The MENA2050 Regional Vision Team

Opinion Note

Integrating the EU and MENA Power Systems

Authors: Omar Al- Ubaydli, Layal Alghoozi, Noora Alozaibi, Arnon Bersson, Noor Elgallal, Ben Grischeff, and Munya Yusuf; with support by ChatGPT

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Designers: Karim Al-Nassar, Hayvi Bouzi.

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Executive Summary

The European Coal and Steel Community, launched in 1952, was a visceral demonstration of how energy integration can be the conduit for lasting peace and prosperity. In 2024, several projects are underway to deepen the connections between the EU and MENA power systems, but they remain modest in scope. Huge potential gains – be they on the economic, geopolitical, or humanistic front – will remain unrealized unless leaders on both sides ramp up their efforts to forge an integrated inter-regional power system.

Figure 1: The inauguration ceremony of Interconnector held on October 14, 2022, was attended by EU Commissioner for Energy Kadri Simson, President of Cyprus Nicos Anastasiades, Greek and Cypriot Energy Ministers Kostas Skrekas and Natasa Pilides and CEO EuroAsia Interconnector Nasos Ktorides. By Stavros Ioannides.

This note advocates for such a vision. It provides a non-technical introduction to the returns associated with such a bold project and presents some broad strokes on some of the major steps required to make it a reality. The note also explores the major barriers to the integration of the EU and MENA power systems. A full description of the method can be found in [Note 0], including information about the authors and MENA2050. The key conclusions are as follows.

Conclusion 1: Done right, integrating the EU and MENA power systems offers a large array of potential benefits, including orthodox economic returns in line with theories of economic integration, in addition to less tangible ones such as deeper geo-political ties between the two regions.

Conclusion 2: Were it not for the prospect of a large increase in the contribution of renewable energy to the mix, there would be no major technical barriers to the project. This is reflected in the existence of several interconnectors that have been either activated or are under construction.

Figure 2: EuroAfrica Interconnector CEO Nasos Ktorides signed the historic InterConnector agreement between Egypt and Cyprus in the presence of Moustafa Madbouly, the Prime Minister of Egypt, Minister of Electricity, and Ioannis Kasoulides, Chairman of the EuroAfrica Strategic Council. By Philip Kavalas.

Conclusion 3: Developing new technologies that address the issue of integrating renewable energy is a challenge that can be overcome, and having teams of scientists and engineers from both sides collaborate on it constitutes a welcome additional dimension of cooperation between the two regions.

Conclusion 4: Issues relating to financing, energy security, and regulatory uniformity constitute significant barriers, but as history has shown throughout the world – including in Europe itself – with enough political will, they can be overcome.

Conclusion 5: The proximate and potentially most difficult challenge is the issue of geo-political differences, especially within the MENA region. The Arab League has struggled to forge a consensus on energy integration, and its Pan-Arab power system project is yet to reach the advanced stages of implementation.

Conclusion 6: Leveraging the energy and visionary nature of many of the young leaders and citizens throughout the MENA region can play a crucial role in creating positive momentum, and in helping governments fixate on the large returns waiting to be realized. An important first step could be organizing a more frequent dialogue between policymakers, engineers, and managers, as such efforts can help build trust.

Introduction

Electricity is a uniquely important commodity, as it constitutes an input in the production of virtually every modern good and service (Cleveland et al., 2000). For this reason, in the domain of functions of modern governments, supplying electricity to the economy is comparable in importance to essential services such as providing internal and external security. While countries differ in the levels of private versus public power generation, transmission, and distribution, all governments share a commitment to the oversight of an effective power system.

Figure 3: A steam turbine used to provide electric power

With the advancement of modern engineering, governments have also begun to integrate their power systems using advanced infrastructure. These investments initially fulfill basic needs, such as the emergency provision of electricity during unforeseen blackouts. However, over time, they usually grow to function as markets for trading large volumes of electricity, as neighboring countries exploit each other's comparative advantage in generating certain types of power (Abrell and Rausch, 2016). Many such interconnections exist in Europe, and they have improved the efficiency of European electricity markets, ensuring lower cost and more stable power for hundreds of millions of people throughout the continent. While it lags behind Europe in terms of its interconnections, the MENA region does boast several successful projects, such as the Gulf Cooperation Council (GCC) grid.

The integration of the European Union (EU) and MENA power systems represents a transformative opportunity for enhancing energy security, optimizing resource utilization, and fostering economic growth. As the EU strives to meet its ambitious climate targets and transition to a more sustainable energy system, leveraging the abundant renewable energy resources in the MENA region, particularly solar and wind power, could play a crucial role. This integration is anticipated to provide substantial economic benefits, including cost savings, increased market liquidity, and improved grid stability, while also facilitating the cross-border exchange of electricity.

Historically, the EU and MENA regions have operated largely independent power systems, with limited interconnections primarily focused on specific projects like the Morocco-Spain and planned Tunisia-Italy interconnectors. However, with advancements in high-voltage direct current (HVDC) technology and a growing emphasis on renewable energy, the feasibility and potential returns of a more integrated trans-Mediterranean electricity

network are becoming increasingly apparent.

This note explores the technical, economic, and regulatory challenges and opportunities associated with integrating the EU and MENA power systems. It is based on a combination of academic references and interviews with three energy experts from or working in the MENA region, which will be quoted throughout the text. The questions posed can be found in the appendix. Further details on the method can be found in Note 0. Chat GPT was also used to help write this note.

1. The Current State of Power Systems in the EU and MENA

1.1. The EU Power System

The EU power system is a complex and interconnected network designed to provide reliable, sustainable, and affordable electricity across its member states. This system has undergone significant transformations over the past few decades, integrating renewable energy sources, enhancing cross-border cooperation, and ensuring energy security. It is governed by a comprehensive regulatory framework designed to ensure fair competition, consumer protection, and environmental sustainability. Key legislative instruments include the Clean Energy for All Europeans package, which sets out rules for market design, renewable energy, energy efficiency, and governance (European Parliament and Council, 2019).

The EU power system is highly interconnected, with national grids linked through a network of cross-border interconnectors (Yu and Son, 2023). These interconnectors enable electricity to flow between countries, improving system reliability and allowing for efficient distribution of renewable energy. The European Network of Transmission System Operators for Electricity (ENTSO-E) plays a crucial role in coordinating these interconnections and ensuring grid stability (ENTSO-E, 2023).

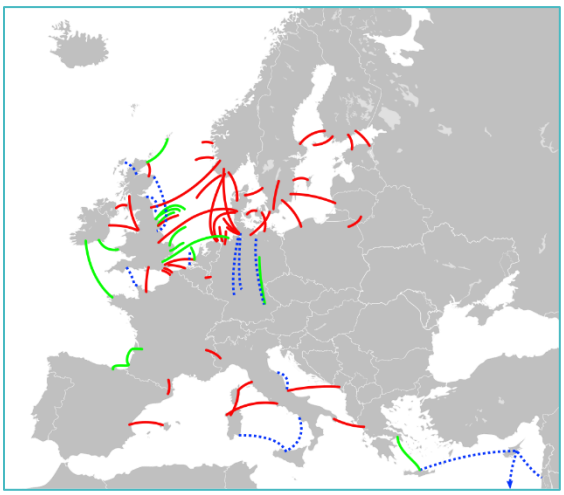


Figure 4: Existing (red), under construction (green), and proposed (blue) interconnections in the European electricity market, by J. Messerly.

One of the most significant trends in the EU power system is the integration of renewable energy sources. The EU has set ambitious targets to increase the share of renewables in its energy mix, aiming for 32% by 2030 under the Renewable Energy Directive (European Commission, 2018). Wind and solar power have seen substantial growth, supported by policies and investments in grid infrastructure to accommodate the variable nature of these energy sources (Eurostat, 2023).

These renewable energy investments also fall under the broader umbrella of the EU's commitment to reducing greenhouse gas emissions and achieving climate neutrality by 2050 as part of the European Green Deal. The power sector is central to this effort, with initiatives to phase out coal, increase renewable energy deployment, and improve energy efficiency.

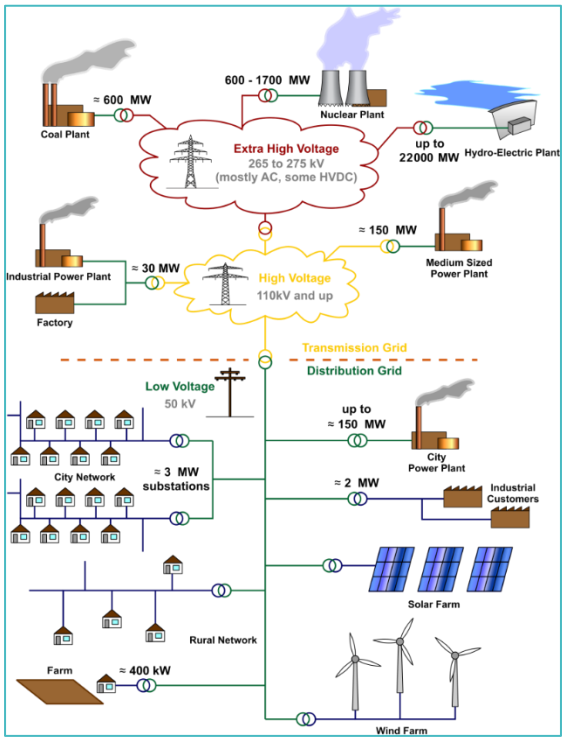


Figure 5: General layout of electricity grids. Voltages and depictions of electrical lines are typical for Germany and other European systems. By MBizon

On the regulatory side, the EU Emissions Trading System (ETS) is a key tool for reducing emissions in the power sector by putting a price on carbon (European Commission, 2019). Moreover, the EU has worked towards creating a single electricity market to enhance competition and reduce prices for consumers. This involves liberalizing national electricity markets, promoting cross-border trade, and establishing common rules for market operation. The Internal Electricity Market (IEM) initiative aims to harmonize market rules and facilitate the free flow of electricity across borders (ACER, 2023).

From the perspective of regulators, producers, and consumers, energy security is a critical concern for the EU, particularly in light of geopolitical tensions and dependence on external energy imports. The EU's Energy Union strategy focuses on diversifying energy sources, enhancing energy efficiency, and building infrastructure to secure energy supply. Strategic reserves and emergency response mechanisms are also in place to manage supply disruptions (European Commission, 2015).

Despite significant progress, the EU power system faces several challenges. Integrating high shares of renewables, ensuring grid stability, and maintaining affordability are ongoing issues. Additionally, the transition to a low-carbon economy requires substantial investments in infrastructure and innovation. The EU continues to work on policy measures and initiatives to address these challenges and move towards a sustainable and resilient energy future (Ember, 2023).

One manifestation of these continued efforts is the use of digital technologies to improve grid management and enable the integration of distributed energy resources. Smart grids, demand response, and energy storage solutions are being deployed to enhance grid flexibility and resilience. Investments in research and innovation, such as the Horizon Europe program, support the development of new technologies and business models (European Commission, 2021).

1.2. Power Systems in the MENA Region

The Middle East and North Africa (MENA) region encompasses a diverse array of countries with unique power systems characterized by varying levels of development, resources, and challenges. The region is characterized by a mix of oil-rich countries with substantial energy exports and countries with limited energy resources. This dichotomy influences the power generation mix and infrastructure development across the region.

In general, fossil fuels are the dominant source of electricity in the MENA region. Countries like Saudi Arabia, Iraq, and Algeria have significant oil and gas reserves, which they utilize for power generation (BP, 2022). Natural gas is a critical component of the energy mix in countries like Egypt, which has substantial gas reserves in the Mediterranean Sea (IEA, 2020).

There is a growing trend towards the adoption of renewable energy sources across the region. The UAE's Masdar City and Saudi Arabia's NEOM projects are examples of large-scale renewable energy initiatives (IRENA, 2020). Morocco is the regional leader in renewable energy adoption, with significant investments in solar and wind power, exemplified by the Noor Ouarzazate Solar Complex, one of the largest concentrated solar power plants in the world (World Bank, 2019). Moreover, the region has invested in nuclear energy too, with the UAE being a pioneer with its Barakah Nuclear Power Plant, which began operations in 2020. Saudi Arabia and Egypt are also exploring nuclear energy options (WNA, 2021).

The electricity grids in the MENA region vary widely in terms of development and connectivity. Countries like Saudi Arabia and the UAE have well-developed national grids with high reliability and extensive coverage (SEWA, 2021). Conversely, countries like Yemen and Libya have grids that suffer from frequent outages and limited reach due to ongoing conflicts and political instability (IEA, 2021).

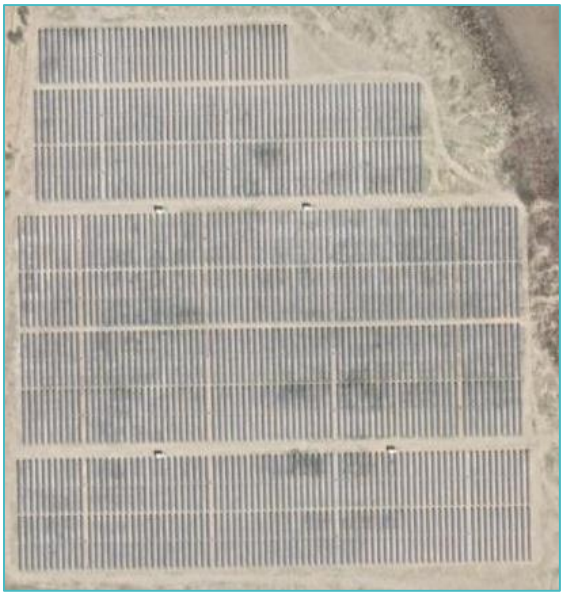


Figure 6: A solar station in Khafji, Saudi Arabia

Israel has a diverse energy mix with a significant share of natural gas, following major discoveries in the Mediterranean Sea. The country is also investing in solar power and aims to increase the share of renewables in its energy mix (Israel Ministry of Energy, 2021). Its grid is well-developed, with plans for further integration with neighboring countries and Europe through projects like the EuroAsia Interconnector (EuroAsia Interconnector, 2020).

Turkey's power system relies on a mix of coal, natural gas, hydro, and an increasing share of renewables. The country aims to

expand its renewable energy capacity to reduce dependence on imported fossil fuels (TEİAŞ, 2021). The country is strategically positioned as an energy bridge between Europe and Asia, with plans to enhance its interconnections with neighboring countries to support energy trade (ENTSO-E, 2021).

Figure 7: Drilling for natural gas in the Mediterranean, Noa gas field.

In contrast to these two countries, Iran has vast oil and gas reserves, making fossil fuels the dominant source of power generation. However, the country is also exploring renewable energy options to diversify its energy mix (IEA, 2021). Iran's power infrastructure faces challenges due to international sanctions, which impact its ability to attract foreign investment and technology (IEA, 2020).

Beyond the aforementioned examples, the region's power systems demonstrate some degree of interconnectedness. The GCC Interconnection Authority (GCCIA) has established a grid linking the Gulf Cooperation Council (GCC) countries, enhancing electricity trade and grid stability among member states (GCCIA, 2020). The Arab Gas Pipeline project aims to create an interconnected gas network to support power generation across the region (World Bank, 2021). The Euro-Mediterranean electricity partnership aims to link the North Africa region with Europe, enhancing energy security and facilitating renewable energy exports to Europe (European Commission, 2020). Other planned integration projects include connecting the GCCIA grid to Iraq, and further connections between Jordan and Israel, and Egypt and Saudi Arabia.

The first significant attempt to establish a unified Pan-Arab electricity market was initiated in 2017 when Arab Ministers of Electricity and Energy signed a memorandum of understanding (MOU) to develop the Pan-Arab Electricity Market (PAEM). This MOU set out a five-stage development plan to create a fully integrated Pan-Arab grid and a wholesale competitive market by 2038 (PAEM, 2023). The effort marked a structured approach towards regional energy integration, aiming to optimize the use of energy resources and enhance economic cooperation among Arab countries.

However, the current utilization of existing cross-border lines is low, averaging 5-7% annually. Enhancing utilization to 36% could save up to $71 billion in total system costs between 2020 and 2035 (PAEM, 2023). Further, the effective operationalization of PAEM requires greater commitment and support from

participating governments. Past regional integration efforts have often stalled due to a lack of political will and economic stability, including the violent conflicts that continue to affect many countries in the region (Brookings, 2021). In addition, regulatory heterogeneity is a persistent barrier that is likely to take considerable time to overcome (World Bank, 2021).

Looking forward, continued investment in solar and wind power projects is expected, driven by falling costs and increasing environmental awareness (IRENA, 2020). These are likely to be supported by advances in energy storage, smart grids, and digital technologies, which will enhance grid reliability and support the integration of intermittent renewable energy sources (World Bank, 2021). Various MENA region countries have national climate commitments, albeit not quite as ambitious as those in the EU. For example, Saudi Arabia and Bahrain are committed to net zero by 2060, while the UAE has set itself a target year of 2050.

2. How and Why to Integrate the EU and MENA Power Systems

2.1. A Brief Primer on How to Connect Two Neighboring Electricity Grids

Non-specialists would be forgiven for thinking that integrating grids requires nothing more than laying a connecting cable. The reality is far more complex. For those without a background in electrical engineering, it is worth briefly outlining the steps typically needed to take to connect two adjacent power systems.

The first step is an agreement by the two sides on technical standards, as the two grids have to operate at the same frequency and voltage levels. Thereafter, an interconnecting cable is installed, which is a high-voltage power line that allows for the electricity in one grid to flow to the other. This must be coupled with substations where the electricity is converted to the appropriate voltage and frequency before it enters the neighboring grid. At this point, the key physical infrastructure investments are complete.

Figure 8: Cross section of a submarine power cable. By Z22.

The two sides then turn to the soft aspects of the connection, including legal agreements detailing how much electricity can be traded, pricing, and cost-sharing. This also includes a discussion of how emergencies will be handled, and how stability will be maintained. Moreover, to operationalize these agreements, grid

operators in both countries set up monitoring systems to manage and control the electricity flow, preventing overloads and faults. A final step is conducting environmental assessments and engaging with local communities to ensure the project is sustainable and socially acceptable.

2.2. Existing, Planned, and Potential Integration Methods

As indicated at various points in section 1, there already exist several connections between the EU grid and the MENA region (note that there is no integrated MENA grid yet). Moreover, several connections have been negotiated and are under construction.

The Morocco-Spain interconnection is one of the most significant links between the EU and the MENA region. This connection includes two high-voltage direct current (HVDC) submarine cables across the Strait of Gibraltar, facilitating electricity trade between Morocco and Spain. It enables the export of surplus renewable energy from Morocco to Spain and enhances grid stability in both countries (IEA, 2021).

The planned Tunisia-Italy interconnection, known as the Elmed project, aims to link the Tunisian grid with the Italian grid through a submarine HVDC cable. This project is expected to enhance electricity trade between North Africa and Europe and support the integration of renewable energy sources. The project is currently in the planning and development stages (European Commission, 2020).

The EuroAfrica Interconnector is a proposed electricity interconnection project linking Egypt, Cyprus, and Greece through HVDC submarine cables. This project aims to enhance energy security, facilitate the export of renewable energy from North Africa to Europe, and support the EU's energy transition goals. The interconnector will provide a direct link between the Egyptian grid and the European grid via Cyprus and Greece (EuroAfrica Interconnector, 2023).

Figure 9: President of the European Commission Ursula von der Leyen at the University of Cyprus on July 8, 2021, announces approval and funding of €100 million for EuroAsia Interconnector out of the Cyprus RRP program. By Stavros Ioannides, P.I.O. Photo Department.

The EuroAsia Interconnector is another significant project that will connect the Israeli electricity grid with Cyprus and Greece through HVDC submarine cables. This interconnection aims to enhance energy security, promote renewable energy integration, and support electricity trade between the Eastern Mediterranean and

Europe. The project is expected to strengthen the link between the MENA region and the EU electricity market (EuroAsia Interconnector, 2023).

As mentioned above, Turkey is interconnected with the EU electricity grid through its connections with Greece and Bulgaria. These interconnections facilitate electricity trade between Turkey and the EU and support regional energy security. The Turkey-Greece interconnection, in particular, has been operational since 2011, enhancing the integration of the Turkish grid with the European Network of Transmission System Operators for Electricity (ENTSO-E) (TEİAŞ, 2021).

Figure 10: HVDC in 1971: this 150 kV mercury-arc valve converted AC hydropower voltage for transmission to distant cities in Canada.

However, it is important to note that the capacity of the current interconnections between the EU and MENA region is very limited. Moreover, though this capacity will increase substantially once the various projects that are underway are completed, it will still be limited compared to the level required for unfettered inter-regional trade, or for the two grids to be considered unified.

For full integration, numerous options are available given the length of the border between the two regions. These include implementing large upgrades to existing or planned links, in addition to constructing entirely new connections. We explore some of these options more below in the discussion of potential barriers.

2.3. The Potential Benefits of Integration

Integrating the EU's and MENA region's power systems could potentially confer large benefits on all of the participating countries. There are different classes of benefits, with the most straightforward being the traditional gains associated with economic integration in any domain – electricity provision or otherwise (Baldwin and Venables, 1995). Specifically, such an interconnection would open up new energy markets for both regions, potentially leading to reduced electricity prices due to increased competition and more efficient energy production. These benefits are likely to be particularly acute for the MENA side, as electricity providers have tended to be shielded from competition throughout their history, in contrast to the EU, where a common electricity market has been increasing efficiency and lowering prices for many years (Newbert et al., 2016).

Integrating markets also provides smaller countries on both sides with an opportunity to overcome problems associated with the

minimum efficient scale of production. For example, for a country like Bahrain with 1.5m residents, the fixed costs of investing in traditional forms of nuclear energy cannot be recouped as the local power demand is too small. However, by allowing a prospective nuclear power plan the opportunity to sell its electricity to parts of the EU and MENA region, the cost barriers can potentially be overcome.

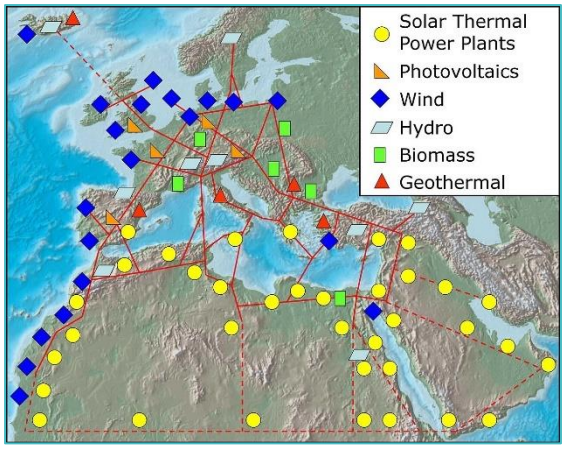


Figure 11: One conceptual plan of a super grid linking renewable sources across North Africa, the Middle East, and Europe. By Trans-Mediterranean Renewable Energy Cooperation.

Another dimension of the economic benefits is the ability to exploit seasonal differences in demand.

Expert 1*: If you think about it, in the MENA region, we have peak demand in summer [for air conditioning], and in Europe, you see that the peak is in winter [for heating]. So we are talking about different electricity consumption behaviors, which can complement each other. The way that I can provide them electricity through the winter and they can provide me electricity through summer. Then we will minimize the investment we have and we will have more smart investments together but to build those kinds of relations, we have to work to build very strong establishments and organizations, and there needs to be a lot of investment and political consensus.*

In both regions (or at least in parts thereof), the variation in seasonal demand is acute, resulting in the need for large investments in generation capacity that might lie idle for significant parts of the year, just to serve during the transient periods of elevated demand. Integrating the grids allows countries the possibility of scaling back their capacity investments and instead exploiting the "other side's" excess capacity during times of high demand. Thus, the fact that EU-MENA power system integration runs across many degrees of latitude means that it offers straight economic returns that cannot be realized by sub-regional integration, such as within North Africa or the Levant. These are in addition to the generic benefits of increased energy security through diversification of supply sources and improved reliability in electricity delivery that are seen in grids such as the GCCIA.

A further dimension to the economic returns comes from exploiting heterogeneity in renewable energy potential (Fälth et al., 2023). The MENA region has certain long-run advantages in renewable energies stemming from the greater abundance of solar radiation, in addition to having a population density that is less than half that of the EU, meaning more space for solar farms. Given the aggressive targets that the EU has set itself for greening its energy mix, having access to an integrated MENA grid may allow it to rapidly attain those targets, especially as hydrogen increases in attractiveness as a contributor to clean energy (Braun et al., 2023).

For example, Saudi Arabia has a population density of 15 people per square kilometer, compared to over 100 in the EU, and it has a large land area, too; this makes it well-suited to export solar energy to countries that are not merely looking to procure electricity but are specifically looking for clean electricity. On the flip side, having access to the EU market would allow countries that have traditionally imported fossil fuels, such as Morocco, to transform into major power exporters, contributing to their economic development.

Figure 12: Luigi Di Maio, EU Special Representative for the Gulf region.

Integrating the two regions' power systems also offers technological benefits, too. Developing the infrastructure for a transcontinental electricity grid would require advancements in power transmission technology, such as high-voltage direct current (HVDC) lines, which could further push innovation in the energy sector. While the EU has a long history of innovation, many countries in the MENA region have struggled to realize high levels of innovation, enhancing the benefits associated with contributing to the integration of the two regions' power systems. Moreover, an expected corollary of the need to cooperate on the interconnection and regulation would be cooperation in research and development in renewable energies. The resulting knowledge transfer would further enhance the efforts expended by various MENA region countries to improve their innovation levels.

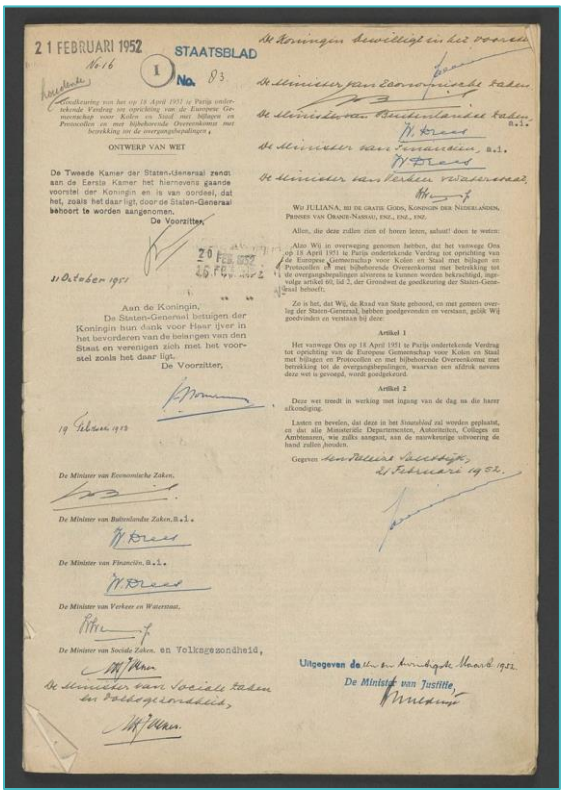
Finally, looking beyond the electricity-related benefits, the development of a shared electricity grid could foster stronger economic and political ties between the EU and the Middle East, promoting stability and cooperation (Keulertz and McKee, 2021). Though MENA2050's note 1 was somewhat skeptical about the political benefits of economic integration within the MENA region, many of the reasons for pessimism do not apply when considering EU-MENA integration, where the incidence and intensity of conflicts are considerably lower.

Given the large number of unknown parameters, such as where the interconnecting cables would be laid, their specifications, the levels of electricity demand and supply, and so on, it is way beyond the technical capabilities of this note's authorship team to provide a dollar value estimate of the net benefits of integrating the grids. Nevertheless, the question of whether integrating the power systems would yield a net positive return was posed to the three experts interviewed for the note, and they responded as follows.

***Expert 1**: Yes! I think the opportunities and benefits if we have these types of projects—I am an optimistic researcher—[are great]… I see the benefits and the profits if we work together to overcome the challenges… [even if they] are very difficult… I think the benefit will always be better… These types of [projects] will create a lot of prosperity and development within the region and it is worth studying it and planning it and advocating for it, and also o convincing the younger generation that now is the time to have bolder projects and directions. Influential leaders, active communities, universities, students, and different societies have to play a role in achieving this because we are living in a world that is interconnected. I believe we have to think beyond our borders and we have to have these visions for the future… Working together will provide a win-win situation for both.*

If you think about the EU before its establishment, relations between countries were very complicated. They had different religions, cultures, and languages but they worked it out. The way they worked it out was by looking at the benefits in the energy sector, unifying their interests. I think this is a lesson we need to learn in the [MENA] region. [The EU] is one of the biggest markets in the world, they have lots of regulations and they can force any company to do whatever they want because they are a big market, so they are a big consumer and also a producer, so definitely this type of integration will have [a net] positive [effect]. I advocate for doing more work in that direction.

***Expert 2**: For the grid interconnection with the EU, I think [the net benefit is not positive]. I think we need to have an interconnected grid in the ME with NA to feed into African countries. But I think the EU is going to be challenging and probably not worth the money because it is going to be very, very expensive to get the electricity there. So, if there is profit, it is probably going to be minimized… I think there isn't much benefit from it, and the EU is… investing a lot in energy efficiency measures to reduce their electricity demand, so they have decoupled economic growth from electricity demand. So, I am not sure if the EU is the best market for this, but I think Africa is.*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De Voorzitter,

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De Minister van Justitie,

Figure 13: The Treaty of Paris, the founding document of the European Coal and Steel Community in 1951.

***Expert 3**: Yes, I believe [that the net benefit is positive]. It should be made very clear, and with a deep understanding, that the challenges are justified.*

3. Barriers to Integrating the EU and MENA Power Systems

Despite the benefits that integrating the EU and MENA power systems may potentially confer upon stakeholders in both regions, the project is itself highly ambitious. This section explores a selection of barriers to the realization of the project.

3.1. Technical Barriers

The first class of barrier is technical and/or technological. This refers to the technical compatibility of the two regions' power systems and the technological feasibility of fabricating interconnectors that allow for the exchange of electricity at the target volume without compromising system stability.

Overall, the experts interviewed intimated that the basic technology required exists.

***Expert 1**: If you are talking about technological challenges, I don't think there is any technological challenge regarding the availability of a mature technology for creating these interconnectors between both regions. We notice that in the EU itself, they have interconnections throughout the whole of Europe and we saw that in the GCC as well. We have interconnections in India, Australia, and the US. The concept of electrical interconnections has been there for more than 50 years and it is developed based on a mature technology.*

However, the experts also remarked that three distinct technical issues need to be addressed in light of the proposed interconnection's long-term goals. The first is that – unlike its European counterpart – the MENA grid is largely unintegrated, with technical factors contributing.

***Expert 2**: The power systems in North Africa are connected to the EU, and the power systems across the Middle East and North Africa are not connected or just have minor connections. So there are existing connections, but it's very difficult to say because the grid needs to be connected from one specific country location to another… We don't know where the connections are going to be because the distance is very relevant…. Moreover, we need to have a functioning grid interconnection in the Middle East before integrating into the EU because integrating the grid into the EU grid means that the MENA grid, which doesn't exist currently, needs to be synchronized at the same frequency level and a lot of the other technical details needs to be aligned and synchronized.*

Figure 14: The 150 MW Andasol solar power station in Spain is a parabolic trough solar thermal power plant that stores energy in tanks of molten salt so that it can continue generating electricity when the sun is not shining

The second is the issue of integrating renewable energy into the grid, which – as argued above – constitutes a key factor in

the attractiveness of the proposed integration.

***Expert 1**: The issue with renewable energy; solar, wind, and other things; is that it is intermittent, and having this type of penetration in the grid will increase a lot of the challenges and will also require another technology to be developed which is also not that mature, like energy storage. So, on the one hand, renewable energy can provide free or cost-effective power sources, but on the other hand, it will create challenges on the demand side and will also require a lot of research and development in energy storage applications.*

The third issue, which relates to the first two, is the lack of grid stability in the MENA region.

***Expert 3**: The infrastructural side is difficult. We see that projects are heading in this direction now – in Egypt, and Tunisia, there are connections to Italy and Sicily, from Morocco there are some connections, also from Iraq to Turkey then Europe – there are some connections, but weak points exist. Weak points exist in Algeria from the Western side [of the MENA region]. From the eastern side, you have Iraq, Syria, and Lebanon. Here, there is a very weak connection – stability is required to have a stronger and complete cycle… The solution may consist of a cost-benefit analysis that segments the project to open it step-by-step and piece by piece.*

3.2. Economic Barriers

The second class of barrier is economic: there is a large, up-front capital cost associated with this project, as one of the experts illustrated by zeroing in on just one component.

***Expert 2**: One of the key challenges would be the distance because one kilometer of HVDC cable, for example, is close to $1 million, so the distance is very relevant in terms of where the connection is going to be. North Africa is the closest, so it makes sense, but to other places in the Middle East it could be tricky, and the challenges could increase.*

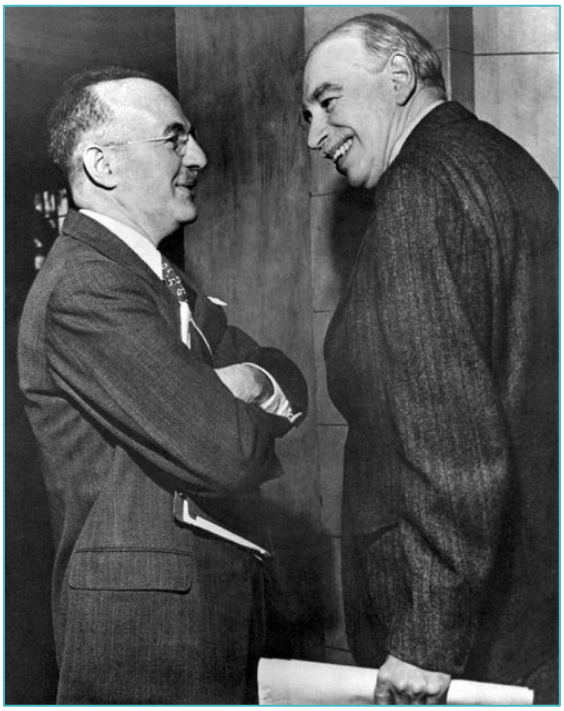

Figure 15: Harry Dexter White (left) and John Maynard Keynes, the "founding fathers" of both the World Bank and the International Monetary Fund (IMF), two international bodies that frequently fund development projects across the world, as well as assisting countries facing fiscal challenges.

As explained above, the project requires much more than a connecting cable: additional infrastructure such as substations and monitoring equipment is needed, as well as a large investment in human capital for the teams who will manage the interconnection. Moreover, there exists significant intra-regional variation in the

fiscal health of EU and MENA countries, with some of the most logical connection points (in terms of distance) linking countries with limited means. These issues are further complicated by the multilateral nature of the agreements, which are considerably more challenging to formulate than bilateral ones.

***Expert 1**: This type of interconnection requires multilateral agreements between different countries. It is not bilateral but multilateral, so there are a lot of investors, partners, and stakeholders. [Securing] buy-in from all the stakeholders is very difficult, even if [we set aside] the geopolitics associated with that.*

This barrier makes the design of the interconnection, and how it is pitched to potential funders, more important.

***Expert 1**: I think we have to rely on the younger generation to promote these ideas to the leaders of these countries. We have to be more pragmatic in [proposing] a cost-effective way of having these interconnections because it will provide a lot of stability for the region and also the growth of the economy, so we have to be advocators for these projects. I think the most effective and best practice around the world is to engage the private sector in actually funding these projects, and this is what the GCC interconnection is doing now, involving a lot of banking sectors within the GCC to fund the interconnections between Kuwait and Iraq, Basra. To attract the private sector, you have to show them the feasibility study and guarantee that we can minimize the risk as much as we can… The right approach is to provide a platform for the private sector to be more active and to attract these funds in the right direction.*

An additional economic barrier takes the form of the EU's proposed carbon taxes, as this could necessitate a large, complementary investment in renewable energy by the MENA region countries, bringing to the fore the technical challenges mentioned above, in addition to the straight issue of capital costs.

Figure 16: Renewable energy projects, such as these wind turbines near Aalborg, Denmark, constitute one common type of carbon offset project. By Neutronic.

***Expert 2**: The EU is [shortly] going to account for the carbon intensity for some of the goods imported to the EU, including electricity. So if you're exporting electricity to the EU from the MENA region, it has to be low carbon. We're currently at a very low share of renewable energy in the power mix [in MENA], so the first thing is - before getting into the cost of it - is that you need*

to green the electricity mix across the region and add a lot of renewable energy and eliminate oil. So it will be renewable energy and gas. You will probably also need carbon capture, Or it has to be exporting renewable energy-generated electricity, which is directly from those plants to the EU. That would require different types of cables. Those cables are also very expensive, and then we need to figure out who is going to pay for these expenses.

Chronically what we've seen in grid interconnections is that there is a lot of enthusiasm, but when it gets to the payment, and there are so many challenges, and you're going to pay for what? There are also always assumptions across North African countries that the EU is eager to get this electricity. Clean electricity that they're going to pay a lot of money for, and it might be true, or it might not be true because we've seen a lot of projects fail.

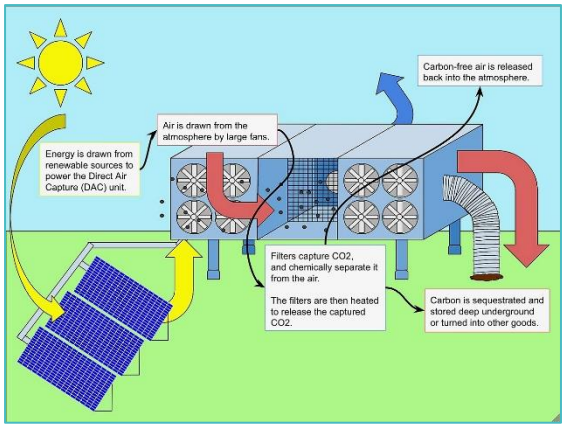

Figure 17: An example of direct air capture technology, which Saudi Aramco has announced it will use as the country works toward its net zero by 2060 target. By StevenGandhi.

On the flip side, even if the MENA countries can export green electricity to the EU and overcome the economic challenges, there remains the issue of the MENA countries having their green targets.

***Expert 2**: The next question [in MENA] is going to be: why are we investing and exporting the [green] electricity that we need ourselves? Do we want to have all this renewable energy and take all this land and then have the electricity sent to the Europeans instead of me benefiting from it? How do we meet our aggressive renewable energy targets and how do we meet our net zero targets if we're exporting this or if we're building those plants just for export purposes?*

An additional challenge is that there are so many countries within the MENA region that are struggling with electricity challenges, especially in summer [as demand rises]. As long as the temperature keeps increasing, the electricity demand is going to increase, so there is going to be a lot more backlash from citizens: why am I exporting this electricity instead of keeping it for ourselves?

However, as recent experience shows, these barriers are not insurmountable, and when one adopts the right approach, the interconnections can be implemented in an economically viable way.

***Expert 3**: The main thing here is political will: showing the clear cost-benefits for different parties and creating shared will between the related parties. Once we are here, the technical [and economic] issues will be resolved. To cultivate this political will there needs to be direct, face-to-face meetings and cost-benefit analysis. Some of the models that are already announced are not clear and seem to be more beneficial to some parties than others.*

We have made several pan-Arab projects of this nature seeking to connect Arab countries, [but we see a deficiency in efforts to ensure that projects are] cost-benefit analyzed. There is one project based on cost-benefit analysis linking the GCC with Iraq, this is now under construction – and it is expected that within one and a half years, it will be completed. There is also a mega project between Egypt and Saudi Arabia. So, there are actual projects of this kind going on. There is a big potential for these mega-projects, especially with the renewable energy potential involved in the GCC countries. I believe there should be some direct communication [between the EU and MENA countries] because the idea of opportunities can be illustrated, and more mega projects can be constructed under good contracts between the parties.

3.3. Security Barriers

The third class of barrier is security, which has a dual meaning. It refers to conventional hard security, i.e., protecting the infrastructure from sabotage, such as that witnessed in the case of the Nord Stream 2 pipeline linking Germany to Russia. It also refers to the reliability of electricity supplies, and their ability to withstand technical and/or politically-induced outages, as in the case of the disruptions to American refined petroleum supply caused by hurricanes in the Gulf of Mexico.

***Expert 3**: Security is very important to keep in mind, but it is not so significant as to halt trade and development.*

In terms of the security grid, this is partially an issue of making sufficient investments.

***Expert 1**: For instance, there are a lot of interconnections around the world that fail to satisfy the demand because the number of cables there is not sufficient… [This can be solved with sufficient infrastructure investment:] Instead of having 4 cables, you'll have 6 cables; which will allow you to have more secure energy.*

Security also depends on the scope of the interconnections. The biggest potential gains on offer depend upon the countries using the grid as a major source of electricity, rather than as a stop-gap during emergency blackouts.

Figure 18: A map of the Nord Stream 2 pipeline

***Expert 1**: Are you using a power trailing platform, are you using a day-ahead approach for the market? Whose market are you looking for? I mean in Europe, the US, and Australia there are different markets, so in the MENA region if we have a market, how will it be? This market has to work in two things, to maximize the profits and also to acknowledge the physical limitation of the grid you have. For example, if you have a good price, you can sell it to one country in the region but you might not have the infrastructure to sell it. So, you end up with a congested or fully loaded cable; that is one thing you have to consider to have it security-wise.*

As mentioned above, political disruptions are a key consideration, especially in the MENA region.

***Expert 1**: [One of the points of consideration is political disruptions.] We saw that during the [example conflict], the [countries involved] continued operating the interconnections… so there was no disturbance in the business model around the electricity. We need to see more examples like that. If you… have decoupling between the political and economic agendas, that will definitely develop a more progressive market which will also provide international investors with a lot of trust.*

Figure 19: A Sudanese farmer and his land. Drought and low rainfall have severely reduced the farmer's capacity to grow crops. By Oxfam.

***Expert 2**: There could be several security risks, but I think the biggest risk is the risk of conflicts internally. For example, in Syria, it has damaged the grid. There is currently a grid interconnection in the levant with Palestine, Jordan, Lebanon, Turkey, and Syria, but the grid from the Syrian part has now been damaged through the conflict, so this network, if it were to operate--it doesn't operate that much anyway--but even if it were to operate, the conflict has done damage to the grid. I do worry about the impact of climate change on increasing the conflict in the region, so this brings me back to the original point I had. The point of connection of the grid to the EU is a way to mitigate this, but it needs to be planned based on where the lower the risks are in the region and the cost of the connection to the EU. I would assume the lowest risk would be in the Gulf but it would be far and in terms of costs. I don't have an answer for this because it needs a feasibility assessment.*

3.4. Geo-Political Barriers

Within the previous sub-section on security, political barriers took the form of disagreements that emerged following the establishment of an integrated grid, and that disrupted the supply of electricity. However, political factors can also impede integration before it starts, by undermining the coordination and cooperation efforts necessary to engineer interconnections.

In the case of an EU-MENA grid, three classes of political conflict must be considered. The first is intra-EU conflict.

***Expert 3**: For an EU-MENA grid, [intra-EU conflict] it is not likely to affect the southern states that don't import Russian energy. Maybe [the issue] is more important to the northern side, but the source of energy is not from Russia, so it is not significant.*

Next is the possibility of political conflict between the EU and MENA.

***Expert 1**: I don't think MENA and the EU have a big conflict. I think the EU has been showing throughout the whole of history that they are very pragmatic in terms of providing or having connections and*

technology, I think it is not a big challenge at all.

***Expert 2**: [The solution] is to plan the grid interconnection points between the EU and the MENA region on the points with the lowest geopolitical risk. So the least cost and the least risks. That is one way to overcome it but it's something that needs a geopolitical and technical assessment.*

***Expert 3**: Here, the mechanism of the market should avoid political conflicts. When there is an issue, there will be no prioritizing of politics over economics, because these projects are for the welfare of the whole region as citizens. If it is structured well, the conflict will be overcome, and the project will be more resistant to politically driven issues.*

The final potential political fault line is within the MENA region.

***Expert 1**: I think it will be very difficult for us in the MENA region to overcome the conflicts we have, and I think that we have to rely on the younger generations and also on the influential leaders in the region. I think it is very important that we are seeing a lot of reforms now [important countries] in the MENA region. We also need stable countries to provide support for the countries that are facing a lot of political instability… I see it as a huge challenge, but we have to rely on more stable countries to support other countries to overcome these challenges, as well as, rely on younger generations to develop more advanced solutions.*

***Expert 3**: There are connections from Jordan to the West Bank, to Israel. There is some trade in fuel between countries in this region. If there is no [trade] dominance… these issues can be overcome. It should be fair; business based and done equitably. If we abide by proper standards, equal treatment, and access, it will be much easier and a good base. The size of the energy market in the region is so huge that it can accommodate regional issues and remain operational.*

3.5. Regulatory Barriers

The final class of barrier is regulatory: a large number of countries have to agree to a minimal level of harmonized rules regarding issues such as safety, trading protocols, emergency procedures, and so on.

Figure 20: Stone memorial in front of the entry to the Limburg Province government building in Maastricht, Netherlands, commemorating the signing of the Maastricht Treaty.

By virtue of the existence of the EU single market since the early 1990s, and with it the suite of overseeing entities such as the

European Commission and the European Court, the EU is in an advantageous situation. In contrast, save for some pockets of harmonization (most notably the GCC), the MENA region faces major challenges in this regard. However, appropriately enough, the EU's own experience in generating consensus gives cause for optimism.

***Expert 3**: I believe that Europe offers a strong example here. Conflict has always been there, but if proper management toward reaching agreements is present, this challenge can be overcome.*

***Expert 1**: I think it will be a big challenge to arrange harmonized regulations between two regions: the EU and MENA. It will be because the economic structures and also the political structures between the two regions are different. Even within MENA, we have different structures… and there are a lot of conflicts and difficulties in arranging a unified entity. But one thing is to [try to compartmentalize these issues].*

For example, if we are talking about providing electricity, we don't have to involve [issues like] human rights and gender equality. Instead, we need to focus on providing interconnections, regulations, and markets that support growth in both regions… I think there is a lot of alignment between the MENA region and Europe. We have very strong connections through different channels and I think there are a lot of opportunities for actually thinking about the [potential] prosperity… and to provide a more sustainable approach to integrating these benefits.

Europe is looking for new partners in the region. I think there are a lot of opportunities to create connections and work on these things. We need initiative from both sides… We see some regional initiatives in the MENA region… but we need more regional initiatives from Europe and also from the MENA region.

I remember now a very good initiative by the Indian Prime Minister called "one sun, one world, one grid". It has a target of interconnections between all the regions around the world, allowing us to benefit from the sun whenever its radiation hits the earth.

Figure 21: Indian Prime Minister Narendra Modi, who proposed the One Sun, One World, One Grid initiative

So imagine we have one grid connected to the whole world and we have one sun which will always be there so that we can extract this power 24/7. These types of regional initiatives are very important because, without dreams, vision, and initiatives, we cannot see action plans and more advanced programs to unify the efforts between two regions…. We need to focus more on enhancing our collaborations to more

outcome-oriented projects rather than lecturing each other about different things.

***Expert 2**: I think it's one big challenge but one way to address it is to have a discussion platform including all concerned entities and whole state borders to start this kind of discussion. If you want to take lessons from the EU grid interconnection, it took several decades.*

Figure 22: Gasoline prices in Germany. In Europe, gasoline is taxed, while in much of the MENA region, it is subsidized, mimicking the complexity of integrating electricity markets with differential tax/subsidy regimes. Picture By Manecke.

[In MENA, there is the added issue of heterogeneous] electricity subsidies… which makes it difficult to calculate the exact cost of electricity recovery. Unless you have the cost of recovery in each country, then no country would want to exchange electricity that is subsidized…. Eliminating the subsidy is a first step, and then doing the [unified] regulatory framework.

Conclusion

Economists have been advocating for the integration of markets since as early as the Enlightenment era, with classical liberals emphasizing the efficiency and humanistic gains of allowing businesses and consumers to interact in larger markets. For a variety of geo-political reasons, the prospect of integrating the EU and MENA economies is totally off the table for the foreseeable future, not least because the MENA economies themselves refuse to integrate. However, the markedly smaller target of integrating the two region's power systems does lie within the realms of possibility, with several important introductory steps having been taken by both sides.

This note urges the countries of the EU and MENA region to think big and build upon these initial successes. It is no coincidence that after centuries of war, the energy domain marked the departure point for a new era of European integration, taking the form of the European Coal and Steel Community. The benefits from integrating these markets are amplified, and they can be the stepping stone for a peaceful and economically prosperous future.

Despite the considerable benefits that could result from such an ambitious project, several important barriers must be overcome. They include technical aspects relating to the integration of renewable energy into the grid; and geo-political barriers stemming from the difficulty of forging agreements between such a disparate group of countries, some of which

are engaged in active conflicts. This is in addition to the ever-present problem of financing that plagues any major infrastructure project.

Nevertheless, over time, there is a sense that – done right – this project could yield massive returns for all parties. Countries in the GCC and EU need to look no further than their current integrated grids for a proof of concept. The prospect of integrating over many degrees of latitude – and exploiting the gains from heterogeneous seasonal demand and differential annual demand peaks – should make policymakers and citizens alike excited about the gains on offer. As Saudi Arabians walk in the Riyadh streets on a pleasant December afternoon experiencing 21℃ weather, it makes economic sense for massive solar farms in the Empty Quarter to be powering heaters in northern Sweden, returning the favor in July when Saudi Arabians have their air conditioners on full power. As one expert remarked, communication could be the key.

***Expert 3**: Historically, people in the MENA region have not known each other, met each other, or discussed with each other. Communication has been very limited between policymakers, the engineering side, and the management side. Bridges should be built through direct communication, interactions, learning, involving each other, and exchanging knowledge. Without bridging this gap between parties, there will not be an easy path to reach agreements that address issues. When people know each other, they can resolve a lot of these issues. This was practiced in the EU, the MENA region (in the GCC region), and other places.*

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Appendix: Interview Questions

Preamble: Currently, the power systems of the European Union (EU) and the Middle East are not directly interconnected in a significant or comprehensive way. Some peripheral connections exist, and several significant projects are underway. In the long run, a mega-project that could generate considerable benefits for all sides would be creating a transcontinental energy network that integrates the EU and MENA power systems. However, the project faces several obstacles, which will be explored.

Question 1: What are the main technical/technological challenges, and what do you think is the best approach to overcoming those technical challenges?

Question 2: How big of a barrier are the capital and maintenance expenditures needed for the construction and continued operation of the grid? What is the best way to deal with this issue?

Question 3: Do you think that maintaining the security of the grid is a significant challenge? If so, what can be done to deal with it?

Question 4: How big of a challenge are the following geo-political issues, and how can they best be overcome?

- Conflicts within the EU region.
- Conflicts within the MENA region.
- Conflicts between the two regions.

Question 5: Do you think that the establishment of a unified, harmonized regulatory framework is a serious challenge? If so, how should it be addressed?

Question 6: Are you convinced that the potential benefits justify the exertion of the effort necessary to overcome these challenges?

Question 7: Do you have any other comments/suggestions?