by internal differences
J	Unresolved Israeli-Palestinian conflict
K	Smaller GCC members object to not being included
L	Russian resistance as project may impede sanctions-evading route through Iran
M	Opposition / resistance by Egypt if not included in IMEC
N	Project fails to move on from "political or ideological venture"
O	New US administration faces challenges in addressing the complexities of Middle East energy politics
P	Undefined modus operandi for project displeases China, Russia
Q	Middle East trade geography centre moves to Haifa from Suez Canal
R	Exacerbated East Med tensions if Turkey not included in IMEC
S	US lowers commitment to project as it views the BRI directly competing with IMEC
T	Absence of robust security frameworks in the region

Key / Legend		
Impact on Project Success		
	1	Negligible
	2	Minor
	3	Moderate
	4	High
	5	Very High
Probability of Occurrence		
	1	Unlikely
	2	Possible
	3	Likely
	4	Highly Likely
	5	Certain

Figure 22 Chart and Table of Political Risk Matrix of Factors that could impact the Realisation of the renewable energy corridor and Peace Triangle Concept

4. Environmental Analysis

The proposed renewable energy and renewable hydrogen export arms of the Peace Triangle via the renewable energy corridor will provide a clean and sustainable alternative to conventional fuels used currently in the most energy-compromised regions. This should reduce greenhouse gas emissions and air and water pollution. However, several social and environmental risks need to be considered. As green hydrogen is still an emerging and particularly young technology, a fuller socio-economic and environmental impact assessment is required to understand its development and market potentials to meet the goals of the Triangle. National and European regulations and bank financing criteria would also insist on robust social and environmental impact assessments and mitigations prior to approval.

The environmental risks associated with the green hydrogen economy in local and regional contexts have been receiving increasing attention over the last few years, as well as their relationship with socio-economic developments, thereby implicitly and explicitly touching upon renewable hydrogen's impact on employment creation and fostering industrialisation. In particular, water stress and water scarcity have been identified as "environmental impacts of very high concern", followed by land use challenges, hydrogen leakage, and biodiversity and marine life impacts. The indirect environmental consequences of the project also need to be assessed. These include greenhouse gas emissions and other pollutants in the supply chain, the resource use (including mining and processing of input minerals), and the ultimate responsible decommissioning of obsolete solar panels, wind turbines and batteries.

1. **Water Scarcity**
   In the Middle East region, where water stress is already high, the availability and quality of water resources are paramount for the efficient and sustainable production of green hydrogen. Water is also a vital resource for numerous sectors, including agriculture, industry, and households. Balancing these competing demands will be crucial for the Peace Triangle countries to avoid exacerbating existing water scarcity issues. While these countries are ideal for renewable energy production and renewable hydrogen production, they do not have abundant water resources. This geographic misalignment can pose challenges for the aims for the Peace Triangle in areas where water scarcity is already a concern if not managed properly.

   To mitigate water scarcity issues, members of the Triangle – particularly core production states – should embed their local contexts (including the current and future water cycle), the geology, and climate values within national and perhaps regional water and land management strategies as part of the plan to establish the Triangle's renewable energy and green hydrogen export arms. The renewable energy and electricity export projects would not require significant amounts of water. However, a hydrogen project of a similar scale to SoutH2, i.e. 4 million tonnes of hydrogen per year, would need 20-30 litres of pure water per kg[101], or 80-120 million m^3 of water annually. For comparison, Israel's current desalination, supplying about a quarter of its water use, is 585 million m^3 per year, and Saudi Arabia's is about 2900 million m^3. A large proposed hydrogen project therefore represents a material though not insurmountable addition to regional desalination requirements, and would require careful management of siting, water withdrawal and discharge.

   Technologies such as seawater desalination and air-to-water generation can offer potential solutions to mitigate water scarcity risks associated with green hydrogen production, though air-to-water technologies are still at an early stage and not yet at the scale required to support independent green hydrogen production. Desalinated water is not a major cost element for green hydrogen (about 2% of total cost); therefore, desalination is an economically practical solution. Additionally, choosing hybrid systems can also lower the water impact of hydrogen technologies, such as electrolysers, as they may be easier to retrofit with water recovery systems, such as condensation or filtration systems that allow the water used in the electrolysis process to be recycled and reused. Companies like Siemens and Hydrogenics have worked on integrating water recovery systems into their electrolysis units to increase efficiency and reduce water usage. Electrolysers under development may be able to function directly on seawater.

   These efforts will be supported by countries with existing, well-established water management strategies, such as Israel, which has advanced desalination and water recycling programmes, or the UAE, which has developed a robust Water Security Strategy with local context-relevant water conservation practices and policies in place. Additionally, the EU, through funding mechanisms like the Horizon Europe Programme

[101] RMI, https://rmi.org/hydrogen-reality-check-distilling-green-hydrogens-water-consumption/

(Water4All), can support better water management for the Triangle, drawing from experience in addressing water scarcity in regions like southern Europe and the Mediterranean. The EU's LIFE Programme has also provided funding for projects focused on sustainable water use and climate adaptation, which could help support water management strategies in the Triangle countries.

2. **Marine Impacts**
   Brine management technologies can reduce concentrated brine and chemical discharge from desalinated water production for green hydrogen that impacts marine environments. Continuous discharge or leaks into water bodies may represent an immediate danger to aquatic life, with subsequent impacts on the livelihoods of communities depending on it. Mandates to adopt appropriate waste management practices and the implementation of measures to prevent contamination and reduce water consumption can be developed in collaboration with EU states – for example Norway – which have strong regulations in place for waste management in marine environments, or the US, where independent states – such as southern California – have successfully integrated brine management into their coastal protection strategies. In Israel, special monitoring requirements are required for brine disposal pipelines[102], lessons from which could be integrated with strategies developed by the Triangle to mitigate marine impacts.

3. **Land Use & Biodiversity Impacts**
   Land requirements of renewable energy and green hydrogen production projects could additionally potentially encroach upon natural habitats and agricultural areas, posing risks to biodiversity and food security. As shown, the required area of land for the renewable energy installations is only a small part of the total area of interest, and sensitive areas can therefore be avoided. Almost all of the core and secondary production states are desert lands that are typically sparsely inhabited and non-arable, although they have populations of endangered species. Moreover, land use changes entailed by large-scale renewable farms and desalination and hydrogen production stations may imply the loss of natural buffer areas such as mangroves that mitigate the effects of natural hazards such as flooding, landslides, and fire resulting in increased vulnerability. The Rift Valley-Red Sea corridor is the second-most important flyway for migratory birds worldwide (Figure 29), and renewable energy sites will therefore need to be chosen and designed to avoid interference or harm. Experience in mitigating harm to migratory birds has been gained with projects such as the EBRD-funded Gulf of Suez Wind II farm[103], and AI systems may also be helpful[104].

[102] Water Resources and Industry, "Governing desalination, managing the brine: A review and systemisation of regulatory and socio-technical issues", December 2023, https://www.sciencedirect.com/science/article/pii/S2212371723000252
[103] EBRD, "Gulf of Suez Wind II", https://www.ebrd.com/work-with-us/projects/psd/51509.html
[104] R. Szkutak, "Spoor uses AI to save birds from wind turbines", 16 May 2024, Techcrunch, https://techcrunch.com/2024/05/16/spoor-uses-ai-to-save-birds-from-wind-turbines/

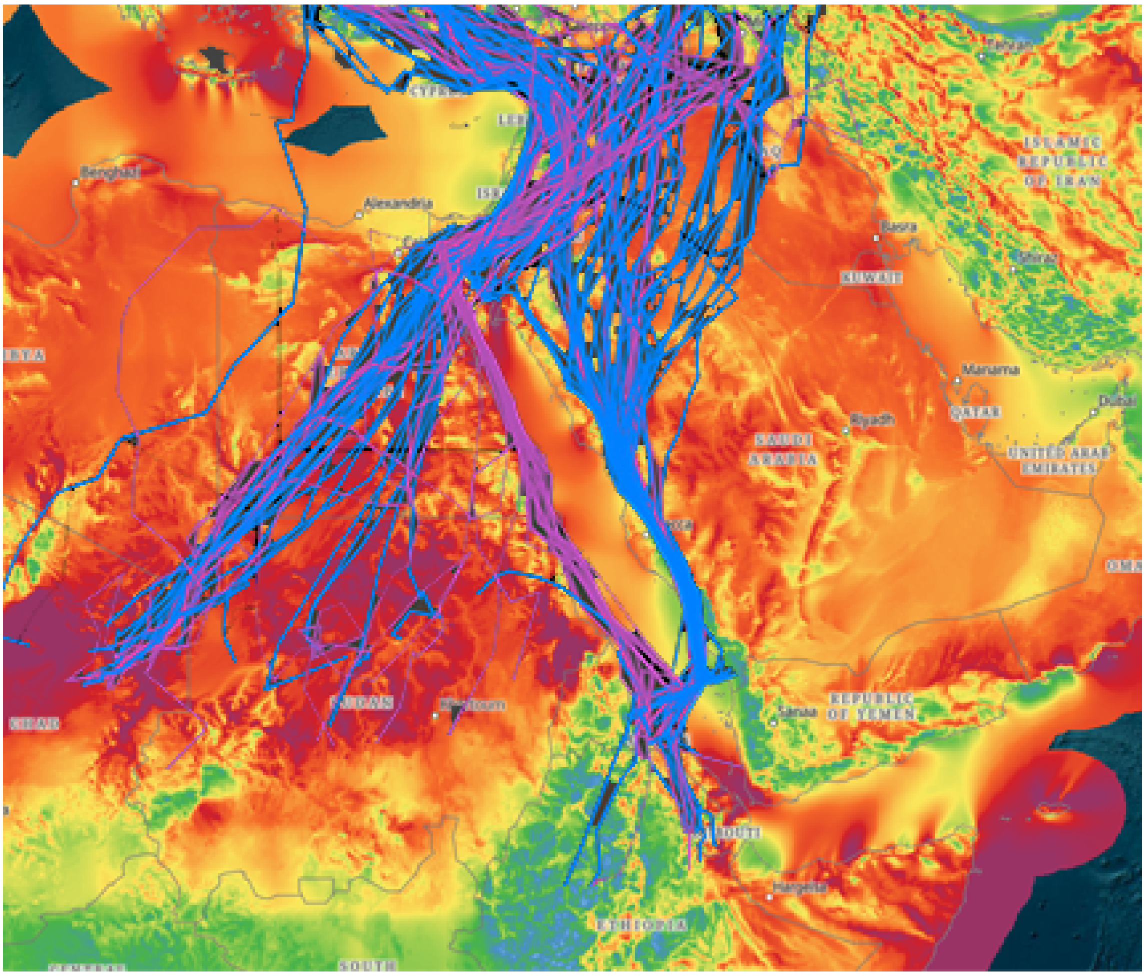


Figure 23 Bird migration routes against wind potential of the Sunrise Region area (purple lines indicate spring migration routes, blue lines winter migration routes); the Middle East region is a bird corridor for many winged species[105]

The sites selected for renewable and green hydrogen production in the core production states are well away from areas designated for urban development or areas with competing land-use priorities, such as residential or commercial zones. However, this may change, since urban peripheries are usually ideal locations for large-scale green energy developments due to their proximity to urban centres and industrial zones. Because urbanisation often involves the expansion of cities, construction of residential and commercial buildings, infrastructure development, and transportation networks, competing interests may arise between allocating land for renewable energy generation for green hydrogen production and land required for residential and commercial sectors if not properly planned for.

To ensure biodiversity and wildlife are protected, and land use risks are minimised, core production states should undertake inclusive planning processes, effective land-use policies, and stakeholder collaboration. For example, combining solar panels with agriculture, for example, could create a symbiotic relationship where the shades improve yield and reduce water use. Simultaneously, plants contribute to the cooling of the panels, increasing their efficiency. Adopting sustainable practices, conducting thorough impact assessments, and incorporating community input can contribute to the successful integration of green hydrogen projects while minimising negative consequences on land use.

The subsea electricity and hydrogen pipelines will need to be assessed for their impact on the marine environment, including the lesser-known and vulnerable deep sea. Dredging and trenching will be required.

[105] Qamar Energy Research, with data from https://www.frontiersin.org/journals/ecology-and-evolution/articles/10.3389/fevo.2019.00323/full

4. **Leakage of hydrogen and derivatives**

Hydrogen is an inherently light and reactive gas. Its small molecular size allows it to escape from containment systems more readily than other fuels during production, conversion, storage, transport, or application. In addition to this unintentional leakage, hydrogen can also be intentionally leaked through operational purging and venting, or by conflict, theft, or sabotage.

Although hydrogen is non-toxic and disperses rapidly in the atmosphere, its release can have an indirect global warming effect by extending the lifetime of other GHGs, offsetting GHG emission reduction gains by switching away from fossil fuels. The global warming potential of hydrogen is estimated at about 37 (relative to carbon dioxide) over a 20-year horizon, reducing to 7.1-9.3 over a 100-year horizon, the more appropriate one for long-term climate policy. While this appears relatively high (methane's GWP is 81 over 20 years and 27-30 over 100 years), it should be recognised that hydrogen has almost three times the energy content per tonne of methane.

Moreover, the risk of leakage is not just for hydrogen but also its derivatives like ammonia, which is a toxic and reactive gas. Leakages in the ammonia value chain could release reactive nitrogen, which has detrimental effects for air quality, human health, ecosystems, and climate. Maritime and pipeline transport of ammonia are well-understood, mature technologies with a generally good safety record. However, the major scale-up of ammonia transport from the East Mediterranean would require proper attention to maritime safety, training and precautionary measures. The combustion of ammonia, whether in power plants or ship engines, can generate nitrogen oxides which contribute to acid rain, so proper engine operations and pollution controls are required. To mitigate the risk of leakage, Triangle members should share best practices and lessons learned with each other on robust containment and safety measures implemented throughout the hydrogen value chain, from production to end-use applications. This includes the use of high-integrity storage and transportation systems, leak detection technologies, and emergency response protocols to minimise the likelihood of hydrogen release and hence mitigate its consequences. For example, recent research on reducing leakages in prior gas pipeline infrastructure points to the usage of hydrogen blends (up to 20% volume) instead of pure hydrogen to reduce leakage potential[106]. This is a possible intermediate step, though eventually 100% hydrogen use will be required.

Secondly, they should establish comprehensive monitoring and reporting mechanisms to accurately track and quantify hydrogen leakage rates. By identifying and addressing sources of leakage promptly, stakeholders can minimise environmental impacts and optimise the efficiency of green hydrogen production systems. Finally, research and development efforts should focus on advancing hydrogen storage and transportation technologies to enhance containment and minimise fugitive emissions.

5. **Material Use**

A large renewable energy and transmission project such as that proposed here requires significant material inputs. These have a corresponding impact via the land use disruption, energy input, greenhouse gas emissions and other pollutants required to mine or recycle and process the inputs. Table 6 shows indicative figures for the material input for each 10 GW phase of export. This is compared to the International Energy Agency's forecast for total 2035 demand for that mineral.

[106] OECD, 2023, from PBL Netherlands Environmental Assessment Agency, "The Green Hydrogen Dilemma: The risks, trade-offs, and co-benefits of a green hydrogen economy in low- and middle-income countries", July 2024, https://www.pbl.nl/system/files/document/2024-07/pbl-2024-the-green-hydrogen-dilemma_5534.pdf

Table 13 Material inputs

Mineral[107]	12 GW wind **(t)**	15 GW solar **(t)**	33 GWh battery **(t)**	10 GW cable, 2100 km **(t)**	Total **(kt)**	% of IEA's 2035 demand projection[108]
Copper	34800	42330	11000	510090	598.22	1.8%
Nickel	4848	15	15950	0	20.813	0.4%
Graphite	0	0	28600	0	28.6	0.2%
Lithium	0	0	3300	0	3.3	0.4%
Rare earths	168	0	0	0	0.168	0.1%
Cobalt	0	0	4400	0	4.4	1.1%
Silicon	0	59220	0	0	59.22	NA
Zinc	66000	450	0	0	66.45	NA
Manganese	9360	0	5500	0	14.86	NA
Chromium	5640	0	0	0	5.64	NA
Molybdenum	1188	0	0	0	1.188	NA
Others	0	480	0	0	0.48	NA

The assumptions used here are pessimistic, as they assume 2020 levels of material input. Material efficiency will improve, and scarcer materials will be designed out. For instance, in the longer term, cobalt-free batteries can be used, lithium-ion can be replaced by sodium-ion or other chemistries, and copper can to some extent be replaced with aluminium. Recycled materials can be used wherever possible. Nevertheless, it can be seen that the required mineral use per phase is quite trivial in the context of global use, and is mostly dominated by the cable (for copper). Materials should be responsibly sourced, meeting appropriate EU environmental and social standards for their extraction and supply chain. Consideration should be given at an early stage to the ultimate decommissioning, replacement or repowering of the system, including re-use, recycling or responsible disposal of the wind turbines, solar panels, batteries and other components, to ensure design decisions today consider the full material life-cycle.

[107] Individual per-unit inputs from https://www.visualcapitalist.com/sp/visualized-how-much-metal-is-used-in-clean-energy-technology/, https://elements.visualcapitalist.com/the-key-minerals-in-an-ev-battery/
[108] International Energy Agency, Announced Pledges Scenario, https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer

5. Conclusions, Recommendations and Further Work

The next steps can be divided into the **planning** phase (Years 0-1), **design and approval** (Years 2-3), **initial implementation** (Years 4-8) and **operations** plus further implementation (Year 9 and beyond).

5.1 Planning Phase

- **Advocacy and Engagement**
  - Secure the required high-level political support from the producing countries, the transit countries, the importing (European) countries, and the extra-regional countries (GCC, EU, US, India).
  - Engage systematically with relevant stakeholders from government, business and civil society in the Sunrise Region, the transit and importing countries, Turkey and Europe.
  - Begin preliminary engagement with key social and environmental stakeholders, including local communities, potentially impacted business communities (e.g. fishing, tourism), and environmental NGOs.
  - Communicate and publicise the concept.
- **Strategy**
  - Confirm the overall concept. Devise a full forward plan for the next phase of more detailed studies, including personnel and funding.
  - Define a governance structure, and whether the initiative would have a new organisation, one located within an existing body (e.g. IMEC, Union for the Mediterranean), or a collaboration.
  - Identify interested investors, including public and private sources, and which part(s) of the project each would be involved in.
  - Understand and identify the key funding bodies and support mechanisms available from the EU and other stakeholders.
  - Identify the key laws and regulations applicable in the EU and the exporting countries, and ensure the project would be compliant (for example, as regards the certification and qualification of green hydrogen and renewable electricity; the presence of tariffs and the effect of free-trade agreements).
  - Delineate the three planned export nodes (Egypt, Palestine - Gaza, Israel), whether they would be developed simultaneously or consecutively, and whether the export cables and pipelines would follow the same route, would converge on a junction (e.g. offshore or on Cyprus), or would run different routes. Determine whether the renewable sites in the Sunrise Region would be connected directly to the local grids in Jordan, Palestine and Israel.
- **Techno-Economic Analysis**
  - Firm up the planning for renewable and hydrogen production sites. Examine numerous candidate sites, incorporate data over multiple years, and include realistic constraints on siting (mountains, urban areas, environmental reserves, military sites and so on). Examine rights of way for electricity lines from these sites to the importing countries and the export nodes. Determine realistic candidate locations for hydrogen production sites, including the provision of desalinated water.
  - Develop a more detailed and realistic economic model for the interconnectors, including the value of reverse flow when European power prices are low or negative; and the average price captured by the interconnector, given the noted negative correlation between renewable generation in the Sunrise Region versus Europe, especially Germany. Integrate other relevant economic aspects such as taxation, hedging/forward power sales.
  - Analyse more deeply the relevant power markets, in the Sunrise Region, the importing and transit states, and the relevant European markets, including the long-term outlook for electricity demand, supply, changes in demand patterns, the costs and scale of new domestic generation (renewables, nuclear and other), the required grid reinforcement at entry points, and other relevant interconnections.
  - Integrate the hydrogen export plan with Europe's hydrogen strategy, including the scale of demand, timing and phasing, fiscal incentives, planned infrastructure in the receiving countries, sectors of demand, and form of hydrogen required.

- Identify who the potential offtakers for electricity and hydrogen would be, locally and in Europe, and what likely conditions they would offer (including price levels, contract length, and demand guarantees).
- Establish a credible timeline and logistic plan for the various phases of the project, including the stages at which individual components would be operational and creating value. Consider other potential optimisations or sources of value, for instance co-location with telecommunications cables, or co-production of desalinated water for local uses. Allow adequate time for consultation, approvals, obtaining financing, and building the required supply chain.
- Integrate the techno-economic plan with a financing plan, including a realistic balance of public funds, private finance, multilateral development finance, export credits and other sources. Devise a schema for the corporate entities or SPVs required for each part of the project and in each country.
- Consider the security aspects and risks to the project's infrastructure, onshore and subsea, the main threats and how they could be mitigated. This is important in view of recent apparent sabotage of undersea cables and pipelines[109].
- Deepen the analysis of the broader regional economic impact, specifically: a) supply chain development, e.g. the contribution of local businesses, existing and new, to the project, and the potential to set up suppliers such as cable manufacturing; b) the supply of renewable energy and hydrogen to local industries such as metals processing, chemicals, plastics and others.

- **Political Analysis**
  - Develop the political and stakeholder analysis. Specifically, consider the role of Turkey, whether it would be a blocker or barrier to the proposed project, and how Turkish interests might be accommodated in the final realisation of the project.
  - Define the specific roles of the key outside stakeholders, in particular the EU, India and US (with the latter, it will be important to monitor how US Middle Eastern policy develops, and the impacts this can have both positively and negatively on this analysis).
  - Consider what security and investment guarantees could be available from participating states and external stakeholders.
  - Consider the potential role of other neighbouring countries, dependent on political developments, including Syria, Lebanon, and the other GCC states (in addition to Saudi Arabia and the UAE).
  - Stress-test the concept in case of various scenarios of political risk, understanding the exposure of the key stakeholders (Sunrise Region producing countries, import/transit countries, and EU importing countries).
- **Environmental and Social Impact Analysis**
  - Conduct an initial Environmental and Social Impact Analysis, including the areas of renewable and hydrogen production, transit, export nodes, the subsea and shipping infrastructure. This would also include the supply chain impacts of the required equipment and materials, in resource use, greenhouse gas emissions and other pollutants. Key issues include land-use and balancing the interests of existing or competing land-users; effects on cultural, historic and religious heritage; labour rights; the impact on onshore and marine ecosystems, particularly the corridors for migratory birds; the required water use and the effect of desalination facilities; direct and indirect greenhouse gas emissions, including hydrogen leakage; light and noise pollution in the immediate vicinity; social disturbance from imported labour.
  - Ensure the project would be compliant with local and EU law regarding issues such as environmental protection, embedded greenhouse gas emissions, anti-corruption, and human rights.

[109] P. Dombrowski and B. Jones, "A New Era of Undersea Conflict Is Here", Foreign Policy https://foreignpolicy.com/2025/03/21/undersea-cables-sabotage-hybrid-conflict-deterrence

5.2 Design and Approval, Initial Implementation, and Operations Phases

The details of the design and approval, initial implementation and operations phases depend on the concept chosen, and can therefore be shown here only in outline.

For an indicative timeline:

- A large solar PV project, Sudair in Saudi Arabia, took financial investment decision in April 2021 and began operations in September 2023, for a total time of 2.5 years
- A wind farm in Egypt, Suez Wind Energy, took financial investment decision in January 2025 and is anticipated to be fully operational in August 2027, for a total time of about 2.5 years
- An international subsea HVDC interconnection, Viking Link between Denmark and the UK, took final investment decision in September 2018 and began operations in December 2023, for a total time of just over 5 years, including the Covid pandemic
- A large hydrogen project, NEOM, signed its engineering, procurement and construction (EPC) contract in December 2022, took final investment decision in May 2023, and is expected to start operations in December 2026, for a total time of 4 years

Therefore, if design can be completed and approvals obtained during Years 2-3, with financial close and construction start in Year 4, the first phase of the renewable generation, electricity export and (if chosen) hydrogen production and export could be operational by Year 8. It is acknowledged that this is dependent on a favourable political and commercial environment for all parties concerned, and on prompt regulatory, environmental and financial approvals. Subsequent phases could proceed more quickly given the precedent, experience, establishment of supply chains, and easier permitting.

Some parts of the project, particularly solar and wind generation for national use or export to immediate neighbours, could be implemented much more quickly, likely by Year 2-3.

Appendix

List of Abbreviations

Abbreviation	Definition
AC	Alternating Current
AEO	Arab Energy Organisation (formerly OAPEC, Organization of Arab Petroleum Exporting Countries)
BRI	China's Belt and Road Initiative
BRIC	Organisation that includes Brazil, Russia, India, China, and South Africa, as well as Egypt, Ethiopia, Indonesia, Iran and the United Arab Emirates
Bt	Billion Tonnes
CBAM	Carbon Border Adjustment Mechanism
CFRP	Carbon fibre-reinforced polymer
CO_2	Carbon dioxide
CSP	Concentrated Solar Power / Concentrated Solar-Thermal Power
DC	Direct Current
DG MENA	Directorate-General for the Middle East, North Africa and the Gulf, the European Commission
EMGF	East Mediterranean Gas Forum
ENTSO-e	European Network of Transmission System Operators for Electricity
EPC	Engineering, procurement, and construction
EWEC	Emirates Water and Electricity Company
FID	Final investment decision
G3	The EU Three (refers collectively to France, Italy, Germany)
G4G	Gas for Gaza (Project)
GCC	Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE)
GCCIA	Gulf Cooperation Council Interconnection Authority
GECF	The Gas Exporting Countries Forum
GHG	Greenhouse gas
GREGY	The Greece-Egypt Interconnector
GW	Gigawatt
GWh	Gigawatt-hour
GWP	Global Warming Potential
H_2	Hydrogen
HVDC	High Voltage Direct Current
ICV	In-country value
IMEC	India-Middle East-Europe Economic Corridor
IRENA	International Renewable Energy Agency
KAS	Konrad-Adenauer-Stiftung
kg	Kilogram
kt/y	Thousand Tonnes Per Year
kWh	Kilowatt-hour
LCOEs	Levelised cost of electricity
LNG	Liquefied Natural Gas
LOHC	Liquid organic hydrogen carrier
MDPD	Multinational Development Policy Dialogue
MED-GEM	Mediterranean Green Electrons and Molecules Network
MENA	Middle East & North Africa
MoU	Memorandum of Understanding
Mt/y	Million Tonnes Per Year
$MtCO_2e$	Million metric tonnes of carbon dioxide equivalent
MW	Megawatt
MWh	Megawatt-hour
OPEC	Intergovernmental organization - Organisation of Petroleum Exporting Countries
OPEC+	Intergovernmental organization that includes OPEC members and additional oil-producing non-OPEC member states
PENRA	Palestinian Energy and Natural Resources Authority
R&D	Research and development
RFNBO	Renewable Fuels of Non-Biological Origin
RNG	Renewable Natural Gas
SNG	Synthetic Natural Gas
Solar PV	Photovoltaic Solar Power
SPV	Special Purpose Vehicle
SWF	Sovereign wealth fund
T&D Networks	Transmission and distribution networks
TWh	Terawatt-hour
UAE	United Arab Emirates
UHVDC	Ultra-High Voltage Direct Current