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Middle East Solar Industry Association

SOLAR OUTLOOK REPORT
SPECIAL EDITION

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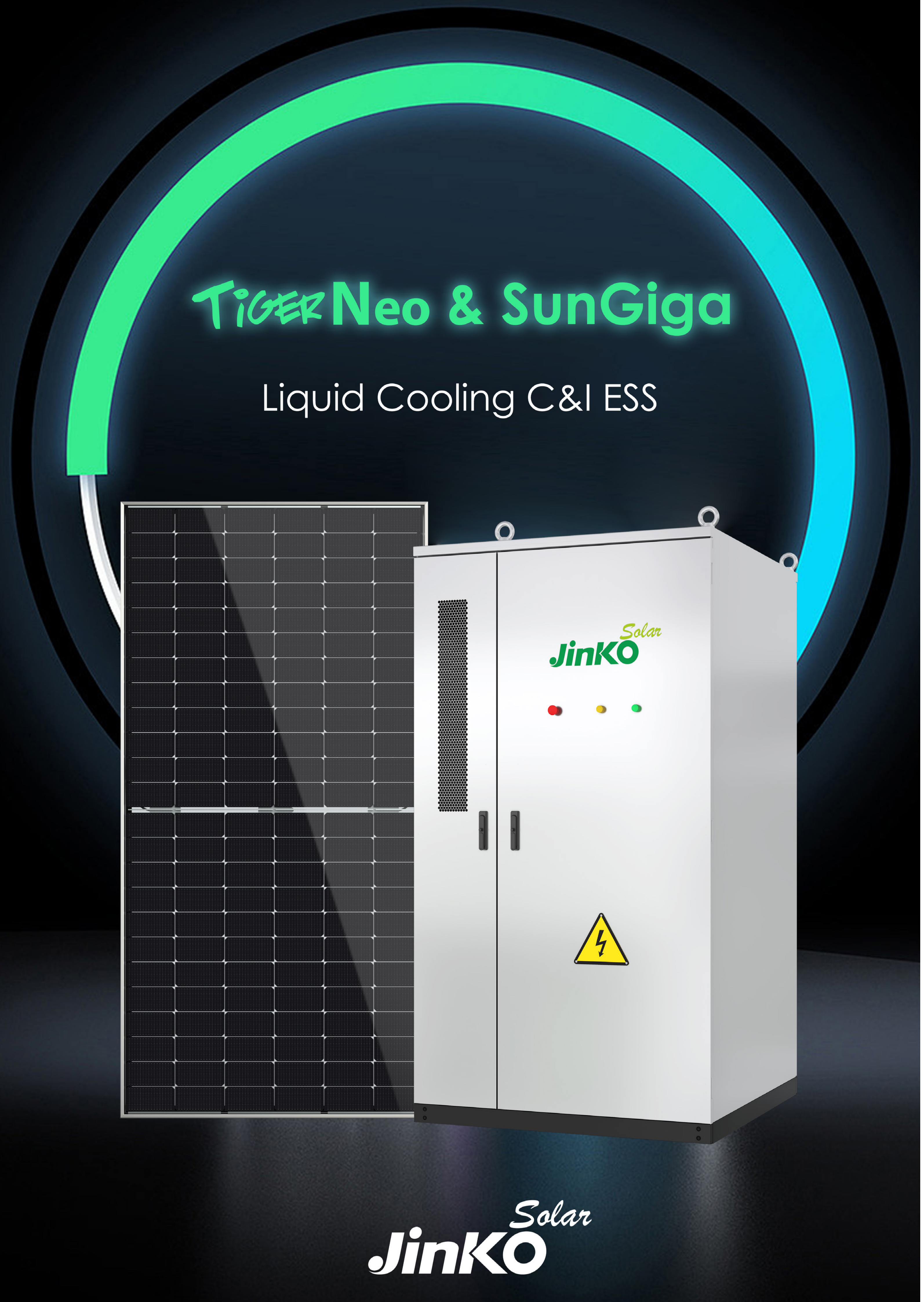
Updates and new countries not included on 2023 Solar report PLUS India coverage for the first time!

NEW Annual MESIA Solar Outlook Report will be released April 2024 at the World Future Energy Summit.



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FOREWORD

Denisa Fainis
Secretary General
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In 2023, the United Arab Emirates (UAE) is at the forefront of sustainable initiatives, marked by its commitment to declaring 2023 as "The Year of Sustainability." This dedication underscores the nation's ambition to emerge as a global leader in addressing the critical issues outlined by the United Nations' 2030 Sustainable Development Goals. As anticipation builds for the UAE hosting COP28, the world looks to the region with expectations of meaningful climate change mitigation commitments.

A pivotal focus of the UAE's journey is the ascendant prominence of green hydrogen. This report thoroughly investigates green hydrogen, exploring its production and its transformative impact on the UAE's energy landscape. Notably, it highlights the potential for the Gulf Cooperation Council (GCC) region to become exporters of this clean energy source. However, challenges persist, especially in the transportation sector, as green hydrogen establishes its presence in the market.

ADNOC's carbon credits program, anchored by the Habshan Carbon Capture facility, exemplifies the UAE's environmental stewardship. The collaboration with the Public Investment Fund (PIF) in orchestrating the world's largest sale of voluntary carbon credits through the Regional Voluntary Carbon Market Company (RVCMC) further underscores Saudi Arabia's commitment to innovative solutions that intertwine economic growth and sustainability.

The region's audacious plan to add 209 GW of solar PV capacity propels the transition to renewable energy, positioning the Middle East as a global leader in green hydrogen production for export. This move not only diversifies national economies but also contributes to a more sustainable global energy landscape. Egypt, Saudi Arabia, and the UAE lead the charge in utilizing solar power for desalination, addressing vital regional water security concerns and emphasizing regional cooperation for a more water-secure future.

Innovations in asset management revolutionize the efficiency and sustainability of utility-scale solar plants, with manned aircraft and drones, equipped with AI and machine learning capabilities, transforming the inspection process. Concurrently, the Middle East makes significant strides in electric vehicle (EV) deployment, powered by solar-produced energy, showcasing a robust commitment to e-mobility and reducing carbon emissions in the transportation sector.

As the UAE charts its course toward sustainability, it sets an inspiring example for the region and the world. This report, serving as a compass for policymakers, businesses, and individuals navigating the dynamic landscape of solar energy and sustainability, expresses gratitude to our expert contributors. Their insights serve as a guiding light for foreign investors and market analysts, offering objective information crucial for making critical decisions in this rapidly evolving sector.

Acknowledging the contributions of expert contributors, this report extends an invitation to collaborate and explore new horizons in the solar energy landscape. The commitments of Afghanistan, Egypt, India, Saudi Arabia, Kuwait, Syria, and Yemen to renewable energy are also examined, each grappling with unique challenges and opportunities.

Afghanistan aspires to generate 40% of its electricity from solar energy by 2032, with a distributed generation market showing promise despite setbacks in utility-scale projects. Egypt aims for 8,778 MW of solar capacity by 2022 and a 50% renewable energy share by 2035, showcasing commitment amid economic reforms. India makes significant strides toward its goal of 500 GW of renewable capacity by 2030, supported by regulatory updates and innovations fostering widespread solar adoption.

Saudi Arabia targets 40 GW of solar power by 2030 and net-zero carbon emissions by 2060, with recent regulatory amendments signaling a promising shift. Kuwait faces challenges in achieving its 15% renewable energy target by 2030 but shows potential with regulatory amendments and resumed projects. Syria, amid an electricity crisis, sees growth in distributed generation, while political reconciliation offers hope for large-scale solar projects.

The UAE, with its remarkable 25,000% increase in solar capacity from 2012 to 2022, showcases its commitment through initiatives like financing programs and strategic projects. Yemen, grappling with an electricity crisis, presents opportunities for growth in its solar sector, emphasizing the need for support and investment.

In conclusion, the Middle East's commitment to sustainability and renewable energy is evident across nations, with each contributing to a more sustainable global energy landscape. The journey toward a greener future is intricate, but with dedication, collaboration, and innovative solutions, these nations are paving the way for a brighter and more sustainable tomorrow.

Our profound thanks go to our expert contributors for their invaluable insights, serving as a guiding light for foreign investors and market analysts. Their expertise is an open invitation to collaborate and explore new horizons in the solar energy landscape. We express our gratitude to the MESIA team for identifying topics that provide value to our members and readers, showcasing unwavering support in our collective pursuit of a sustainable and environmentally conscious future.

IMPROVEMENTS IN SOLAR CELL TECHNOLOGIES TO ACCELERATE THE 1.5°C GOAL AT COP28

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DASOLAR

The Paris Agreement's 1.5°C target represents a critical threshold for global climate action. To limit global warming to this level and avoid the worst effects of climate change, all sectors of the economy must take swift and transformative action. Solar energy's widespread adoption is one of the most promising means of achieving this objective. This road map describes how solar cell technology can be crucial in achieving the 1.5°C goal at COP28 and beyond.

Solar energy is a clean and abundant source of power that can significantly reduce greenhouse gas emissions, offering a multitude of benefits. Firstly, solar power generates electricity without emitting carbon dioxide (CO2) or other greenhouse gases, making it a key contributor to decarbonization efforts. Moreover, solar energy can be deployed at various scales, from small residential installations to large utility-scale projects, allowing for widespread adoption. Furthermore, solar energy reduces reliance on fossil fuels, enhancing energy security and resilience. In recent years, solar photovoltaic cell technology has emerged as a preeminent and eagerly awaited research frontier.

ADVANCEMENTS IN PHOTOVOLTAIC CELL TECHNOLOGIES

In the field of photovoltaic cells in solar energy, the P-type PERC (Passivated Emitter Rear Cell) photovoltaic technology has reached a high level of maturity in the field of photovoltaic cells. As of 2021, it held a significant market share of 91.2% with a large-scale electricity generation efficiency of 23.1%, nearing the limit of approximately 24.5%. However, there is minimal space for future efficiency improvements. In traditional p-type cells, the crystalline silicon photovoltaic industry has encountered an efficiency bottleneck after more than two decades of development. There is presently a 23.5% efficiency limit for the p-type PERC cell, approaching the laboratory limit of 24%, thus more advanced technology is required. N-type cell technology can play a significant role in achieving the 1.5°C goal outlined in the COP28 roadmap by contributing to the transition to sustainable and low-carbon energy systems.is required. N-type cell technology can play a significant role in achieving the 1.5°C goal outlined in the COP28 roadmap by contributing to the transition to sustainable and low-carbon energy systems.

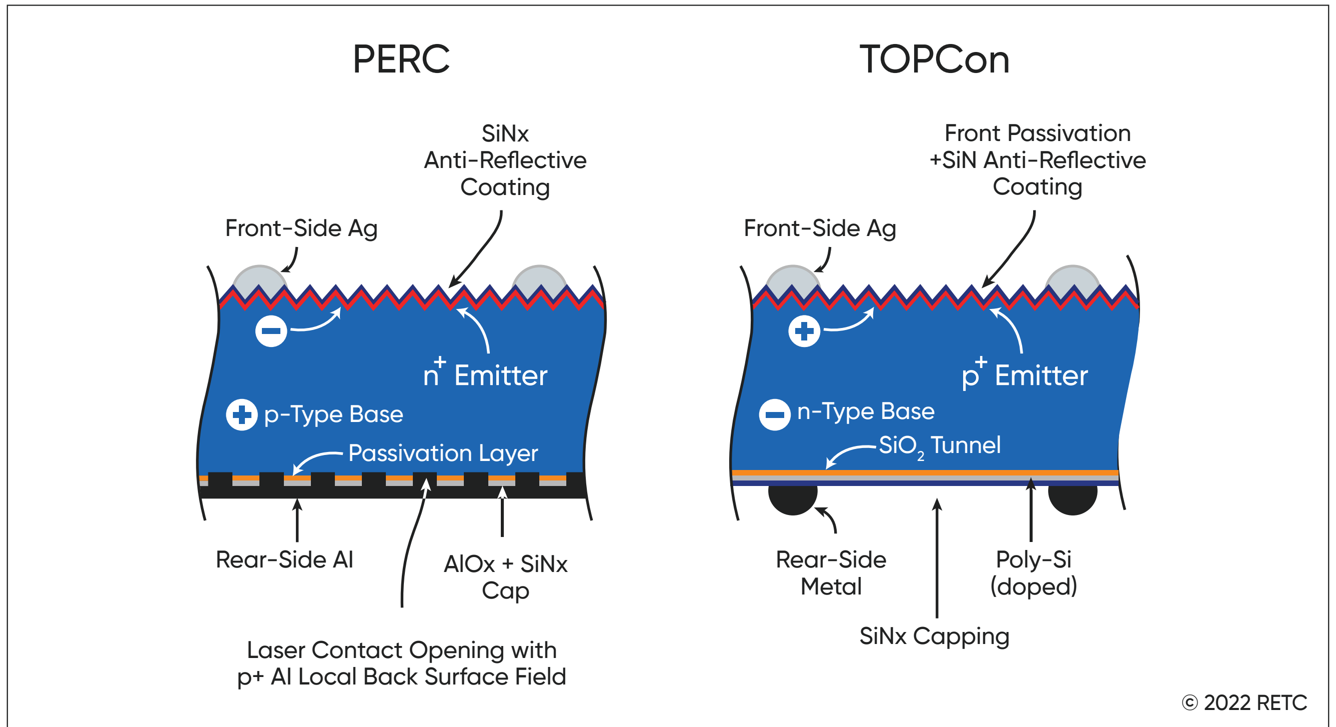


Figure 01: A Comparison of p-type PERC and n-type TOPCon Silicon Cell Designs

N-type cells, including TOPCon and HJT cells, have emerged with higher conversion efficiencies than P-type cells within the crystalline silicon cell potential. The theoretical power conversion efficiency for both TOPCon and HJT cells can exceed 27%, with actual production average conversion efficiencies of 24% and 24.2%, respectively. In contrast, perovskite monolayer cells have a theoretical conversion rate of up to 33%. If they are stacked, the theoretical conversion rate can surpass 43%, and the conversion rate can continue to increase with an increase in the number of layers. Compared to HJT cells, TOPCon cells offer the advantages of high conversion efficiency and low production costs. TOPCon cells achieve a theoretical maximum efficiency of 28.7%, surpassing HJT cells by 27.5% and PERC cells by 24.5%, according to authoritative testing conducted by the German Institute for Solar Energy Research (ISFH). Furthermore, TOPCon comes closest to the theoretical maximum efficiency of crystalline silicon solar cells, which is 29.43%.

Technology	Typical Maximum Cell Efficiency (%)	Typical Maximum Module Efficiency (%)
P-type PERC	24	21.5
N-type (TOPCon)	26	22.8
N-type (HJT)	26	22.3
Perovskite	26	22

Table 01: The Present Levels of Maximum Efficiencies of Cells and Modules for P-type PERC, N-type TOPCon, N-type (HJT), and Perovskite Technologies

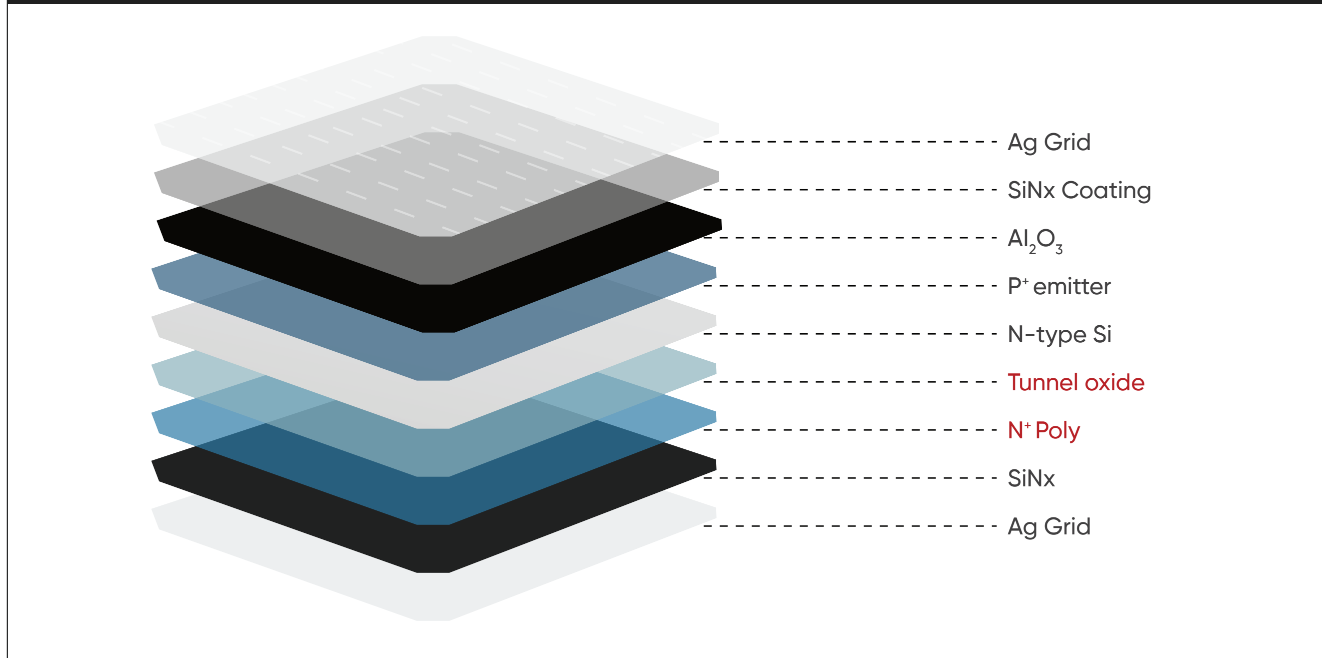


Figure 02: The structure of a TOPCon Cell

As a solar cell technology based on the principle of selective carrier tunnelling oxide layer passivation contact, TOPCon offers high efficiency, minimal optical attenuation, a low-temperature coefficient, and excellent low-light response compared to P-type crystalline silicon cells. Topcon also exhibits high compatibility with mainstream PERC cell processing routes, allowing the use of most equipment and certain processing steps. In addition to enabling production line upgrades, TOPCon leverages the existing talent pool in PERC cell technology, providing a cost-effective and innovative technology path that is compatible with PERC equipment manufacturing.

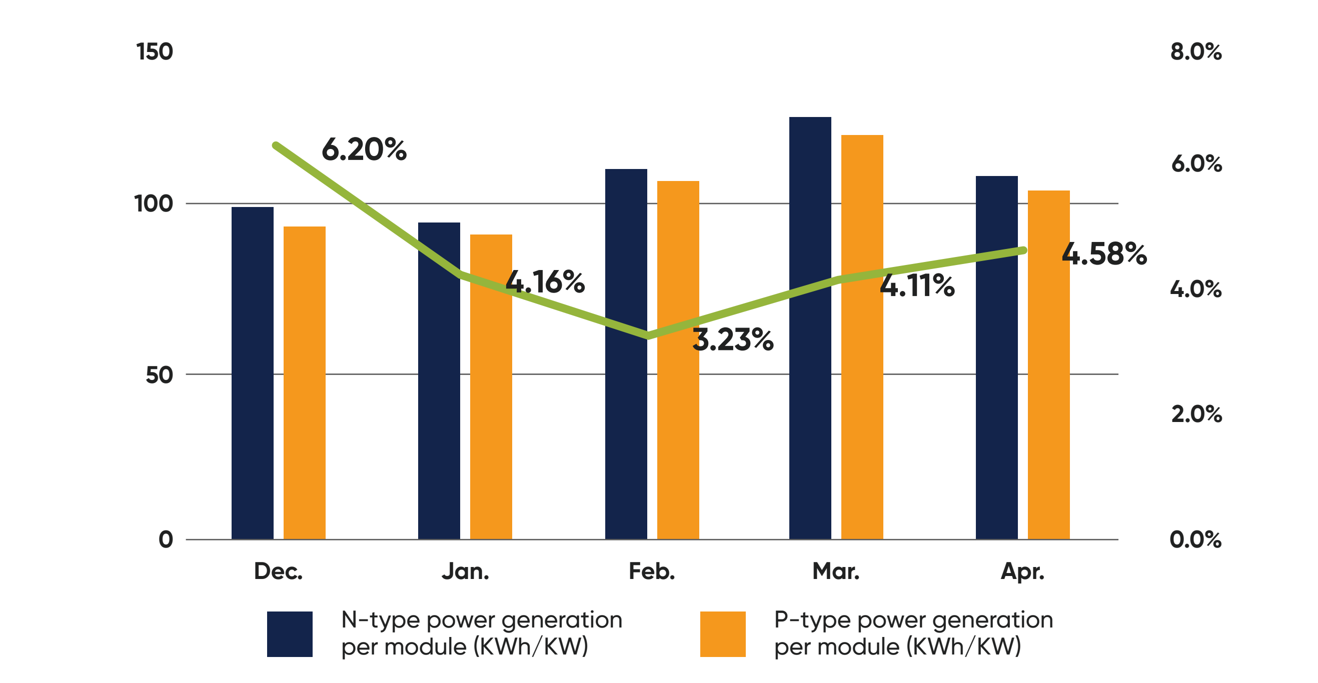


Figure 03: Comparison between Power Generated by N-type and P-type Modules from the Same project location at Hainan

THE IMPERATIVE OF GLOBAL RENEWABLE ENERGY ADOPTION AND COLLABORATION FOR CLIMATE MITIGATION

Global environmental issues include addressing the changes brought about by climate change and accelerating the switch to clean, low-carbon energy, as well as promoting inclusive energy development. It is crucial to make the switch to renewable energy globally to avoid a climate crisis. Developing countries dominate many emerging economies around the world. With the growth of global trade, these nations are experiencing substantial economic progress. As their economies expand and new infrastructure is introduced, there is an increasing demand for additional power sources to meet their energy needs. It is most convenient for developing countries to accelerate the development of renewable energy sources. Moreover, each country needs to establish operational models for both renewable energy generation and energy storage. This will facilitate the cost-effective integration of renewable energy and energy storage into the grid, ensuring power system reliability, and minimizing the land use impact associated with large-scale wind and solar power project development.

DRIVING THE GLOBAL ENERGY TRANSFORMATION: THE ROLE OF TOPCON TECHNOLOGY AND COLLABORATIVE STRATEGIES

The mission of photovoltaics is to substitute fossil fuels, constituting the "transformation" against fossil energy sources. Only when the cost becomes more competitive than that of fossil fuels can we expedite this transition and achieve the global goal of reaching the 1.5°C target. To achieve the 1.5°C goal, global collaboration is essential. TOPCon technology, being adaptable and widely compatible, can be implemented across different regions and countries, fostering international cooperation in the deployment of sustainable energy solutions. Promoting economies of scale, facilitating knowledge transfer, and coordinating supply and demand, will help accelerate knowledge transfer. This ensures that the new demand for clean energy technology in one region aligns with the development of supply capabilities in other international energy agency areas.

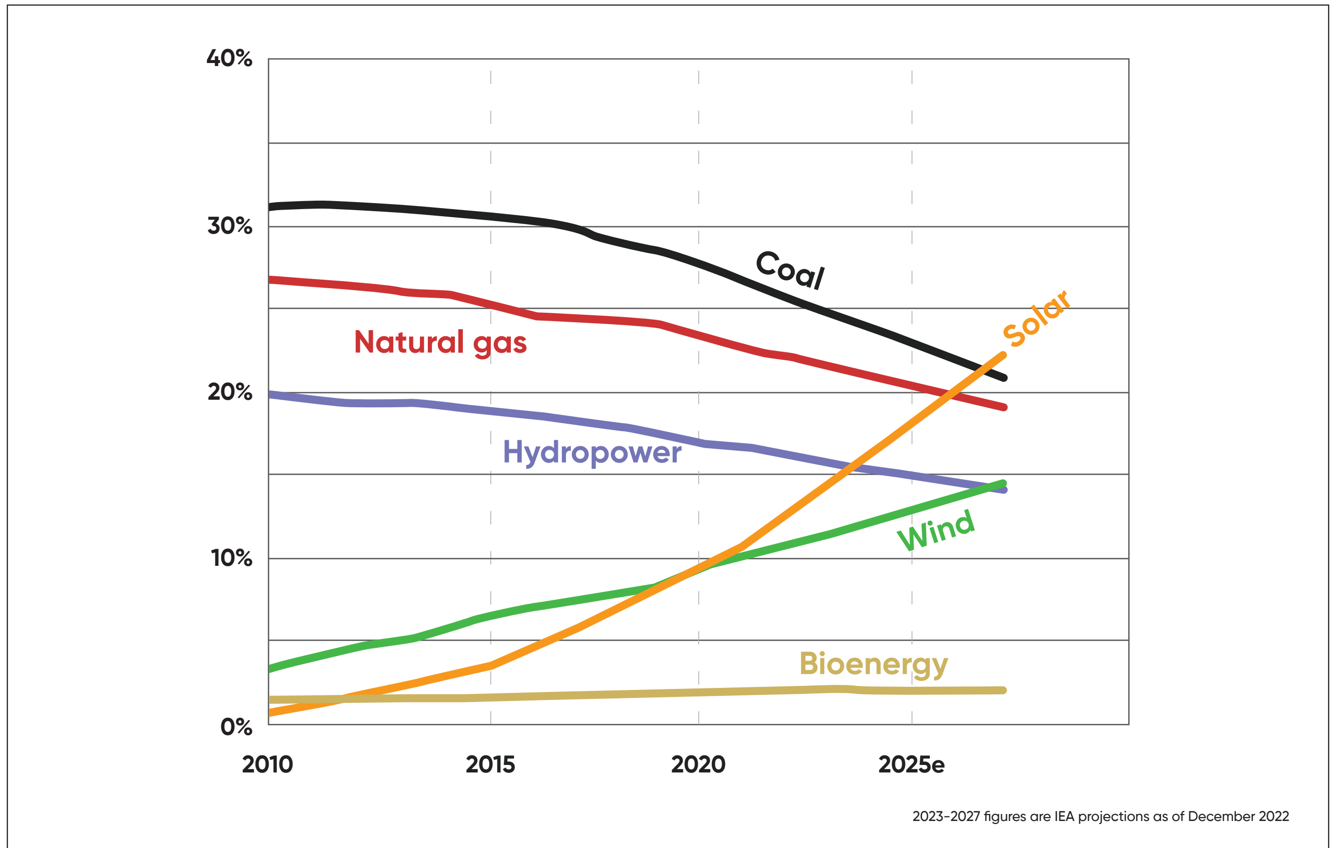
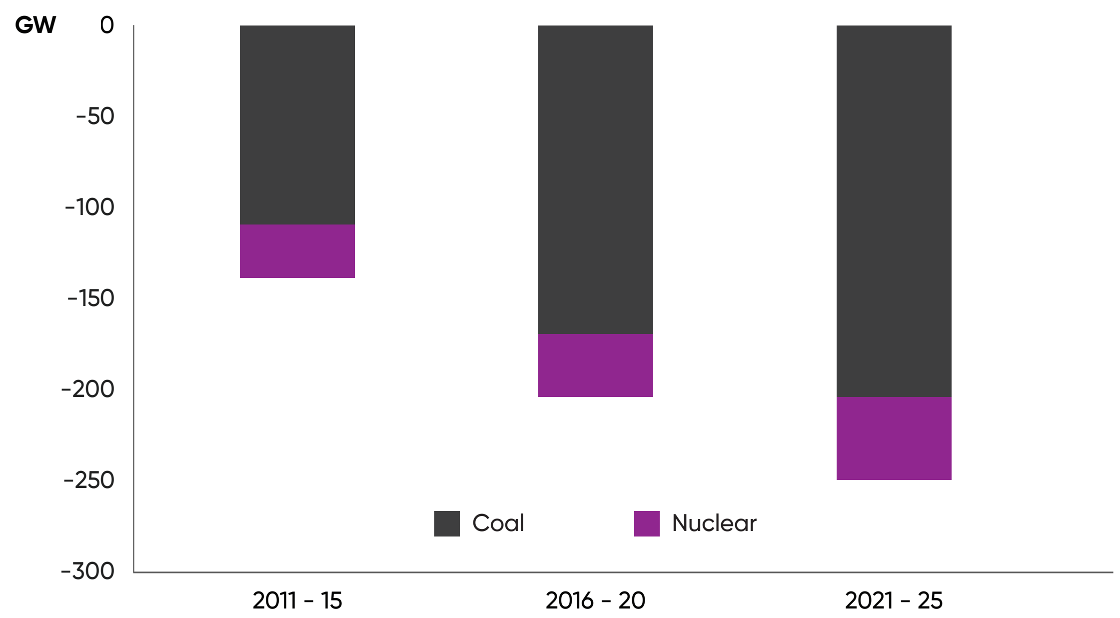


Figure 04: Renewable Energy Sources and Share of Power Capacity



Significant retirements of dispatchable, long-duration resources from the global power fleet are taking place around the world, presenting a challenge for grids as well as an opportunity for renewables and storage.

Source: S&P Global Commodity Insights

Figure 05: Global coal and nuclear capacity retirements accelerating

CONCLUSION

In summary, solar cell technology offers a tangible and scalable solution to address climate change and achieve the 1.5°C goal set out in the Paris Agreement. At COP28, nations must commit to aggressive action plans that prioritize solar energy adoption, backed by policies, financial support, and international cooperation. By following this roadmap, we can harness the power of the sun to create a more sustainable and resilient future for all.

GREEN HYDROGEN'S IMPACT ON MENA'S ENERGY TRANSITION

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The Middle East and North Africa (MENA) region is poised to gain considerably from a renewable energy transition. According to some indicators, this transition may be just around the corner: since May 2022, some countries have added 6.7 GW to their operating large utility-scale solar capacities, an increase of 90%. With 7.8 GW of solar projects under construction and set to be completed by the end of 2024, the region's solar fleet is expected to grow a further 50% by next year.

The region also has significant plans for developing solar capacity in the future. Currently, MENA boasts 209 GW of prospective utility-scale solar capacity, meaning projects that have been either announced or are in the pre-construction or construction phases. However, a full 50% of this capacity is designated for the production of green hydrogen, despite the uncertainty and risk involved with this nascent technology. Nearly half of MENA countries are embracing either green hydrogen or direct energy export in a bid to diversify their economies. While Oman and Morocco appear to be threading the needle by planning sufficient solar projects to meet their domestic green electricity targets, in many MENA countries the focus on green hydrogen may undermine efforts to provide ample domestic electricity access or transition national electricity sectors away from fossil fuels.

These planned hydrogen projects are massive — averaging 2.3 GW of solar power per phase (15 times the global average) — and have distant estimated start years. Additionally, the technology and infrastructure for transporting green hydrogen, especially over long distances, are still being developed. These attributes, combined with risks in finding buyers, market competition, and higher capital investments, make the likelihood of these projects becoming operational lower than if they were instead being built to supply electricity to the grid.

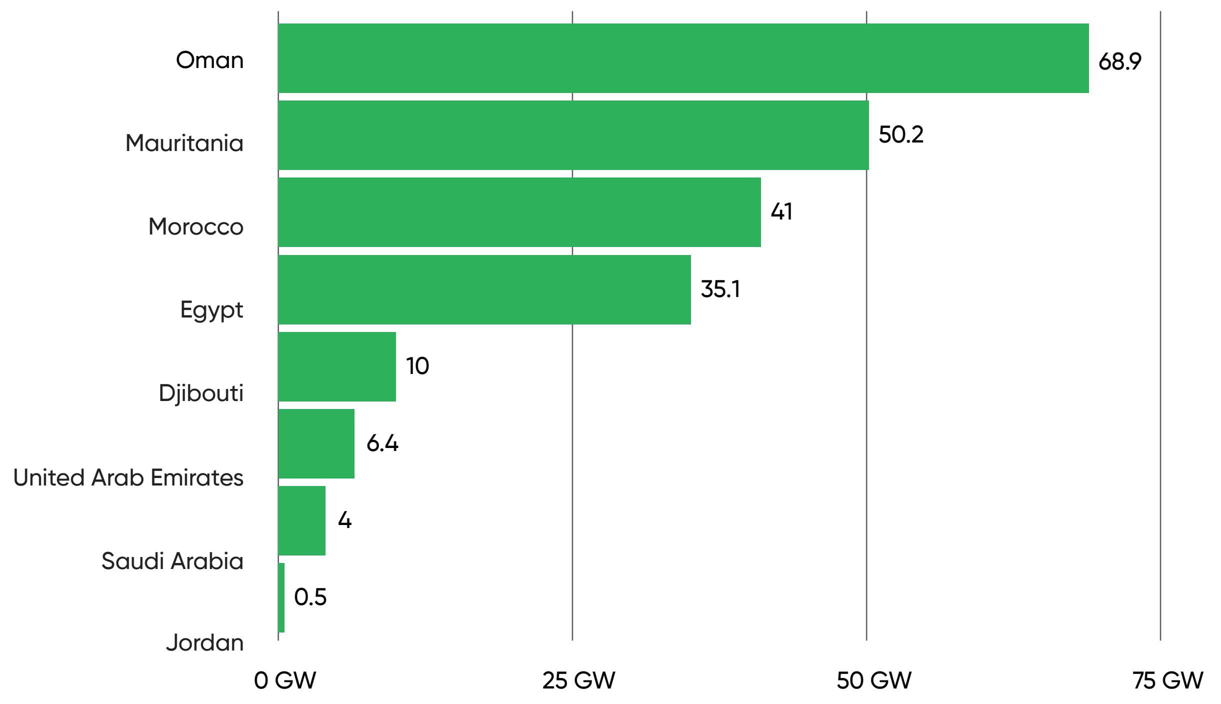
The intention behind most of these projects is to export abroad, rather than use them in situ to decarbonize local industry and electricity sectors. Nevertheless, green hydrogen is an essential piece of meeting global climate goals by replacing coal in fertilizer, steel, and cement production. These replacements are most effective if the hydrogen being produced is used in close proximity to its production site.

Six nations in the region — Iraq, Kuwait, Libya, Oman, Qatar, and Saudi Arabia — earn more than a quarter of their GDP from oil and gas extraction. If the world transitions away from fossil fuels, these nations could face a tremendous economic loss. Under this context, for some countries in the region green hydrogen represents a way for them to potentially diversify their economies while staying in the familiar business of energy export.

In Oman, where the oil and gas industry makes up 25% of GDP, the government is considering a gradual transition of their economy from one highly dependent on fossil fuels to one focused on green hydrogen. It has established a state-owned company, Hydrogen Oman (Hydrom), to execute its green hydrogen strategy which has already led to a $20 billion investment across six green hydrogen projects. 72% of Oman's 46 GW of total prospective large-scale solar capacity is specifically intended for generating hydrogen. If Oman brought 40% of the remaining 13 GW of prospective utility-scale solar not earmarked for hydrogen they would meet their 2030 goal of having 20% of their electricity fed by renewables.

Renewables currently make up 19% of electricity generation in Morocco, and the country's goal of having 52% of electricity from renewables by 2030 might be the most credible target in the MENA region. Not considering increasing demand, Morocco would need to add about 2.1 GW of new solar along with 1.5 GW of wind capacity to reach their target. Discounting the 26.5 GW of utility-scale solar capacity allocated for either hydrogen or direct electricity export to Europe, the remaining 2.5 GW of prospective utility-scale solar in Morocco, if realized, would be very close to achieving this target. Not all identified prospective projects will be built, but as long as the large hydrogen and export projects do not divert resources and financing, and the country continues to double down on renewable energy, it is on track to meet its target.

Prospective capacity in gigawatts (GW) of green hydrogen projects in the region



Note: Data includes only project phases with a capacity of 10 megawatts (MW)
Source: Global Wind Power Tracker, Global Solar Power Tracker Global Energy Monitor

Figure 01: MENA Growing Commitment to Green Hydrogen

In Mauritania, a country where less than 50% of the population has access to electricity, three colossal green hydrogen projects have been announced totaling 50 GW. The remaining 34 MW of prospective utility-scale solar capacity, if built, would increase the national electricity capacity by about 5%. By comparison, if each Mauritanian resident were allocated 3000 kilowatt hours per year (kWh/year), approximately the global average power consumption, the country would need to install about 3.2 GW of solar capacity along with 2.3 GW of wind capacity.

Djibouti finds itself in a similar situation, with a 10 GW green hydrogen facility proposed and only 1.3% of that amount (126 MW) of electrical capacity is currently in place for the entire country. Fully electrifying Djibouti to the global per-capita electricity usage would take roughly 1.7 GW of solar capacity.

Both Mauritania and Djibouti have very small power sectors and low electricity access. Green hydrogen might bring green jobs and local investment for these economies, but the multinational energy companies proposing these projects need to recognize they have the potential to fully decarbonize and electrify entire nations with a fraction of the power they are trying to extract and export.

The region's current path to a green economy relies overwhelmingly on hydrogen exports, but such a focus on green hydrogen projects could potentially divert resources, financing, and focus away from providing energy access and progress towards replacing gas, oil, and coal power with clean energy. Setting and working towards ambitious renewable targets can and should go hand in hand with developing green energy export opportunities.

References:
[1] *"Green Hydrogen References. (2023). MESIA 2023 Special Report. GEM Wiki. https://www.gem.wiki/MESIA_2023_Special_Report_Green_Hydrogen_References.*

MENA'S EMERGING ROLE IN GLOBAL SOLAR MANUFACTURING

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The global landscape of solar panel manufacturing is rapidly evolving, with mainland China currently dominating over 90% of the supply chain. From polysilicon to modules, China's influence is pervasive, setting the tone for supply-demand dynamics worldwide. However, as the urgency to transition to renewable energy intensifies, other regions are entering the fray, aiming to diversify the supply chain and reduce dependency on a single market. One such emerging market is the Middle East and North Africa (MENA) region, which presents a mixed bag of opportunities and challenges, albeit with significant variations between the sub-regions.

The global photovoltaic (PV) supply chain has surged in recent years, with several announcements across the value chain increasing the outlook for manufacturing capacity. However, polysilicon, ingots, wafers, cells, and modules – the key components in the manufacturing process – are largely sourced from China. As global renewable energy targets become more ambitious, there is a growing need for diversification in the supply chain to mitigate risks and ensure a more resilient energy transition.

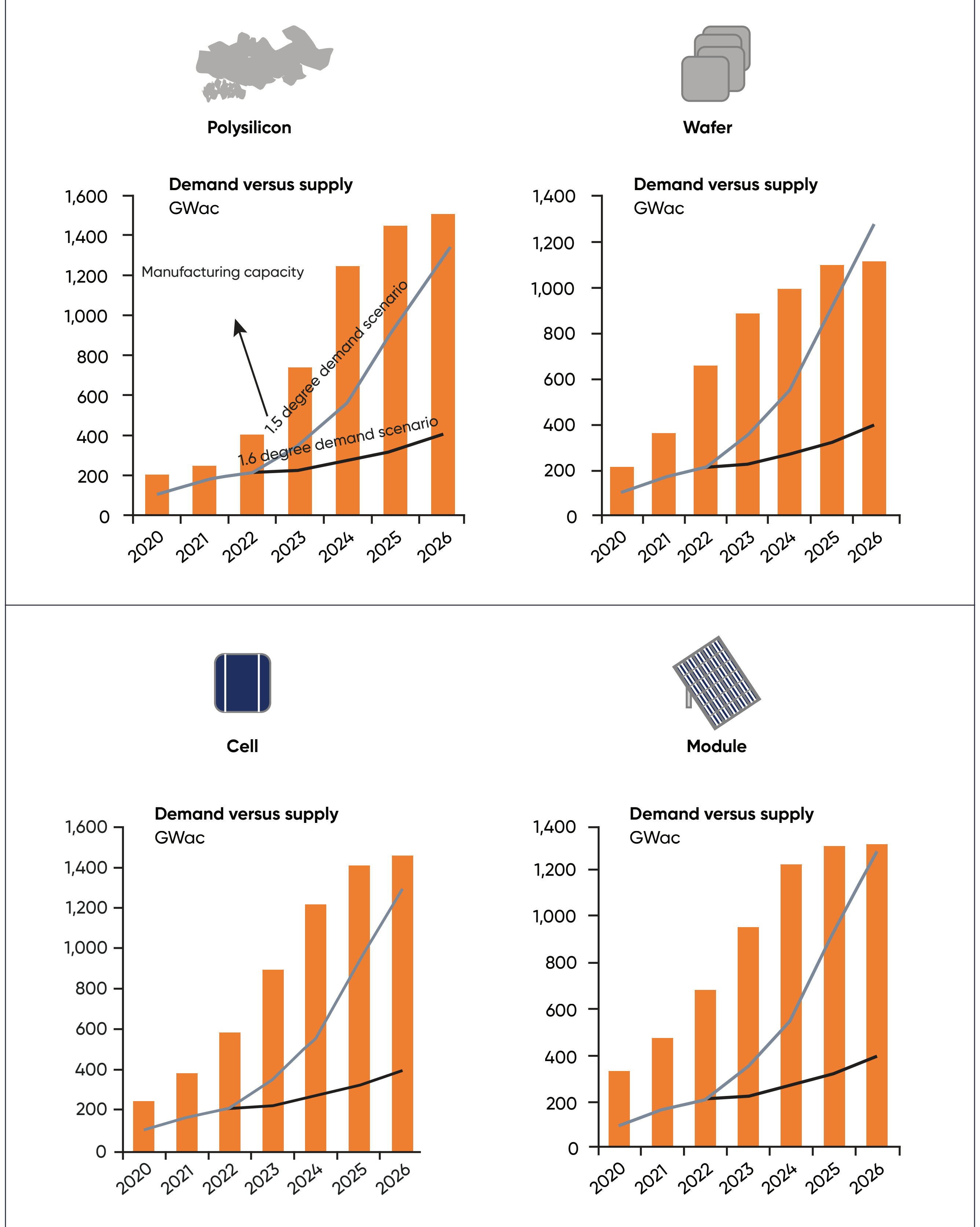

Figure 01: Global Solar Manufacturing Capacity Well Placed to Meet Demand [1]

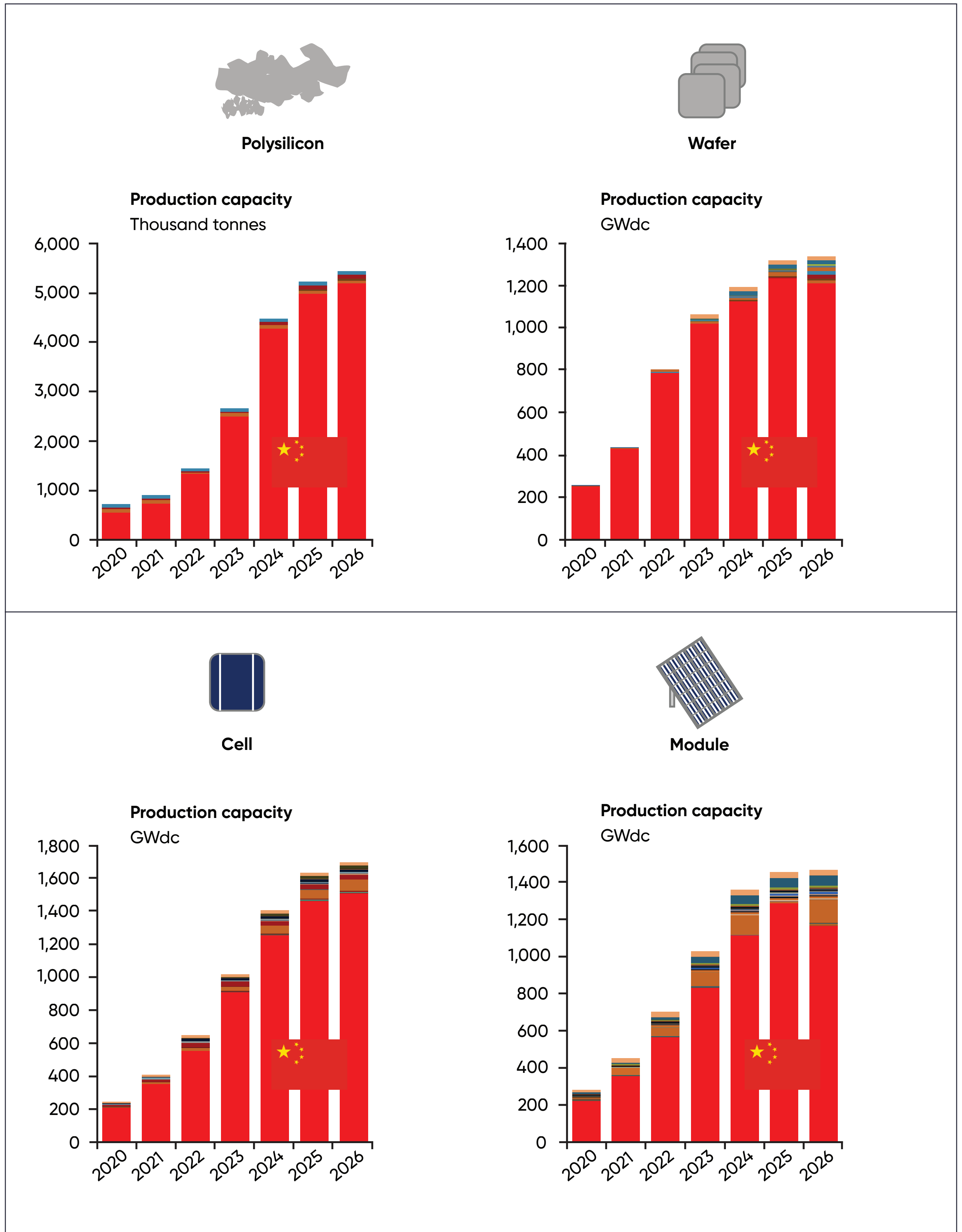

Figure 02: Solar Supply Chain Largely Connected in China [1]

THE MIDDLE EAST: A NEW POLYSILICON EXPORTER?

The solar sector in the Middle East is a study in contrasts. On the one hand, the Middle East is making significant strides in module manufacturing, with projections indicating a capacity of over 17 GW by 2025. In this context, Turkey stands out as the dominant force, holding a commanding 80% share of both the current and projected future manufacturing capacity in the Middle Eastern solar sector. On the domestic front, companies like Smart Solar, Elin Enerji, CW Enerji, Kalyon, and HT Solar are not merely participants but key players. Each of these Turkish firms either currently operates or has concrete plans to scale up their module manufacturing facilities to exceed 1 GW, reinforcing Turkey's substantial influence in the market. However, the narrative isn't solely focused on domestic companies. The Turkish market has started to lure international attention as well. Specifically, Germany's AE Solar and China's Talesun are not only entering but are also slated to join the ranks of Turkey's "gigawatt club." This international participation emphasizes Turkey's strategic attractiveness for manufacturers, demonstrating that the region is ripe for both domestic and foreign investment in solar module manufacturing.

Yet, it is lagging in the manufacturing of wafers and cells, the critical components of these modules. This creates an imbalance in the supply chain, making the Middle East dependent on external suppliers, primarily from China. This dependency exposes the Middle East to global market fluctuations, which could jeopardize its renewable energy ambitions.

The story for polysilicon has the potential to be different, however, with the recent announcement from Chinese player GCL Technology that it is considering the establishment of a 120,000-tonnes-per-annum manufacturing facility in Saudi Arabia. Should this materialize, it could be a game-changer, not just for Saudi Arabia but for the entire Middle East, positioning it as a significant player in the global polysilicon market.

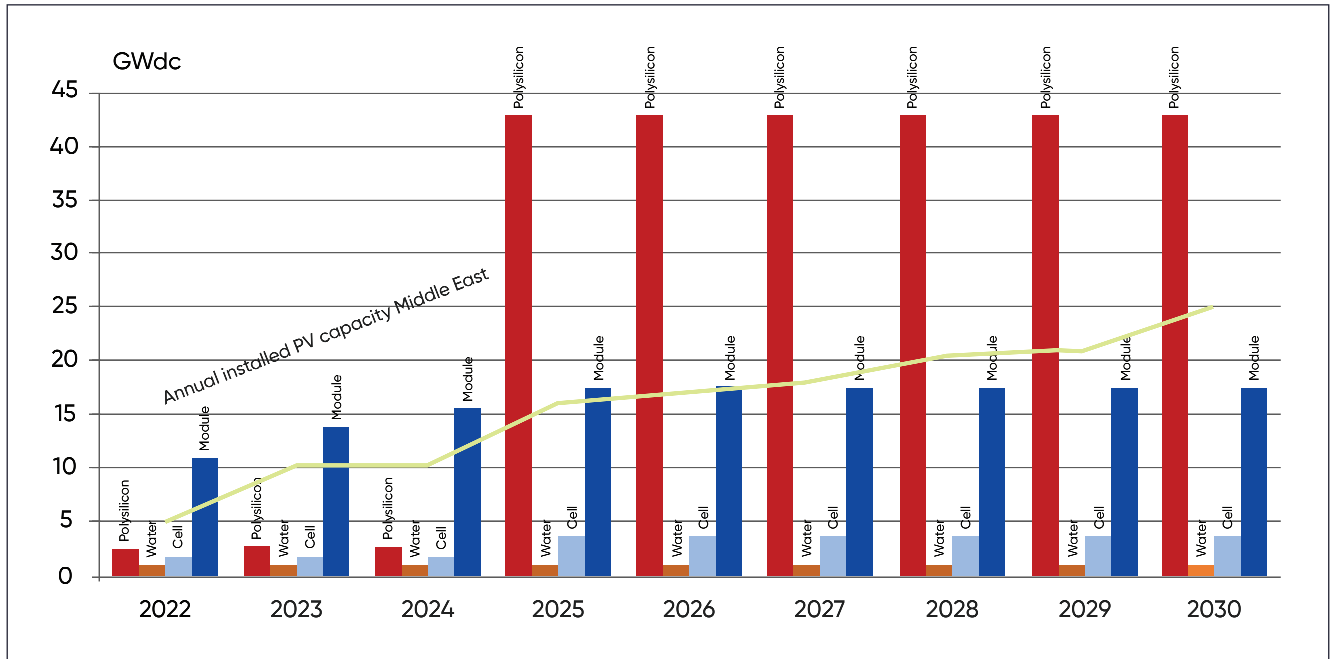

Figure 03: Middle East Positioning to be Polysilicon Exporter [1]

NORTH AFRICA: IMPORT DEPENDENCY

The solar landscape in North Africa is markedly different. North Africa has virtually no manufacturing capacity in the PV panel sector, making it heavily reliant on imports to meet its growing solar energy needs. Given North Africa's abundant solar resources and increasing demand for renewable energy, this lack of local manufacturing capacity is a significant vulnerability, exposing it to supply chain risks and price volatility, which could inhibit the growth of solar installations.

To counterbalance this, the Africa Renewable Energy Manufacturing Initiative was launched at the beginning of this year. This initiative, which aims to unlock USD 850 million to advance manufacturing within renewable energy across the continent by 2050, has the potential to boost the regional PV value chain. Some research has also been carried out on the cost level of module manufacturing in African countries compared to China which implies that at least module assembly is likely to ramp up under the initiative. Looking to other regions that are currently trying to onshore the PV supply chain, it is evident that this will take time in Africa and the primary additions are likely to be within cell and module manufacturing in the coming years.

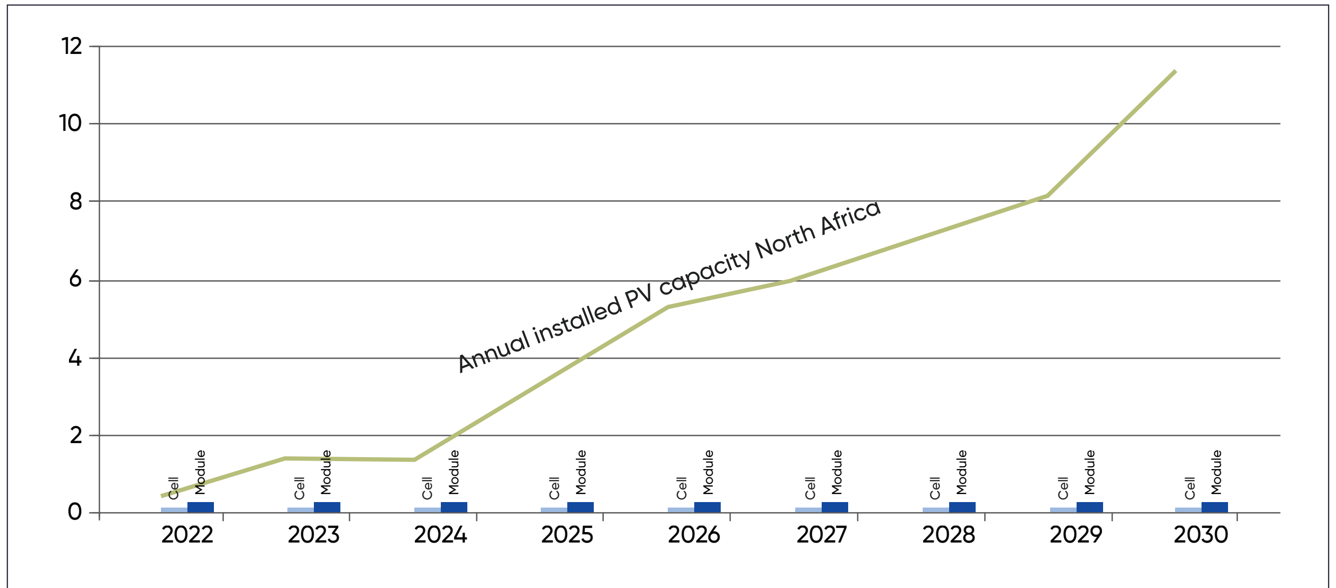

Figure 04: North Africa Fully Reliant on Imports to Meet Demands [1]

AN EVOLVING SOLAR SUPPLY LANDSCAPE

The MENA region presents a complex picture in the global PV panel manufacturing landscape. While the Middle East shows promise in module manufacturing and has the potential to become a key player in the polysilicon market, it needs to address the gaps in wafer and cell manufacturing to achieve a balanced supply chain. North Africa, on the other hand, faces the uphill task of building its manufacturing capacity from scratch – a challenge that requires significant investment.

Both sub-regions within the MENA region have unique challenges and opportunities, but their evolving roles in the global solar market are clear. With strategic investments and industry partnerships, the MENA region could become a significant player in the global solar energy landscape, contributing to both regional and global sustainability goals.

References:

[1] *"Rystad Energy Solar Solution." [Online]. Available: https://www.rystadenergy.com/*

REGIONAL COLLABORATION AND THE MENA REGION'S ROLE IN ENHANCING EUROPEAN STABILITY

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The European Union (EU) is at a critical juncture in its energy transition journey, with the escalating geopolitical tensions and the urgent need for decarbonization, the bloc is increasingly looking towards North Africa as a cornerstone for its energy security and sustainability.

A 3 GW Green Energy (GREGY) Interconnector is planned to be built between Egypt and Greece, this major interconnector could significantly cut gas for power demand in Greece and its neighboring countries over the long term, while potentially also stabilizing the European Union (EU)'s power system.

North Africa is no stranger to large-scale project announcements due to the significance of solar and wind potential in the region. Following the announcement of Xlinks' 3.6 GW Morocco – UK interconnector project; Greece Copelouzos Group and Egypt Infinity Power have joined forces to add the GREGY interconnector to the list of power links envisioned to connect the two continents. This further epitomizes the strategic shift and underscores the pivotal role the Middle East and North Africa (MENA) region is playing in the stabilization and diversification of the EU's energy portfolio.

EUROPE EYES NORTH AFRICA'S ABUNDANT RENEWABLE POTENTIAL

North Africa, boasting countries with the highest electrification rates on the continent, is set to continue experiencing rapid growth in intermittent renewable capacity over the coming years. With the Russia–

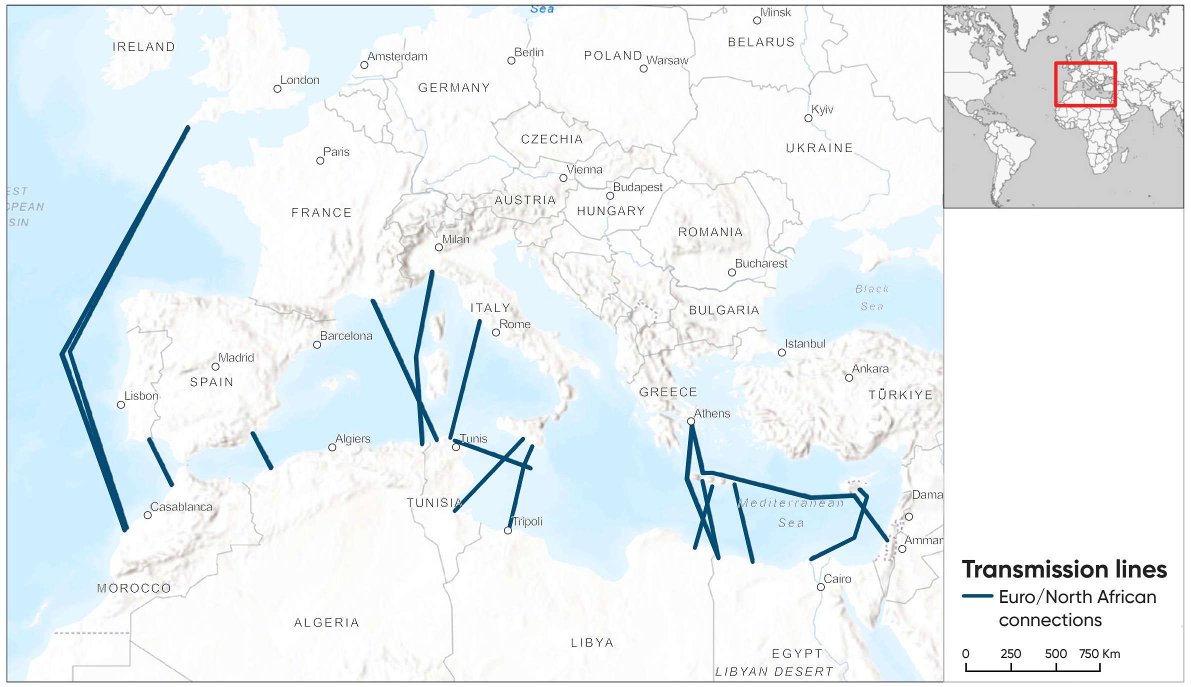


Figure 01: Planned Subsea Interconnectors Between North Africa and Europe [2]

Ukraine war and subsequent disruption in Russian gassupplies that prompted the search for an alternative and sustainable energy source, Europe has rushed to tap North Africa's vast renewables potential by deploying huge solar and wind farms in combination with intercontinental power links and green hydrogen.

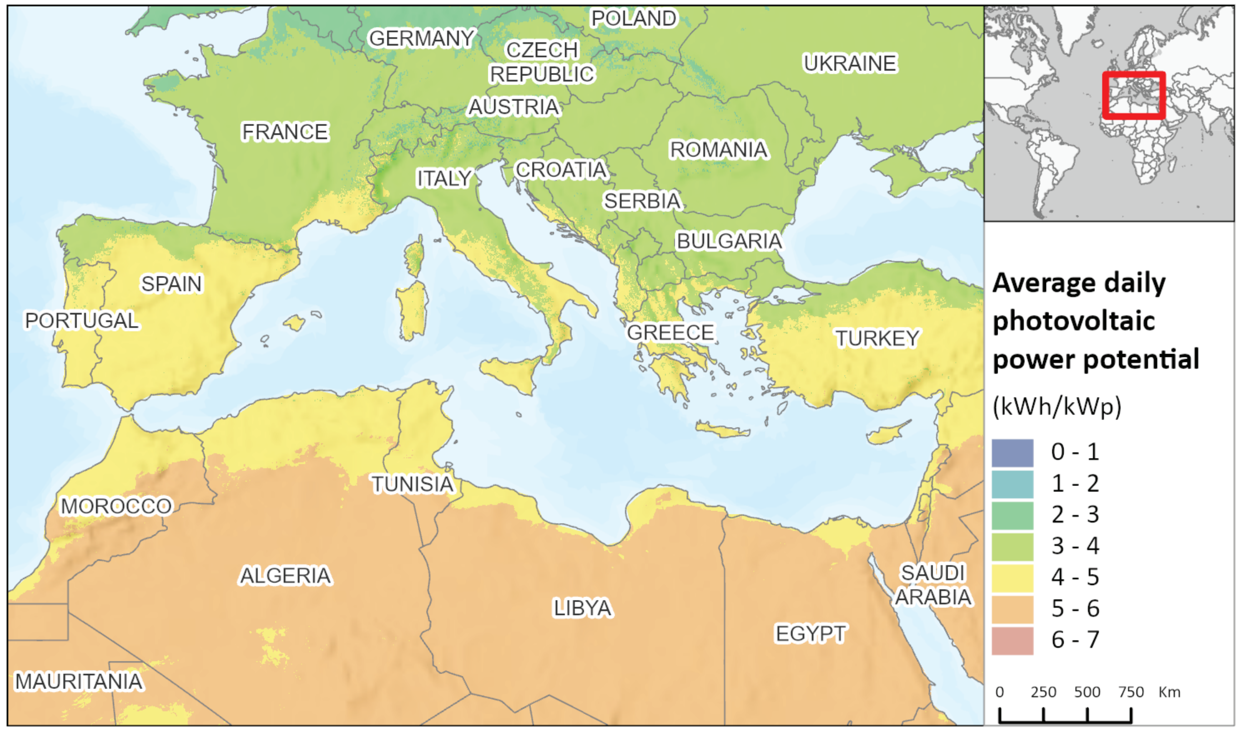
Morocco currently leads the region in this respect, with the country already exporting power via its two existing power links with Spain – Europe's only interconnections with Africa. A subsea interconnection spanning 28 km with a technical capacity of 700 MW was set up between the two countries in 1997, which began commercial operations in May 1998. A second electricity interconnection with identical technical capacity was set up in mid-2016, spanning 31.3 km.

With plans of introducing a third interconnector of the same technical capacity, Morocco launched a green partnership focusing on energy, climate, and the environment with the European Union (EU) prior to the COP27 climate event that was held in Egypt last year. Additionally, UK-based Xlinks aims to connect the sandy fringes of the Maghreb region in northwest Africa to Devon in southwest England, through a 3.6 GW subsea interconnection. Other North African nations have been linked with proposed interconnections, the most notable being the 3 GW GREGY interconnector from Egypt to Greece and the 600 MW Elmed interconnector from Tunisia to Italy (Figure 1).

Courtesy: Bahrain Mall Solar Power Plant -Bahrain -YDE

The planned interconnection with Greece is significant to Egypt's existing ambitions to transform into a major power hub, by being strategically located between Europe, The Middle East and Africa. The country receives abundant solar energy – annual direct solar radiation averages about 1,900 to 2,775 KWh/m2, due to its location in the earth's solar belt. Egypt's daily specific photovoltaic power output lies in the 4.8 to 5.6 kWh/kWp range, while Mediterranean countries, such as Greece lies between 3.6 and 4.8 kWh/kWp. Egypt also enjoys excellent wind potential, particularly in the Gulf of Suez, where wind speeds reach 10 m/s (Figure 2). This contrast in potential can be seen in the capacity factors for both solar PV and onshore wind – North African countries remaining comparatively stable compared to their counterparts in Southern Europe, where the variability peaks during summer and winter (Figure 2).

Solar Potential – Photovoltaic Power Potential



Solar PV Capacity Factors

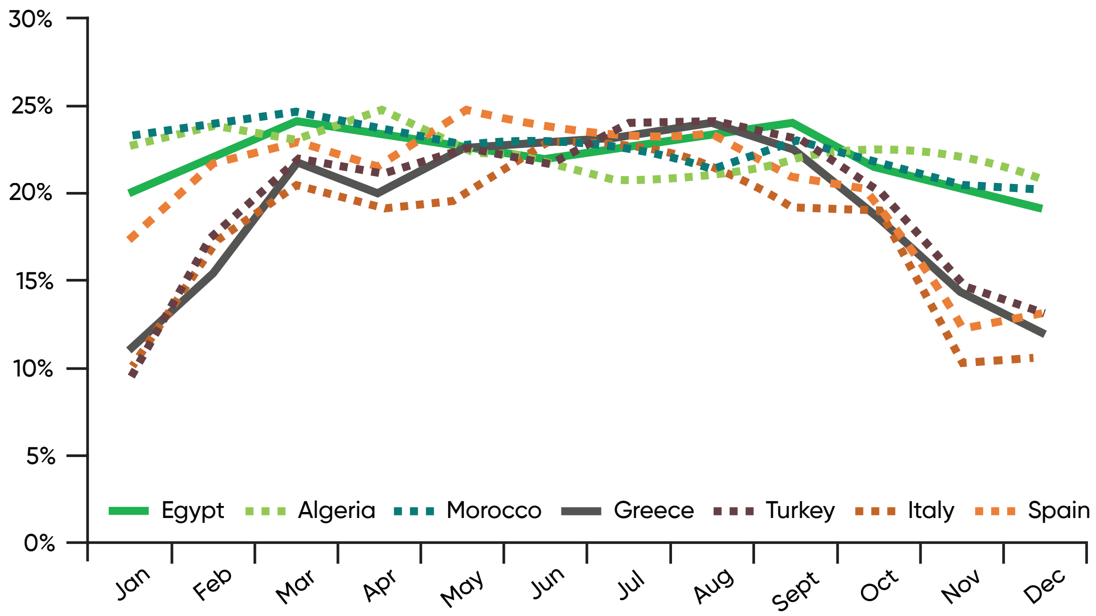
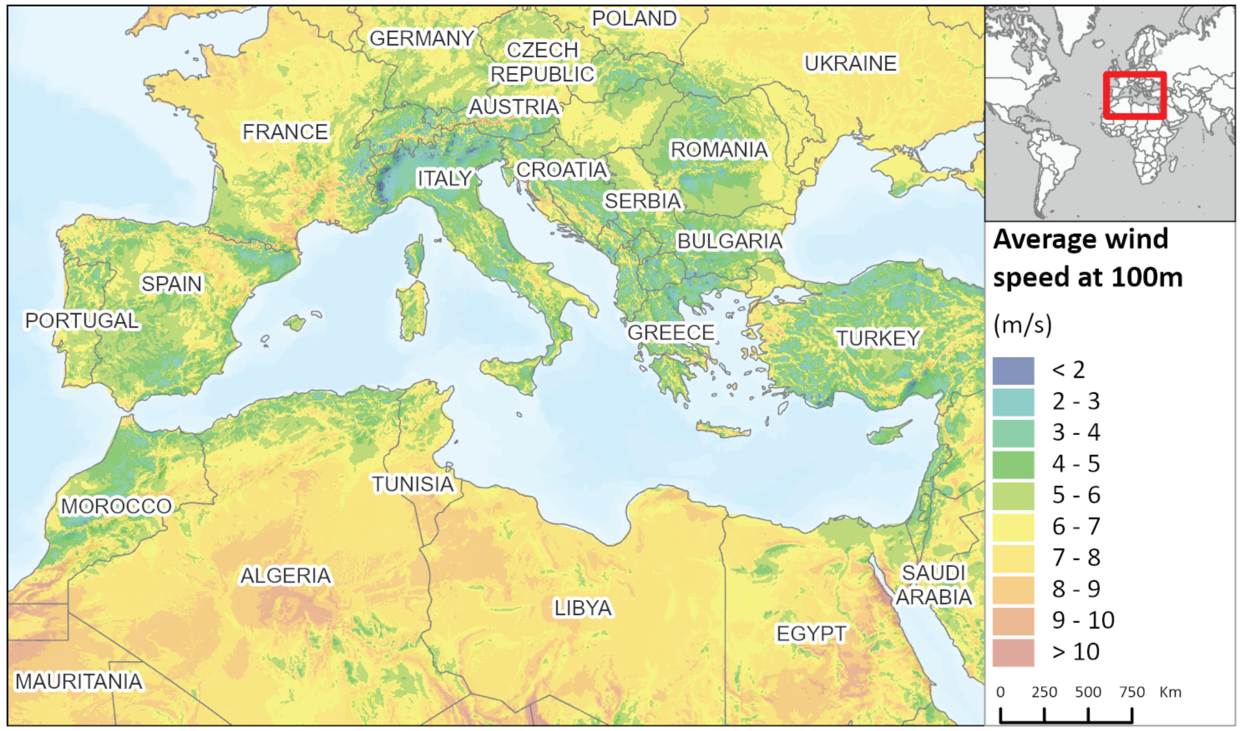


Figure 02: Solar Potential - Mediterranean Nations [1]

Wind Potential – Wind Speed at 100 meters



Onshore Wind Capacity Factors

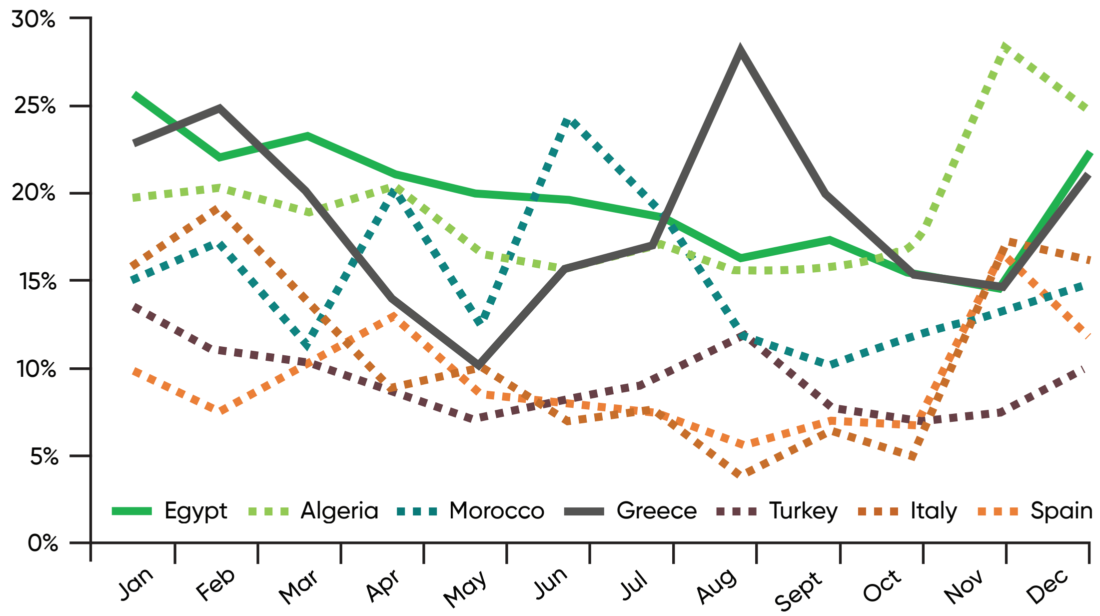


Figure 02: Wind Potential - Mediterranean Nations [1]

Egypt has actively developed and executed such infrastructure projects in the past: a 500MW interconnector with Jordan, increasing to 1 GW through an expansion plan; 80 MW with Sudan, climbing to 300 MW through an expansion plan; 200 MW with Libya, rising to 450 MW through an expansion plan in the near term and 1 GW in the future. Egypt is also finalizing an interconnector with Saudi Arabia – 1.5 GW in the first phase, expected to go live in June 2025, followed by a second and final 1.5GW phase in November 2025. The country also has plans in place to supply 700 MW to Iraq by expanding its interconnection with Jordan.

The MENA region is becoming a key player in the EU's strategy for energy security and decarbonization. The GREGY interconnector or other similar projects exemplify this, serving not just as an energy project but as a geopolitical tool to enhance the EU's energy stability. Aligned with the EU's Fit-for-55 and RepowerEU initiatives, these projects help diversify the EU's energy sources by tapping into MENA's abundant renewables. This is a strategic move to reduce the EU's dependency on natural gas, thereby bolstering its energy security.

MENA is evolving from merely an energy supplier to a strategic ally of the EU. Its stable solar and wind resources can help the EU manage the intermittent challenges associated with renewables. In summary, the growing energy ties between MENA and Europe have both energy security and geopolitical implications. As the EU continues its energy transition, projects like GREGY offer a blueprint for a more secure and sustainable energy future.

References:

[1] *"Rystad Energy Renewables and Power Solution, Rystad Energy GIS Services."*
[2] *""Rystad Energy Renewables and Power Solution, Rystad Energy GIS Services, Rystad Energy Subsea HVDC Interconnector Cables Dashboard."*

COOLING SOLAR PANELS: A KEY FACTOR FOR ENHANCING THEIR EFFICIENCY AND IMPACT IN THE MENA REGION

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FORTUNE BUSINESS INSIGHTS

The Middle East & North Africa (MENA) region, characterized by ample sunshine and high temperatures, offers a lucrative prospect for leveraging solar energy resources. Solar panels have emerged as a hallmark of sustainable energy practices in the area, playing a pivotal role in mitigating greenhouse gas emissions and diminishing reliance on conventional fossil fuels.

Nonetheless, a pivotal element exists that holds the potential to substantially optimize the efficiency and effectiveness of solar panels in this region that is renowned for its extreme heat, which is the integration of advanced cooling technologies.

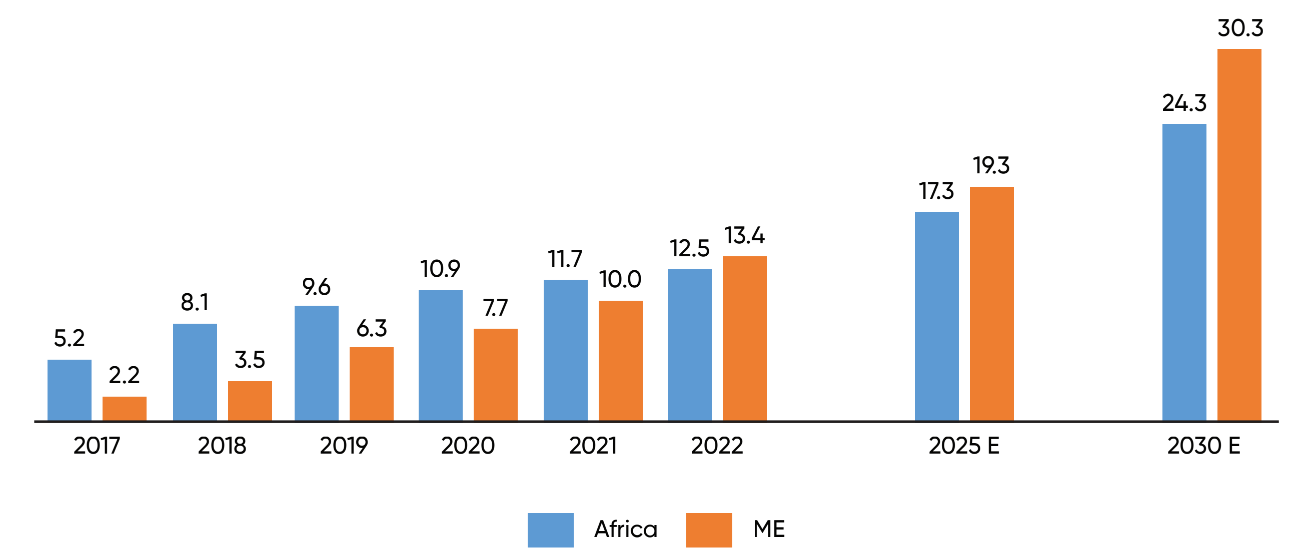

Figure 01: Cumulative Installed Capacity Trend (GW)

CHALLENGE OF EXTREME HEAT IN THE MENA REGION

The MENA region is characterized by its arid and desert climates, where temperatures can soar to extreme levels, often exceeding 40°C (104°F) during the summer season. While this abundant sunshine is advantageous for solar energy generation, the region's relentless heat presents unique challenges that can impact the efficiency and longevity of solar panels.

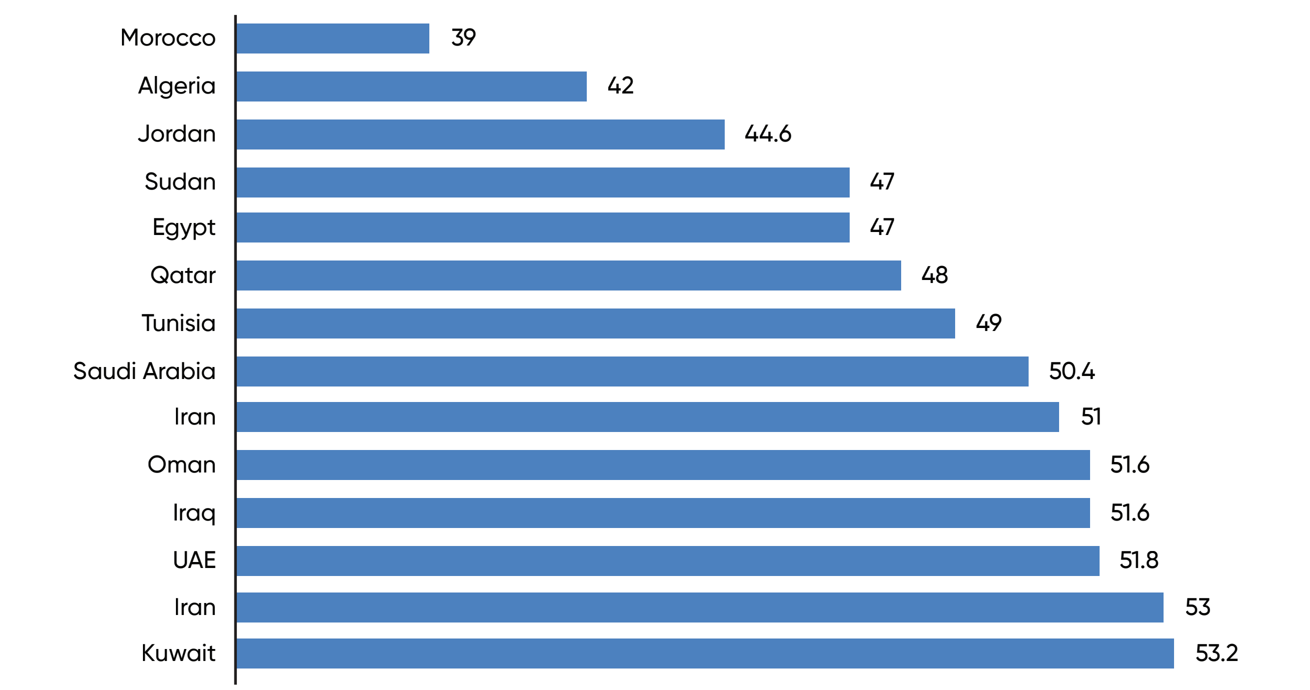

Figure 02: Maximum Temperature Reported in MENA Region (°C) in 2022

Following are some of these challenges:

1. Heat-Induced Degradation:

Elevated temperatures can trigger a phenomenon referred to as "heat-induced degradation" within the realm of solar panels. This process is characterized by the gradual deterioration of solar cell performance resulting from prolonged exposure to extreme heat conditions. Heat-induced degradation can manifest in various ways with direct business implications as:

- Reduction in Efficiency: Elevated temperatures can cause solar panels to operate less efficiently. Solar cells may produce less electricity for the same amount of sunlight, leading to decreased energy output.

- Shortened Lifespan: Heat-induced degradation may shorten the lifespan of solar panels. Overheating could accelerate the wear and tear of the panel materials, potentially necessitating more frequent and costly replacements.

2. Impact on Energy Output:

The performance of solar panels is intricately linked to temperature levels. Solar cells operate at their peak efficiency when temperatures are lower. Consequently, as temperatures rise, the overall efficiency of solar panels tends to decline. This can lead to suboptimal energy generation, especially during the scorching summer months in the MEAN region.

3. Heightened Maintenance Demands:

High temperatures can also increase maintenance requirements for solar panels. Dust and sand, common in arid environments, can accumulate on the panels, further reducing their efficiency. Regular cleaning and maintenance are necessary to mitigate these effects.

4. Inconsistent Performance:

Inconsistent panel performance resulting from extreme heat conditions can disrupt energy generation predictability and optimization. These fluctuations in energy output can undermine the reliability of solar power systems, which is a critical consideration in regions with high energy demand.

5. Economic Implications:

The repercussions of reduced efficiency and shortened panel lifespan due to heat-induced degradation have notable economic implications. Such consequences encompass increased operational expenditures, encompassing higher energy production and maintenance costs. Moreover, the need for more frequent panel replacements can strain financial resources and impact the overall cost-effectiveness of solar projects.

Recognizing and addressing heat-induced degradation becomes essential for businesses operating in the solar energy sector within the MENA region. Implementing strategies to mitigate these challenges is paramount to maintaining the economic viability and sustainability of solar ventures.

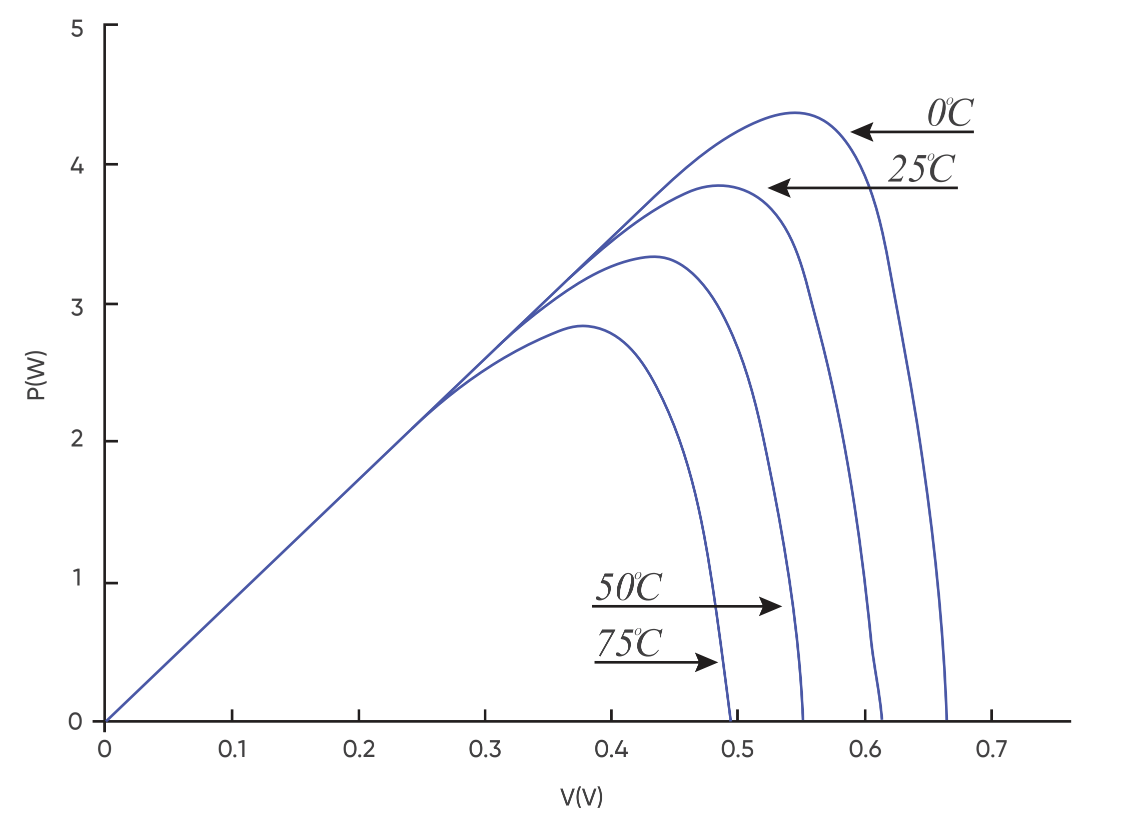

Figure 03: Temperature Levels Impact on Peak Efficiency

COOLING SOLAR PANELS: A GAME-CHANGER

To maximize the potential of solar energy in the MENA region, it is crucial to implement effective cooling systems for solar panels. Several cooling methods have proven successful. The following are some of those methods:

1. Active Cooling Systems

Active cooling systems for solar panels leverage external mechanisms to effectively dissipate excess heat. While they require energy inputs, they offer remarkable efficiency improvements:

- Water-Based Cooling Systems: Water serves as a common cooling medium in active systems. By circulating water through pipes or channels adjacent to the solar panels, heat absorption occurs. This heated water is then directed to a heat exchanger for dissipation, promoting temperature regulation.

- *Eg: In 2020, scientists at Saudi Arabia's King Abdullah University of Science and Technology unveiled a cooling innovation using an atmospheric water harvester. This device, positioned behind commercial PV panels, collects atmospheric water during the night and subsequently vaporizes and releases it during the day, harnessing waste heat from the panels for cooling.*

- **Forced-Air Cooling:** Utilizing DC fans as an air-cooling technique, this method removes hot air, replacing it with cooler air. This approach capitalizes on the higher density of cold air compared to hot air, closely aligning panel temperature with the ambient environment.

- **Phase Change Materials (PCM):** PCMs are capable of absorbing and releasing thermal energy during phase changes, which can be integrated into solar panels. They absorb excess heat during the day and release it at night, contributing to temperature control.

  - *In a study, a photovoltaic-phase change material (PV-PCM) system is employed to evaluate its energy-saving performance throughout the year in a very extreme climate in the UAE. A paraffin-based PCM with a melting range of 38–43 °C is integrated at the back of the PV panel, and its cooling effect is monitored. The increased PV power output due to cooling produced by PCM is quantified.*

2. Passive Cooling Systems

Passive cooling systems offer an energy-efficient alternative, relying on natural mechanisms or specific materials to curb solar panel temperatures:

- **Elevated Mounting Structures:** Elevating solar panels, be it in large-scale solar farms, residential rooftops, or remote off-grid locations, it facilitates airflow beneath them. Natural convection cools panels through conduction and radiation. These types of systems are majorly implemented in the following ways:
  - *Large-Scale Solar Farms and Power Plants*
  - *Residential and Commercial Rooftop Installations*
  - *Remote Off-Grid Locations*
  - *Research and Development Facilities*
  - *Sustainable Urban Development Projects*

- **Cool Roof Coatings:** Applying reflective or cool roof coatings mitigates heat absorption by reflecting a substantial portion of solar radiation away from the panels.
  - *Eg: In a study conducted in Sharjah, UAE, cool roof coatings demonstrated a 5-10% improvement in electricity generation.*

- **High Reflectivity Materials:** Some solar panels integrate materials with high reflectivity. These materials redirect incoming sunlight, reducing heat absorption.

Both active and passive cooling systems have their advantages and are suitable for different applications and environments. The choice of a cooling system depends on factors such as cost, energy availability, climate, and specific project goals. In the MENA region, a combination of these cooling strategies can be employed to optimize solar panel efficiency and ensure reliable energy generation, even in extreme heat.

THE BUSINESS IMPACT OF COOLING ON SOLAR PANEL EFFICIENCY IN THE MENA REGION:

Floating solar farms in MENA are a recent innovation with great potential for boosting solar panel efficiency. Positioned above water bodies, they use evaporative cooling to lower PV panel temperatures, enhancing performance. Cooling effectiveness depends on system design, platform structure, and panel-water contact. Research indicates that floating PVs (FPVs) are on average 11% more efficient than ground-mounted panels, a significant advantage in MENA's increasingly hot climate. Additionally, FPVs resist dust buildup due to their water installation, keeping panels cleaner and ensuring they receive more sunlight compared to traditional PV solar farms.

While the installation of floating solar PV systems entails higher upfront costs when compared to traditional solar PV setups, it emerges as a highly effective solution to address the prevalent challenges associated with PV overheating. Simultaneously, this presents a substantial business opportunity, particularly in major countries like Saudi Arabia and the UAE, where significant megaprojects are on the horizon. Key players in the MENA region, such as Masdar, Istanbul

Enerji, and Mahabad Petrochemical Complex, have experience in deploying floating solar power plants.

- In June 2022, Tunisia inaugurated a 200 kW floating solar power plant in the Berges du Lac district, generating approximately 265 MWh annually with a EUR 500,000 investment, thanks to a collaboration between France's Qair and Tunisian electricity and gas company STEG.

- In 2020, the UAE launched its first floating solar power plant in Abu Dhabi, contributing an additional 80 kW of solar energy to the Zaya Nurai resort, which already had 1,000 kW of rooftop and ground-mounted photovoltaic systems. Notably, floating solar projects like this are roughly three times more expensive than their land-based counterparts.

- Iran made strides in floating solar energy with the launch of the first such power plant in 2020 by Mahabad Petrochemical Company, boasting a 200 kWh daily capacity with the potential to reach 500 kWh in its second phase. An estimated project cost of IRR 8,500 million and government support yield a return on investment in less than five years.

- A significant milestone is anticipated in 2026 with the launch of a large-scale 1,100 MW floating solar PV project in Al Madinah, Saudi Arabia, known as the Al Henakiyah Floating Solar Power Project, developed and owned by the Saudi Power Procurement Company (SPPC). Construction is set to begin in 2024, with commercial operation expected in 2026.

Cooling solar panels is crucial for businesses seeking maximum efficiency in the MENA region. As the demand for sustainable energy solutions rises, optimizing solar panel performance in high-temperature environments becomes a strategic imperative. Innovative cooling solutions can unlock the MENA region's full solar energy potential, paving the way for a more sustainable and prosperous future.

SOILING EFFECT ON SOLAR PV SYSTEMS

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INTRODUCTION

Solar PV soiling refers to the process of contaminants being deposited on the surface of solar PV modules, ultimately obstructing direct sunlight. This deposition layer creates a barrier that reduces the number of photons reaching the solar module surface, leading to a decrease in system yield. This phenomenon is primarily caused by local environmental conditions and can be considered a location-dependent challenge. The size of the deposited soil particles plays a significant role in modelling or studying the soiling mechanism.

Therefore, the soiling effect is inherent in projects within the Middle East and North Africa (MENA) region due to its desert environment, frequent dust storms, and low precipitation levels. Additionally, areas prone to snowfall also experience vulnerability to the soiling effect.

However, for the purpose of this article, our focus will primarily be on the soiling effect caused by the accumulation of contaminants such as dust, dirt, pollutants, and bird droppings on PV.

UNDERSTANDING SOILING EFFECTS

Soiling, as you may know, is a highly site-specific and seasonal occurrence. Its complex and dynamic nature makes it considerably difficult to accurately model and simulate. Though soiling effect can be quantified using the soiling ratio and soiling rate.

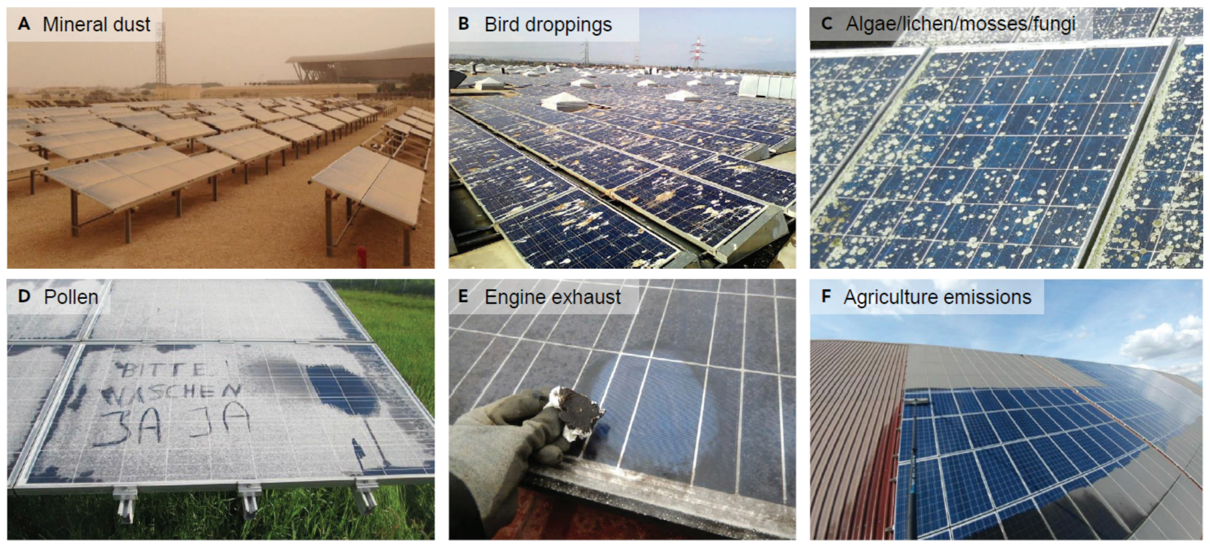

Figure 01: Examples of Soiling [1]

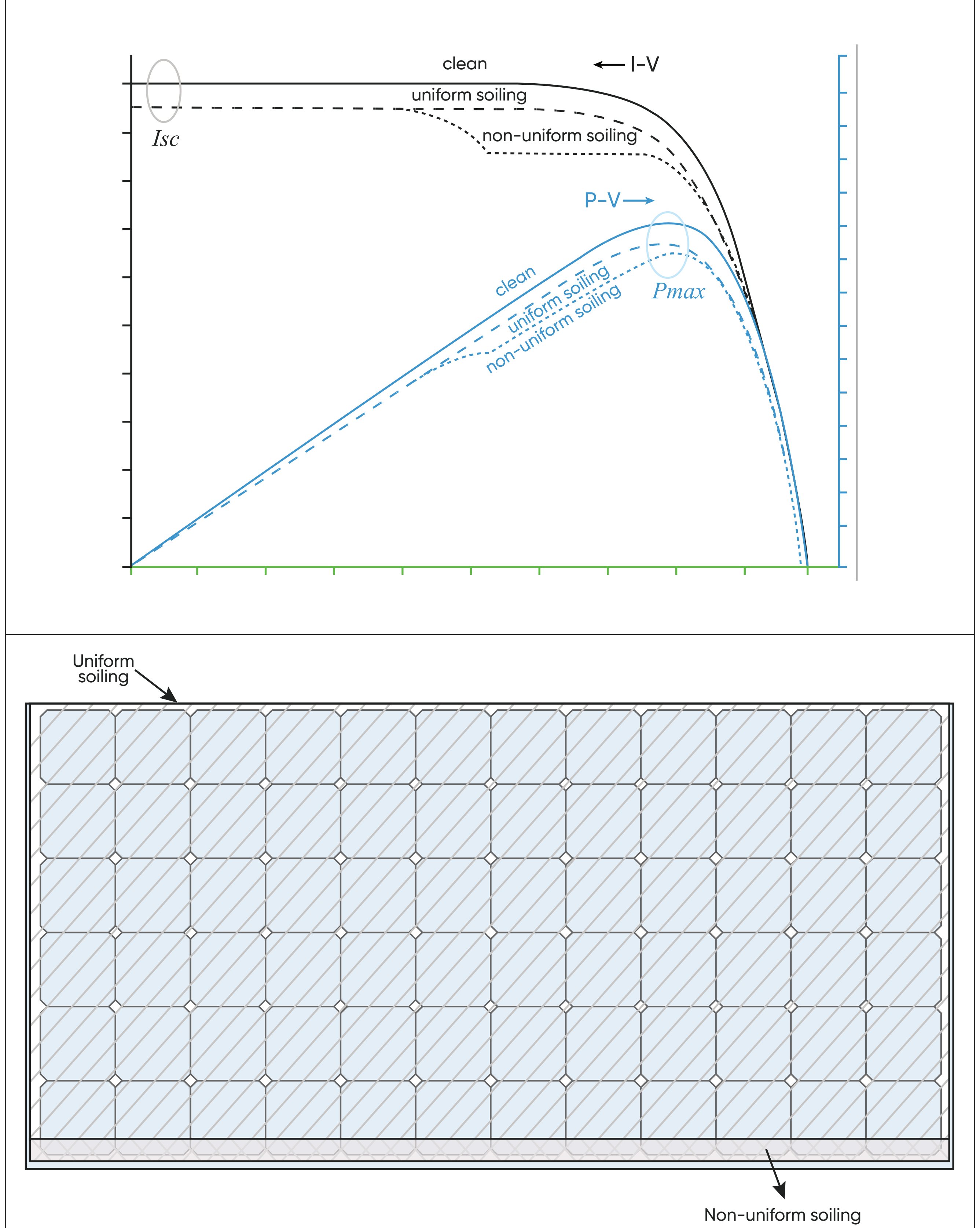

Figure 2: IV and PV Curve Behavior Due to Soiling [2]

According to the IEC-61724 standard, the soiling ratio is determined as the ratio of the power of a photovoltaic (PV) array in soiling conditions to the power of the same PV array in clean conditions. It serves as a measure of the reduction in electrical output of the PV modules due to the accumulation of soiling. The soiling ratio has been used to express the daily, seasonal, or annual impact of soiling on the energy yield.

> *Soiling ratio: ratio of the short circuit current of the soiled cell to the short circuit current of the clean cell under the same conditions (dimensionless).*

The soiling rate refers to the daily variation in the soiling ratio, which represents the amount of accumulated soiling on the PV module surface. It is typically expressed as a percentage per day and conventionally reported as negative. A soiling rate of 0% per day indicates that the soiling ratio is not changing, often occurring when no soiling is being deposited. The soiling rate can be assessed by analyzing the variation of soiling profile slopes between module cleaning cycles.

> *Soiling ratio: daily derate of soiling ratio when no cleaning occurs on the cells (Fraction per day).*

One of the primary factors influencing the amount of contaminant deposition is particle size. Because of that inertia and gravity play significant roles in determining the behavior and movement of dust particles. Therefore, it can be assumed that large particles contribute less to the overall soiling effect.

Also, the presence of moisture can significantly enhance the effect of dust adhesion on the surface of solar modules. This occurrence is primarily attributed to the role of humidity and dew in facilitating dust adhesion through capillarity, caking, and cementation.Desert locations in the MENA region are prone to frequent dew formation during night-time, due to the radiative cooling of PV modules and high relative humidity levels.

THE IMPACT OF SOILING ON SOLAR PV SYSTEMS

Undoubtedly, soiling is one of the most influential factors that directly affect the yield of a solar PV system. Its impact on system yield is particularly pronounced in arid regions, where the accumulation of dust and sand can be substantial. Consequently, soiling becomes a crucial factor to consider when evaluating the feasibility and economic viability of solar projects in such areas. Mitigating or minimizing the effects of soiling requires additional considerations and investments. However, this not only adds to the operational costs, but it also raises questions about the long-term economic viability of the project.

Economic Impact

As per the report "A Comprehensive Review of a Decade of Field PV Soiling Assessment in QEERI's Outdoor Test Facility in Qatar: Learned Lessons and Recommendations" that was published in July 2023 it was indicated that even if the best-optimized cleaning schemes are used, the actual global solar-power production can still be reduced by about 4%, which is associated with at least EUR 5 billion in annual revenue losses worldwide [3]. According to recent estimates, the anticipated loss for 2023 is expected to reach a conservative value of EUR 7 billion. This staggering figure reflects a significant EUR 170 million loss specifically for the MENA region which is associated with approximately 1.305 TWh of energy loss. (Assuming about 4% of soiling loss and from annual solar PV energy generation data [4])

MITIGATION TECHNIQUES FOR ADDRESS SOILING EFFECTS

PV Module Cleaning

This is the most fundamental and common mitigation technique for the soiling effect. However, the scheduling of PV module cleaning cycles and cleaning frequency should be done with the consultation of industry and subject matter experts due to the site specificness and seasonality variation of the soiling pattern.

Typically, it is recommended to have nine to twelve cleaning cycles per annum for solar PV plants in the MENA region. This frequency takes into account the unique conditions in this region, such as high levels of dust and sand, which can accumulate on the solar panels and reduce their efficiency. Considering the scarcity of water sources in the MENA region, it is also suitable to use dry-cleaning-based technologies for solar PV plant cleaning.

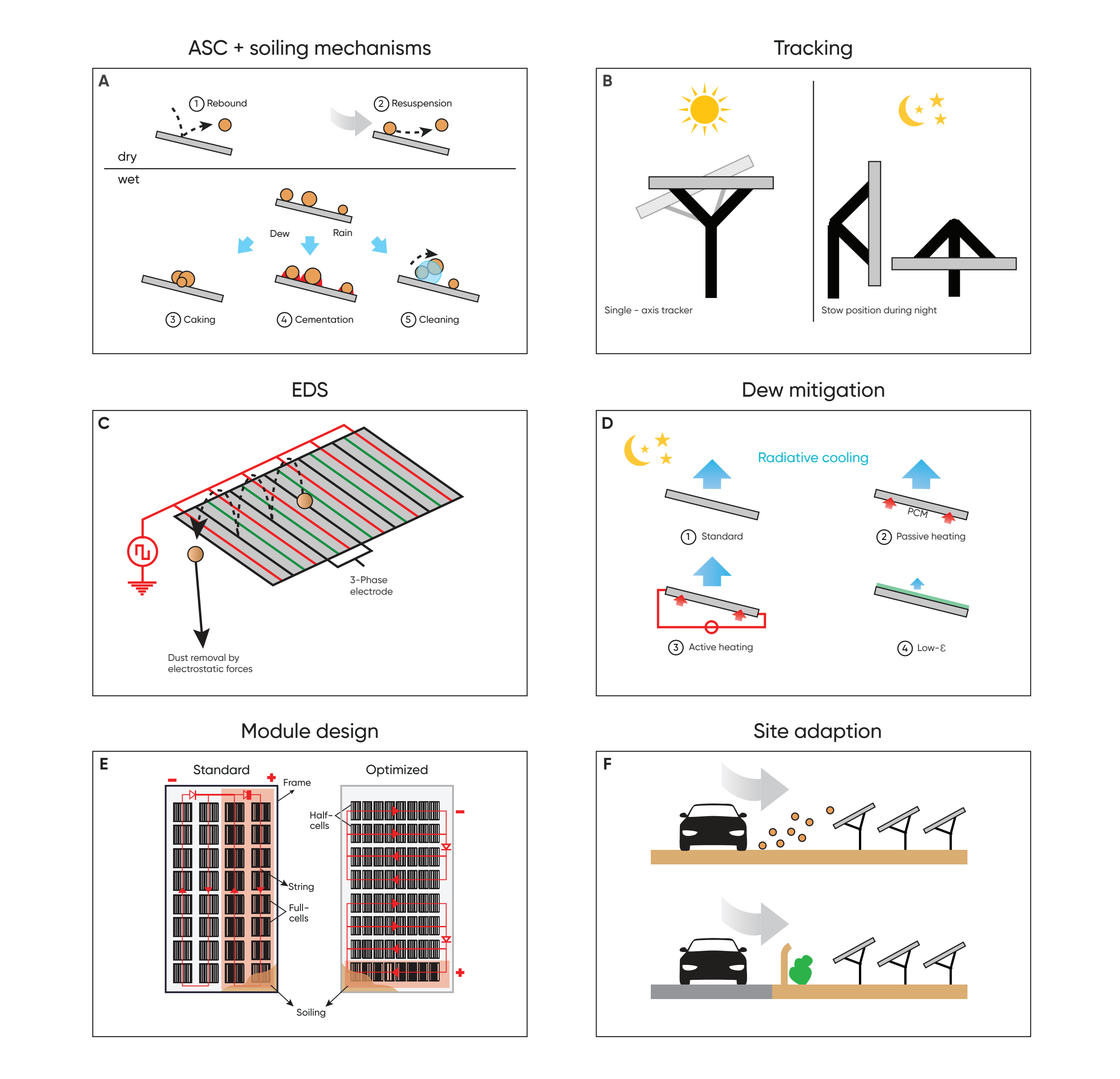

Figure 03: Soiling Mitigation Techniques [1]

Robotic Cleaning

Over the past few years, the use of robotic cleaning techniques has gained popularity in MW-scale PV projects. This automated cleaning method has proven to be more efficient and cost-effective compared to manual cleaning techniques. The potential cost for applying robotic cleaning ranges from 2.4 to 8.2 EUR per square meter [3]

New robotic cleaning techniques are now integrated into cloud platforms to communicate and store data in clouds and by harnessing the power of big data analysis, these robotic cleaning techniques can be trained to provide intelligent and efficient cleaning solutions. With their ability to analyze vast amounts of data, they can now help plan cleaning schedules in a more effective manner.

The Red Sea Project is located on the Red Seacoast and is a key project listed in KSA's "VISION 2030" plan with 400MWp capacity and Qatar's largest solar plant – the Industrial Cities Solar Power Project (IC Solar) with 875 MWp capacity has recently announced the implementation of intelligent PV cleaning robots in their projects.

Modern Technologies for Addressing the Soiling Effect

Soiling can be influenced by several factors, including the type of dust particles present in the area, local weather and environmental conditions, nearby land and road conditions, as well as site design aspects such as array inclination, module technology, and racking systems. It is also important to note that partial shading conditions can occur due to non-uniform or heterogeneous soiling. In light of these conditions, traditional cleaning techniques alone are ineffective for achieving optimum system yield.

Use of anti-soiling coatings, Electrodynamic Cleaning System (EDS) to repel the dust particles via the Coulomb force away from the surface, tracking systems to stow the modules in less dust-vulnerable positions/tilt during night, active heating techniques to mitigate dew formation during night, specially designed modules for desert and arid regions, site barriers to control the possible dust circulation from nearby dusty lands/ high traffic moving roads can are some of the modern techniques and aspects for mitigation of soiling.

FUTURE OUTLOOK

Solar PV energy is one of the most promising solutions to achieve net zero and carbon neutrality targets in the MENA region due to the irradiance levels available in this region. Also, as per the reports Solar installed capacity is expected to increase by almost 40 GW by 2025 in the MENA region only. This will eventually increase the economic loss and energy loss associated with the soiling effect. So, it's clear that the soiling issue continues to be a billion-dollar issue on a global scale.

Soiling mitigation, modelling and forecasting need to be conducted extensively to overcome this issue. At a short-time scale, robotic cleaning, optimized cleaning schedules and forecasting of the soiling phenomenon based on atmospheric factors inputs are the most attractive options with the support of emerging AI technologies. Overtime, passive anti-soiling technologies including anti-dust coatings, could decrease the frequency of the cleaning events and thus the associated cost. There will be a chance of saving about EUR 1.5 billion if we can reduce the energy loss due to soling by just 1% from the existing values through these future initiatives and plans.

References:

[1] *K. Ilse et al., "Techno-Economic Assessment of Soiling Losses and Mitigation Strategies for Solar Power Generation," Joule, vol. 3, no. 10, pp. 2303–2321, Oct. 2019, doi: 10.1016/j.joule.2019.08.019.*

[2] *"Atonometrics User Manual."*

[3] *B. Aïssa et al., "A Comprehensive Review of a Decade of Field PV Soiling Assessment in QEERI's Outdoor Test Facility in Qatar: Learned Lessons and Recommendations," Energies (Basel), vol. 16, no. 13, p. 5224, Jul. 2023, doi: 10.3390/en16135224.*

[4] *H. Ritchie, M. Roser, and P. Rosado, "Energy." [Online]. Available: https://ourworldindata.org/energy*

BENEFITS OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN DATA CLASSIFICATION AND RESOURCE FORECASTING

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The terms Artificial Intelligence (AI) and Machine Learning (ML) have become widely adopted in scientific and professional domains, as well as everyday conversations. Before examining the applications of these terms within the solar energy sector, we'll first explore their wider definitions.

The ISO/IEC 22989 standard defines AI as" an engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives". Machine learning is defined as a" process of optimizing model parameters through computational techniques' that is powered by a model, as well as a 'mathematical construct that generates an inference or prediction, based on input data or information". Simply put, AI systems can be defined as systems created by humans to generate an array of outputs, including forecasts, decisions and even content. By combining AI with ML, computational models and algorithms that use data information can generate inferences or predictions. If we wanted to further simplify and look at relevant applications, AI and ML have the potential to help solve certain challenges within the solar industry that humans face on a daily basis when operating assets. Assisted by computers and digital tools, AI and ML, humans will most likely be able to improve how assets operate.

The Role of AI and ML in the Solar Energy Industry

Indeed, the renewable energy and solar photovoltaic (PV) industries are not an exception: achieving the predictability of operations and generation are long-standing goals in this sector as it is inherently affected by the 'unpredictability' of energy sources. Typical challenges related to operating assets powered by an intermittent energy source include the difficulties of optimizing production and accurately predicting the future. The latter allows for downtime to be minimized when nature decides to provide renewable assets with a relevant resource. Using advanced analytical tools to generate actionable insights and forecasting the future to optimize production are not trivial tasks. They cannot be conducted effectively when only a few pairs of human eyes are responsible for dealing with increasing amounts of data that are generated continuously. Therefore, AI- and ML-enabled advanced analytics and forecasting appear to be the perfect tools for augmenting the work of humans.

The Middle East and North Africa (MENA) region is characterized by high insolation, this is a favorable factor for PV installations and even in this scenario, ML, AI and forecasting can help harvest the resource potential. Utility-scale PV installations in the region have an increasingly high capacity, for this reason, the effects of resource intermittency might have a high impact on grid stability. Good quality forecasts are therefore instrumental when meteorological phenomena affect irradiance. At the same time, when dealing with extraordinarily large installations, a higher-than-usual number of devices have the potential to either malfunction or underperform. A bigger amount of data therefore needs to be analyzed to discover ongoing issues. AI- and ML-driven advanced analytics, alongside accurate data categorization, are even more relevant and helpful in ensuring that assets operate effectively.

Challenges in AI and ML Implementation in Solar Energy

Before examining the potential benefits of forecasting models, we'll explore an interesting challenge related to data handling that arises when applying AI and ML in the solar industry. If it is assumed that no model can operate without data and that the quality of the results is intimately linked to the quality of input data (the old 'trash in, trash out' concept), then the importance of the availability of quality data becomes evident. Solar PV installations have been deployed in a heterogeneous fashion. Assets in operation can be composed of various arrays and combinations of components, including panels, combiner boxes, trackers, meteorological stations, and inverters, just to mention the most common and relevant to this discussion. The various combinations of layouts are reflected in the multiple potential data hierarchies to feed digital tools, as well as AI and ML models. Another challenge is poor data standardization. In the early days, a comfortable and flexible approach to data gathering and classification was used, enabling flexibility and customization for first movers. This attitude is incompatible with current installation capacity and data volumes, posing a risk to the use of AI and ML. To use modern algorithms, it is necessary to know what different data refers to. Reclassifying vast volumes of information to feed algorithms would require armies of experts if performed manually. Therefore, while the use of a standardized data taxonomy is a fundamental requirement for enabling AI and ML in the solar sector, its deployment poses several challenges.

Machine learning algorithms have the potential to save countless engineers from many hours of tedious work because they are capable of assigning standardized nomenclature to data. To grasp the scope of this challenge, one should consider the increasing installed capacity and the subsequent volume of generated data. Simultaneously, the array of data tags created by different users according to their specific needs poses a big threat to the efficient use of data for AI-driven tools deployed on a global scale. Artificial intelligence can be useful for addressing the need for standardization while also benefiting from the comfort of customization. Natural language processing is a useful branch of AI that enables computers to make sense of text created by humans. It is a fascinating area of computer science when one considers how different the rigid structure of the binary nature of computer logic is from human languages. The latter evolves continuously assigning different meanings to the same words depending on context and other external factors. Algorithms using cosine similarity and word mover's distance (WMD) can support the attribution of standard taxonomies to operational assets data tags created in inhomogeneous formats. Cosine similarity helps to identify the likeness of tags between different sets of vectorized data. In simple terms, characters that constitute text are translated in a numerical code (vectorization), and a model based on mathematical logic is used to define the difference between sets of text. To increase accuracy, WMD can be used to move beyond the lexical challenge and detect the semantic distance between sets of texts. The WMD is a ML algorithm trained using predefined sets of data. This method was first presented by Matt J. Kusner and his peers at Washington University. It uses an optimizer developed for transportation problems to understand how many words in a set of text are 'close' to other sets by measuring co-occurrence in sentences and employing semantic similarity metrics. Based on preliminary testing run in-house on sets of inhomogeneous operational data tags targeted for automatic taxonomy allocation, we have found that it is possible to achieve 70%–80% accuracy in standard taxonomy automatic attribution. It is evident that when data tags to standardize are in the thousands (and counting) and are accompanied by obvious multipliers related to devices and tags, AI and ML are helpful tools for solving the problem at hand.

The accuracy of data identification and the capability to deploy AI and ML algorithms at a vast scale are crucial factors in ensuring the success of PV in the MENA region.

AI and ML in Data Standardization for Solar Assets

Hot and dry climate zones are typical in the MENA region, resulting in higher degradation of PV modules, junction boxes and transmission cables, just to mention a few. High operating temperatures are likely to cause inefficiencies when compared to more benign climate zones. Desert conditions expose assets to operate in corrosive environments due to the condensation of water and salt during the night. When planning devices or systems replacements, the accuracy of data identification is crucial to precisely recognize the affected hardware in the control room and to plan interventions accordingly. The latter is even more relevant when plants are situated in remote locations, service and maintenance activities are carried out in critical environmental conditions and plant size is measured in Gigawatts. To minimize workforce exposure to extreme weather, planning needs to be based on accurate data that will enable precisely designed interventions with minimum need for on-site correction.

Resource Forecasting and Machine Learning in Solar Energy

Another interesting application of ML in the solar industry is resource forecasting. Various providers can predict irradiance from multiple sources, including geostationary weather satellites and weather models, a process that is known as numerical weather prediction (NWP). These models primarily differ according to how they combine and interpret various sources of data; this difference also has a significant impact on their accuracy.

Ensemble Models in Numerical Weather Prediction

This combination – which, in technical terms, is referred to as an 'ensemble' – makes it possible to exploit the strengths and mitigate the weaknesses of weather models. It also ensures that the delivery of forecasts is not dependent on one particular source of data. The result is a highly reliable service, even in the event of the failure of one or more input feeds.

Machine Learning Models for Forecast Enhancement

Machine learning can enhance the accuracy of forecasts by extracting the value of the consistent bias in NWP models to identify patterns of uncertainty by cross-checking past predictions against actual conditions. The verified assumption that NWP behavior usually persists, enables ML models to make live corrections to the data. Several types of ML models are used, including regression models, random forests, multilayer perceptrons, and extreme gradient boosting.

Regression models include a variety of ML models trained using available data to predict the relationship between independent variables and a specified output. The models can, therefore, forecast future weather and irradiance. Random forests are instrumental in estimating errors and missing data when some information is unavailable. This is, therefore, an effective method for estimating missing data, as well as gauging and maintaining accuracy when a portion of information is missing. Multilayer perceptron are deep neural networks classified as feedforward algorithms that enable neural networks to understand complex patterns involving input and output data, which are common for meteorological forecasts. Extreme gradient boosting is a model that enables the prediction of future trends based on existing data. It is based on a decision tree approach that is built iteratively until a certain criterion is satisfied. It is well known for its power and speed, as well as its capability to ensemble multiple algorithms to transform an array of predicting algorithms into a combined and powerful algorithm. Artificial intelligence is also used to increase the resolution of NWP and to align them with a typical solar farm size. Physical and statistical models are used to capture localized weather conditions and terrain effects to produce plane-of-array irradiance for each NWP model. The refined NWP data feeds a multilayer stacking ensemble of regression-based power models that are optimized using machine learning techniques to produce the final power and meteorological forecasts.

Depending on the availability and latency of a power signal, self-learning artificial neural networks and analogue forecasting methods can be blended to create accurate forecasts. In summary, resource forecasting is an area that benefits significantly from AI and ML, and algorithms are key to enhancing humans' efforts to understand multiple sources of data and create future scenarios that are evolving at an increasingly fast pace due to the changing global climate.

Challenges and Importance of AI and ML in the MENA Region

Based on in-house experience, blending multiple sources of data is crucial in the MENA region as weather data availability can be patchy and the quality and resolution of NWP models are likely to be inhomogeneous. In some cases, gathering data from local meteorological agencies can pose a few technical challenges and have a detrimental effect on the cost competitiveness of the final forecasting service, at the same time end user resistance to the adoption of data provided by foreign entities could not be a viable option. These scenarios emphasize the need for AI and ML and their capabilities to combine various sources of data to create the best possible forecast with the information at hand. When looking at the use of forecasts, on top of the abovementioned challenges, the accuracy of predictions is quite important when considering the combination of extremely high individual plant capacity and the effect of meteorological phenomena on energy produced by PV installations. If one would consider the effects of sandstorms, aerosols, shifts in precipitation factors and their effect on direct normal irradiation (DNI), the need to model the phenomena accurately is intuitive as it is the effect on potential grid imbalances. Forecasts refinement can be achieved for preconstruction scenarios but are more challenging for live predictions due to time constraints. AI and ML become invaluable tools to support our meteorologists to inform operators about upcoming events that might have a significant effect on immediate PV power generation and on future needs for maintenance like in the case of sandstorms.

In conclusion, this brief overview of the several applications of AI and ML demonstrated the immense potential and invaluable support that digital tools can offer to operators. Indeed, the potential for these tools to ensure a bright future for the entire solar energy sector lies in the combination of the widespread availability of ML models, quality data and the expert use of digital tools. A question might arise on whether AI and ML are the panacea to all the challenges faced by humans in the context of operating PV assets but that's a different topic.

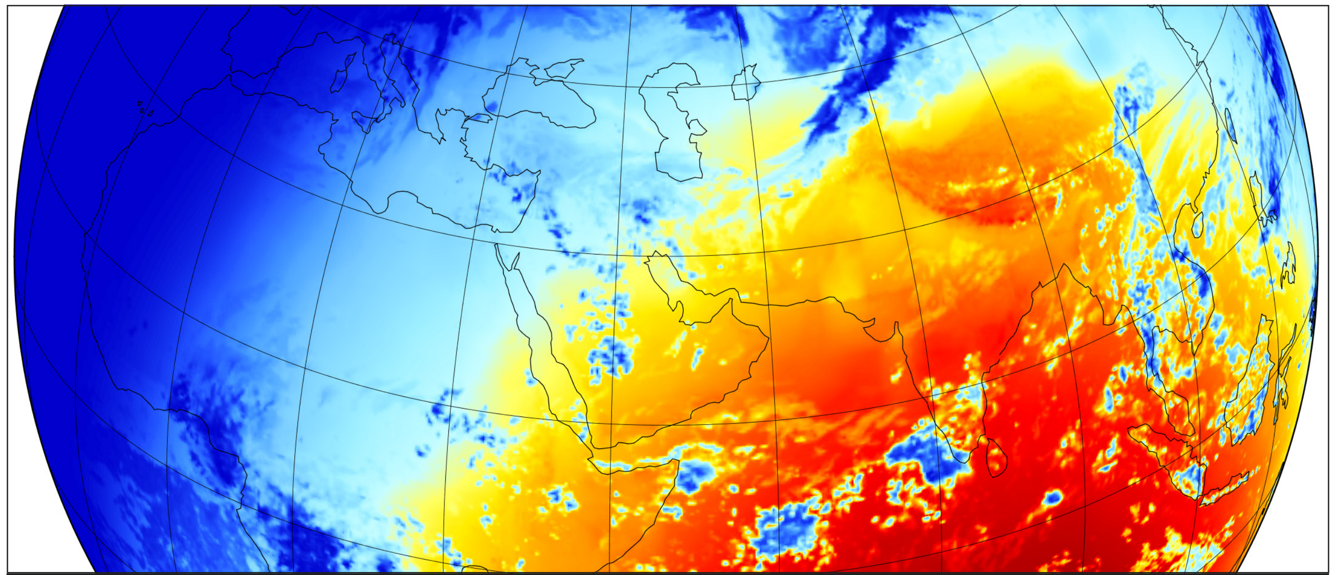


Figure 01: Irradiance Forecast Map Source: DNV Forecaster

Figure 02: Generic Data and Digitalization Source: Getty Images DNV archive

IMPACT OF INTEGRATING ESS WITH PV POWER PLANTS: A TECHNO-COMMERCIAL POINT OF VIEW

Hamza Al Smadi
ESS Technical Services Manager

INTRODUCTION

Renewable Energy (RE) is becoming a more vital resource not only to overcome climate change challenges but also to provide clean energy to the increasing population globally.

Solar Energy is an abundant source of energy on our planet, and today, the most techno-commercially efficient way to harvest this energy is by using Photovoltaic (PV) panels technologies. The share of cumulative power capacity for solar PV is around 1300 GW globally forecasted to overcome other sources by the year 2027 as in Figure (1):

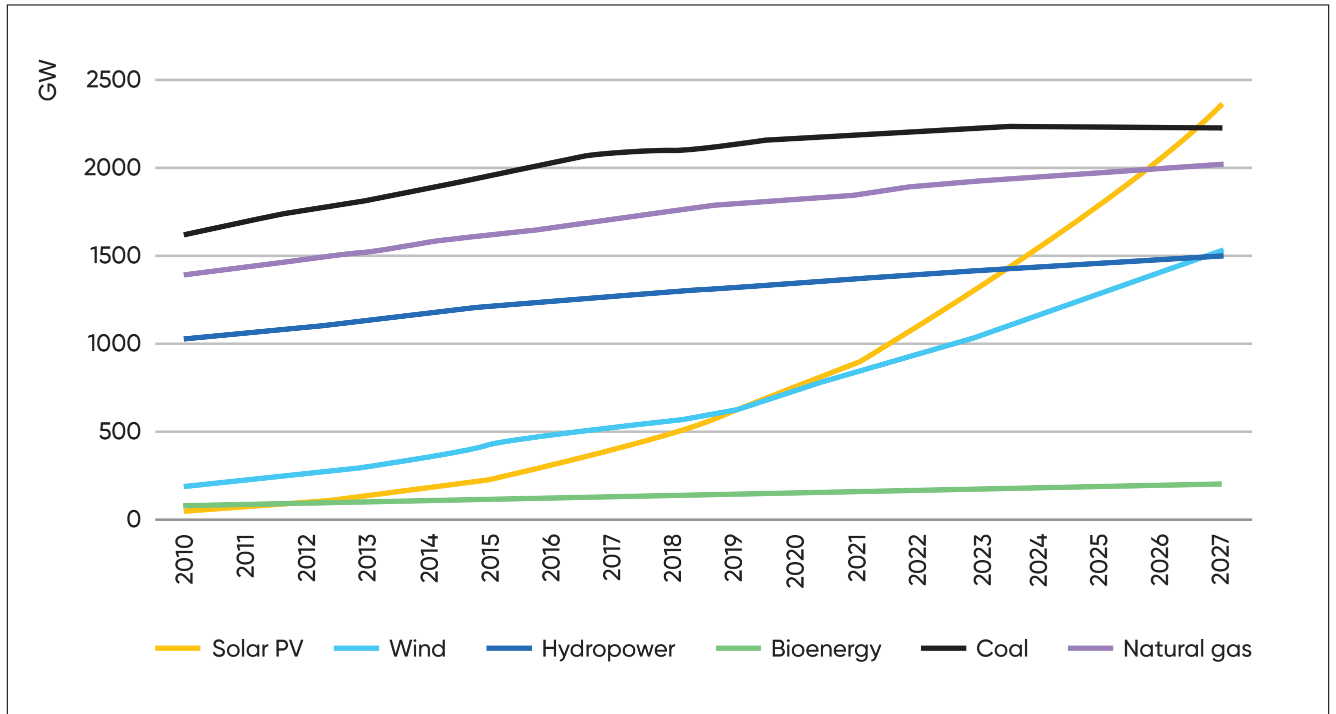


Figure 01: Share of Cumulative Power Capacity Globally by Technology [1]

References:
[1] *IEA (2022), Renewables 2022, IEA, Paris https://www.iea.org/reports/renewables-2022, License: CC BY 4.0*

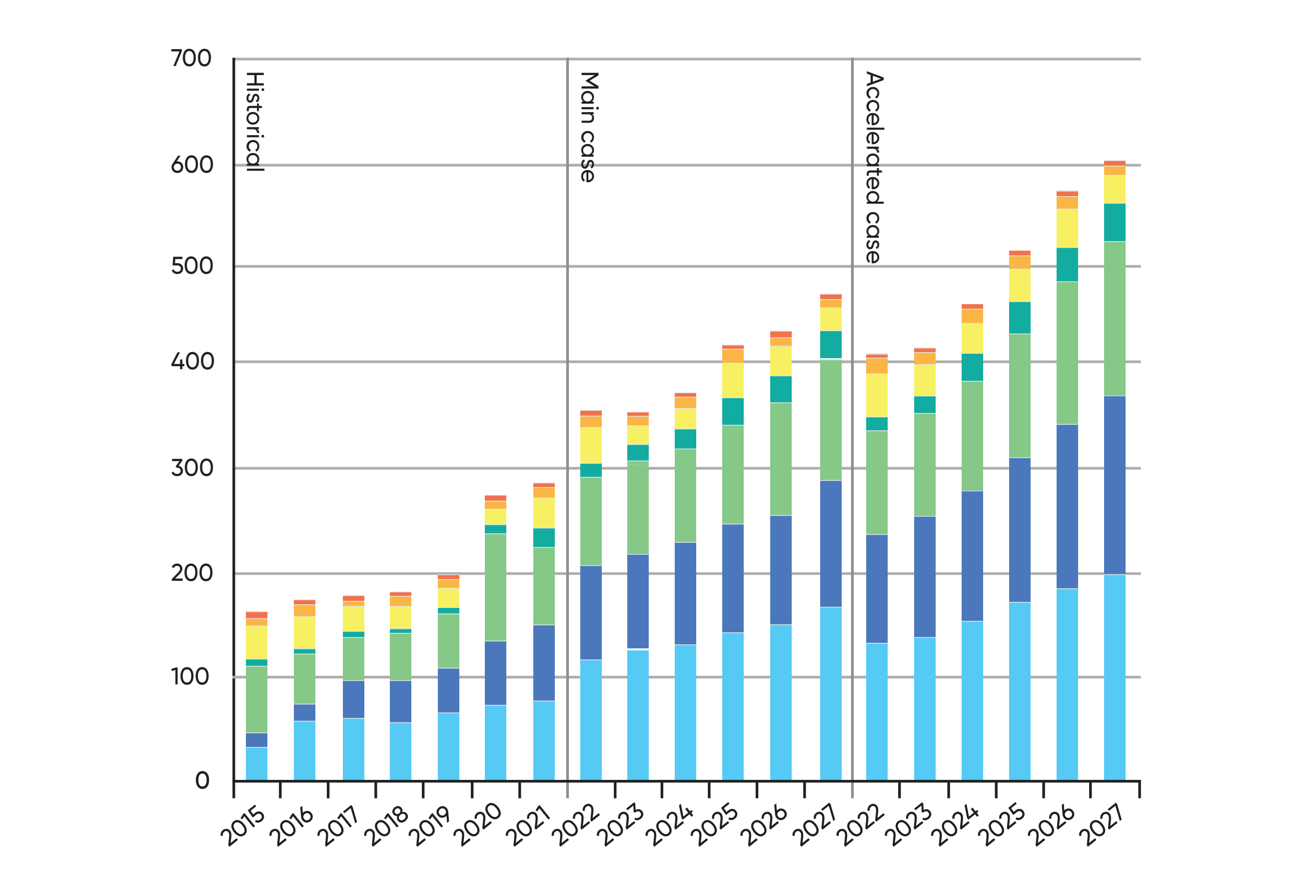


Figure 02: Renewable Annual Net Capacity Additions by Technology [2]

Figure (2) by the International Energy Agency (IEA) indicates the annual net capacity additions by renewable energies technology, showing the exponential increase in capacity additions using various renewable energy sources; however, it is important to mention that the major application of Solar PV are in utility-scale installations.

The nature of energy production using PV panels is dependent on solar irradiance (intensity for a specific location) However, regardless of location globally, the average solar irradiance intensity is based on a Gaussian-distribution throughout the daylight of a day. In addition, the energy consumption profile of populations in cities is concentrated in the early morning and peaks in the evening hours. Figure (3) shows an example of a daily load profile for solar PV production relative to electricity demand in the year 2050.

It is clear in Figure (3) that PV systems peak their generation around noon times, while energy consumption peaks in the evening hours. Having the solar generation peak not aligned with the demand peak creates many challenges both on the infrastructure of the energy network and financially to solar projects' developers. Such a misalignment problem could be solved by applying an energy generation shift from noon hours to evening hours by introducing Energy Storage Systems (ESS). ESS is a solution to infrastructure challenges faced by energy network operators and energy project developers, and today, the ESS industry is facing huge developments paving the way for exponential growth in the demand for ESS as it happened with PV installations 10-12 years ago.

References:

[2] *(EA (2022), Renewables 2022, IEA, Paris https://www.iea.org/reports/renewables-2022, License: CC BY 4.0*

08 ESS IMPACT ON PV POWER PLANTS
SOLAR OUTLOOK REPORT 2023
SPECIAL EDITION

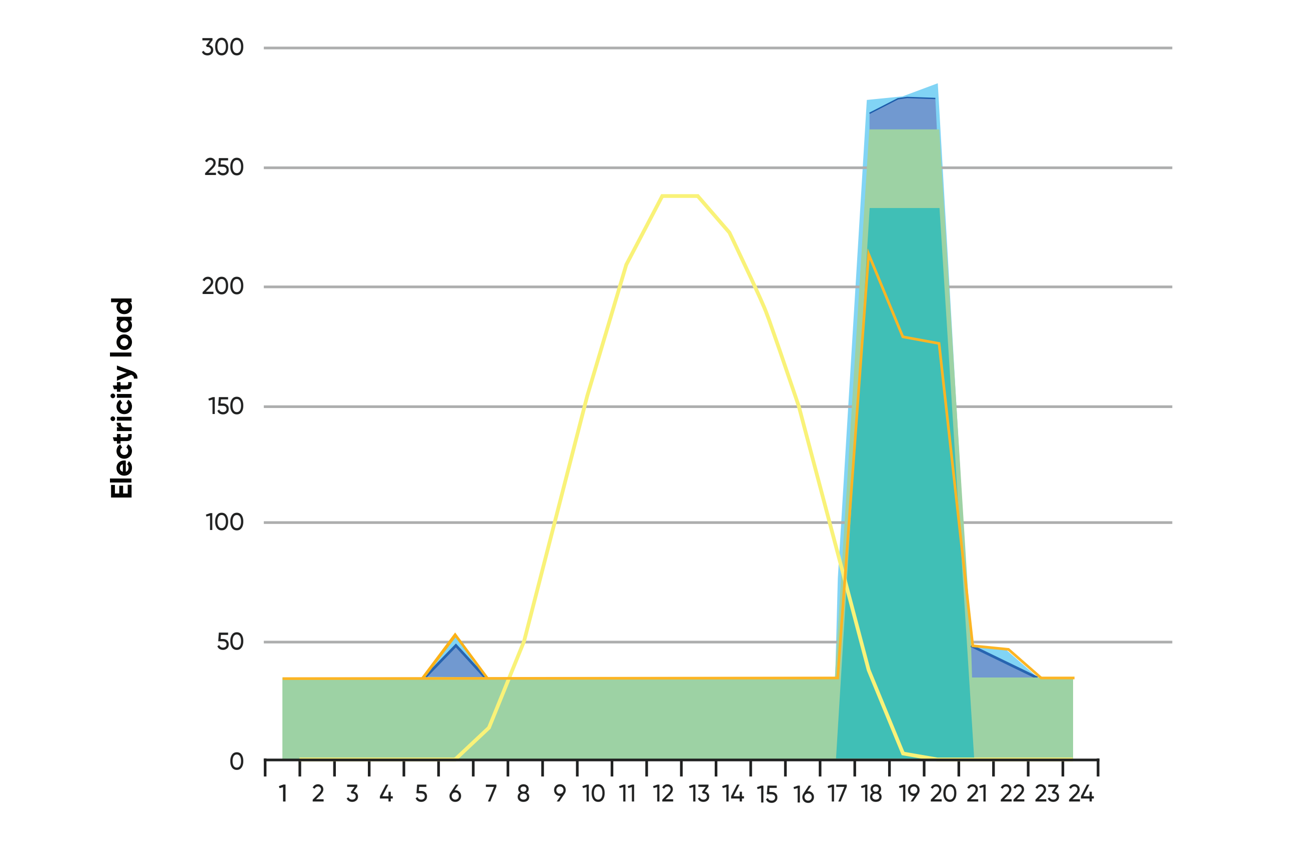


Figure 03: Example of Daily Load Profile for Solar PV Production Relative to Electricity Demand in the Year 2050 [3]

THE CHALLENGE OF HIGHER PV-BASED INSTALLATIONS

With the rapid increase in quality of life and growing population, the energy demand is exponentially increasing. This increase is not only due to population development but also impacted by other factors including the integration of Electric Vehicles replacing conventional cars and means of transportation or the introduction of hydrogen projects as an energy powerplant, carrier and storage. This increase in projects introduces higher energy demands to supply electrolyzers and other auxiliary equipment in the plant.

Figure (4) shows the change in total energy supply by region and fuel over the period 2010-2019 and 2021-2030.

The challenge in this growth is not only summarized by the growth itself but in the readiness to generate energy enough to supply this demand and ensure safe, reliable, and sustainable operation of the technologies used in this energy generation cycle.

When PV power plants are considered to supply this demand, a couple of challenges are faced by utility developers and operators:

References:

[3] IEA, Example of daily load profile for solar PV production relative to electricity demand in 2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/example-of-daily-load-profile-for-solar-pv-production-relative-to-electricity-demand-in-2050, IEA. Licence: CC BY 4.0

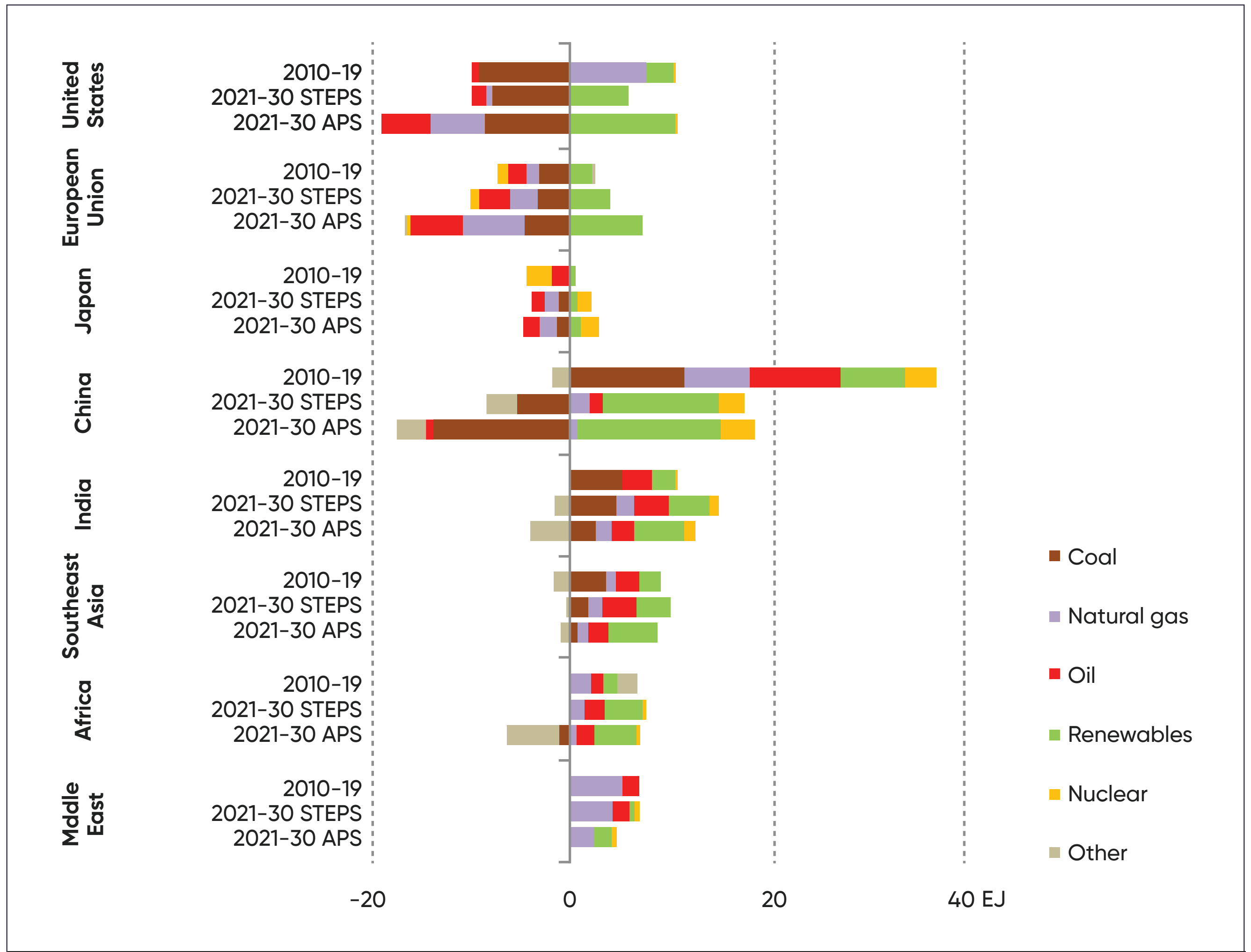


Figure 04: Change in Total Energy Supply by Region and Fuel 2010-2019 And 2021-2030 [4]

1. The Energy Yield Generation Profile vs. Energy Demand Profile

2. Reverse Power Flow on MV & HV Levels

3. Voltage Rapid Fluctuations

4. Reactive Power Fluctuations

5. Increase of Power Losses at Feeder Levels

The introduction of ESS could contribute to solving most of the issues faced by the utility developers and operators. The following sections will provide an overview of the challenges and how ESS integrations could contribute to solving each challenge.

THE ENERGY YIELD GENERATION PROFILE VS. ENERGY DEMAND PROFILE

One of the key challenges in integrating high levels of PV generation into the grid is the intermittent nature of solar energy. PV systems generate electricity based on sunlight availability, which may not always align with the energy demand profile. During periods of excess PV generation, the grid can experience overloading, while insufficient generation can result in power deficits. This imbalance can strain grid stability. Energy storage systems provide a solution to this problem. By storing excess energy when PV generation is abundant and releasing it during periods of high demand, ESS can effectively bridge the gap between generation and consumption. This not only ensures a steady energy supply but also minimizes stress on the grid. Research by the National Renewable Energy Laboratory (NREL) demonstrates how ESS can improve grid reliability by matching generation to demand efficiently [NREL Report, 2020].

REVERSE POWER FLOW ON MV & HV LEVELS

The reverse flow of power, where excess electricity from PV systems is fed back into the grid, is a common occurrence during periods of high solar generation. While this may seem like a beneficial aspect of solar integration, it can lead to voltage and frequency fluctuations, posing challenges for grid operators. Energy storage systems can help mitigate this issue by absorbing excess power during peak solar generation hours and releasing it when needed. This dynamic control of power flow ensures that the grid operates within safe voltage and frequency limits. A study conducted by the Electric Power Research Institute (EPRI) highlights the importance of ESS in managing reverse power flows and maintaining grid stability [EPRI Research, 2019].

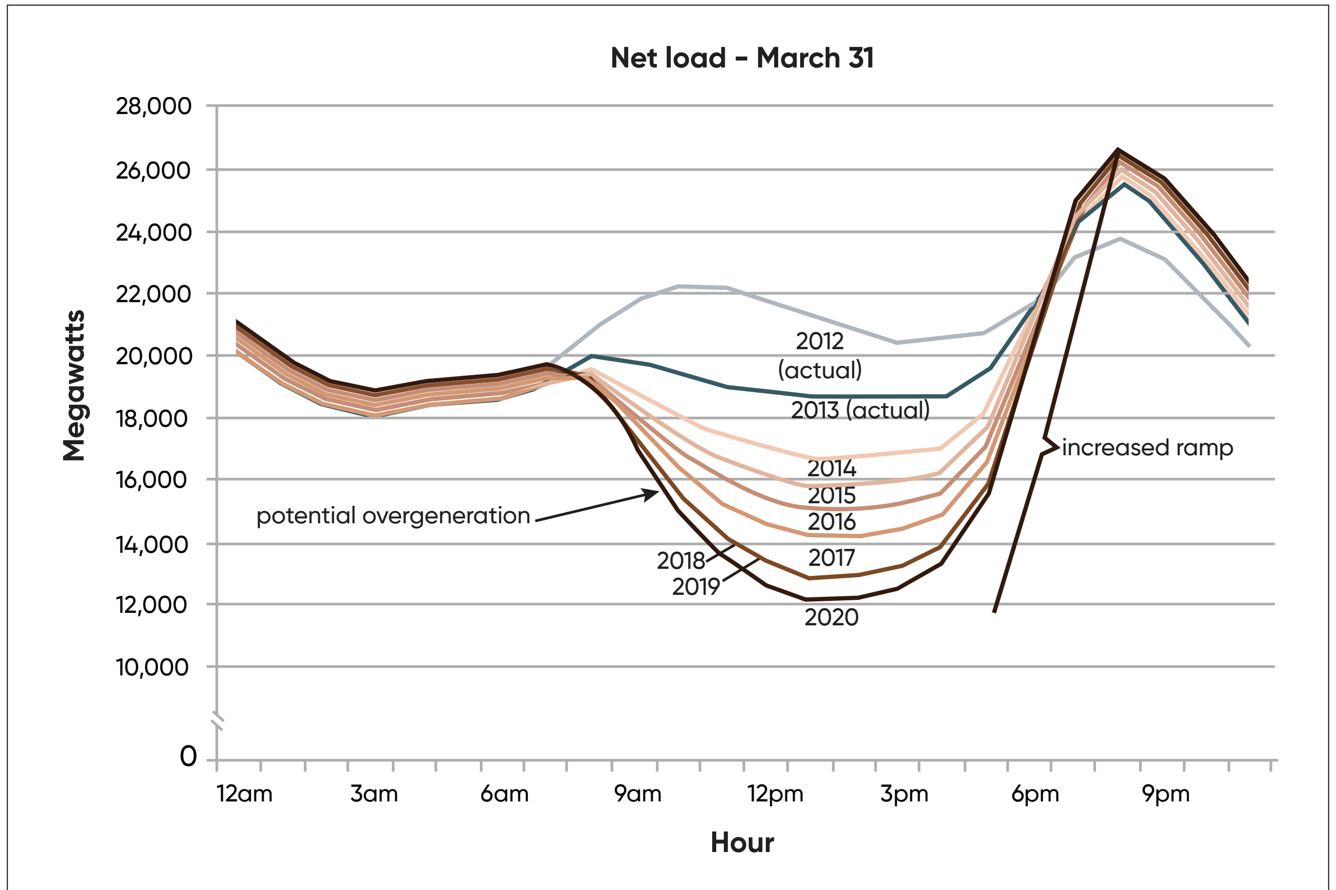


Figure 05: CAISO Duck Curve - CAISO Annual Report 2021 [5]

VOLTAGE RAPID FLUCTUATIONS

PV systems can introduce rapid voltage fluctuations into the grid, especially when cloud cover causes sudden drops in solar irradiance. These fluctuations can be problematic, affecting the quality of power supply and potentially damaging sensitive equipment.

Energy storage systems, with their fast response capabilities, can help regulate grid voltage. By injecting or absorbing power as needed, ESS can smoothen voltage fluctuations and maintain grid stability. The California Independent System Operator (CAISO) has implemented ESS to address voltage fluctuations and enhance grid reliability, as discussed in their recent annual report [CAISO Annual Report, 2021].

REACTIVE POWER FLUCTUATIONS

Reactive power is essential for maintaining voltage levels, it can fluctuate with the intermittent nature of PV generation. This fluctuation can result in voltage instability and increase grid stress.

Energy storage systems can provide reactive power support by injecting or absorbing reactive power as required. This capability helps maintain grid voltage within acceptable limits. A study published in the IEEE Transactions on Sustainable Energy details the benefits of ESS in mitigating reactive power fluctuations in high PV integration scenarios [IEEE Research, 2018].

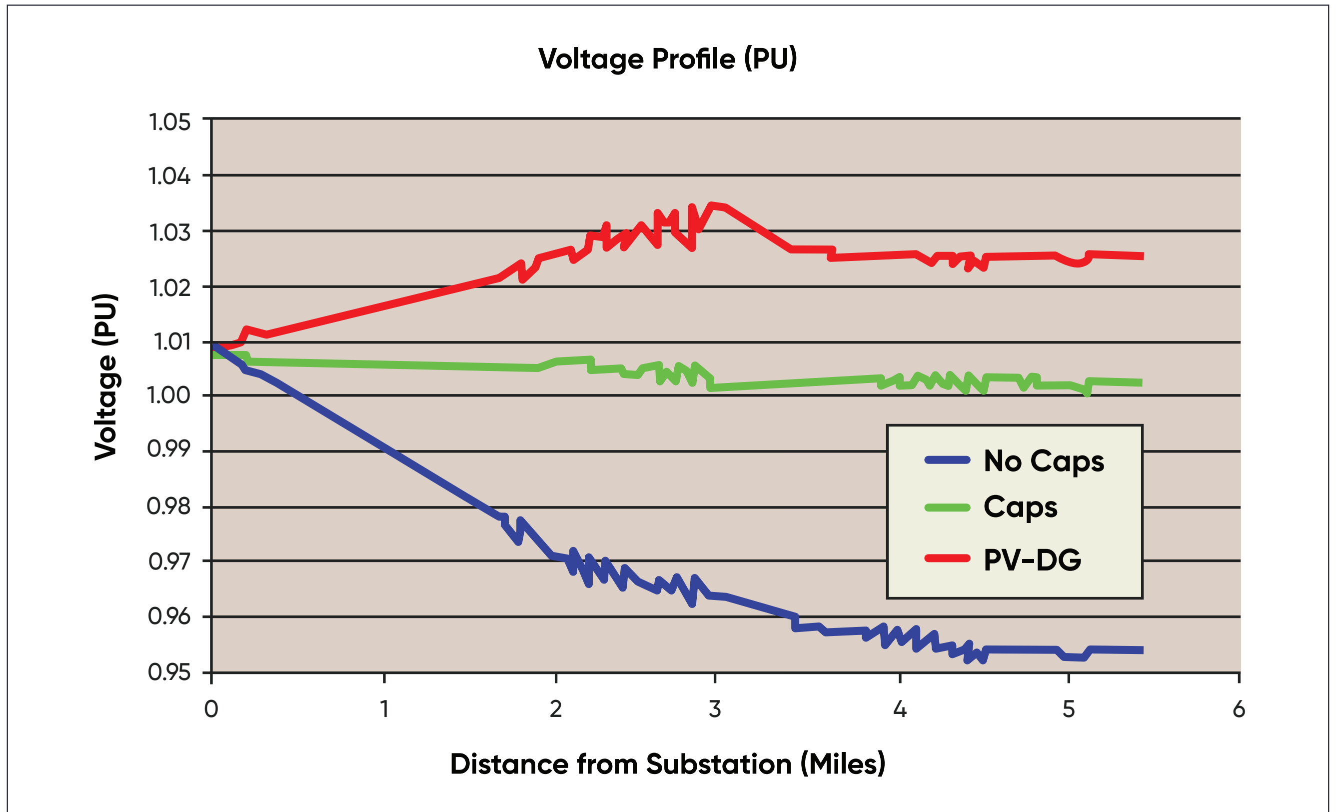


Figure 06: Impact of PV-Distributed Generation on Feeder Voltage [6]

INCREASE OF POWER LOSSES AT FEEDER LEVELS

High PV integration can lead to increased power losses in distribution feeders, as the power flows through a more complex network. This increase in losses negatively impacts grid efficiency.

Energy storage systems can reduce power losses by optimizing power flow and reducing congestion on feeders. By injecting power when and where it's needed, ESS can mitigate feeder-level losses. A case study from Hawaiian Electric Company (HECO) showcases how ESS integration has led to a notable reduction in power losses and improved grid performance [HECO Case Study, 2019].

References:

[4] *IEA (2022), World Energy Outlook 2022, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2022, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)*

[5] *CAISO Annual Report 2021*

[6] *Katiraei, K.F.; Agüero, J.R. (2011). Solar PV Integration Challenges. , 9(3), 62–71. doi:10.1109/mpe.2011.940579*

SHORT FINANCIAL OVERVIEW ON ESS

The economic feasibility of PV-ESS integration hinges on initial capital costs, declining costs of technology, potential revenue streams, incentives, and various cost savings. A well-structured financial analysis that considers all relevant factors is essential for determining the viability of these projects, which have the potential to enhance both the sustainability and economic viability of renewable energy systems.

Figure 07: Cost Overview of Various ESS Technologies By 2030 [7]

CONCLUSION

The integration of high levels of PV systems into utility grids presents numerous challenges, including misalignment between energy generation and demand, reverse power flow, voltage fluctuations, reactive power fluctuations, and increased power losses. Energy Storage Systems have emerged as a vital solution to these challenges, offering grid operators the ability to balance and stabilize the grid, ensuring reliable power supply, and minimizing negative impacts on utility grids.

As the energy landscape continues to evolve, ESS will play a pivotal role in ensuring the efficient and sustainable integration of renewable energy sources into our grids.

References:

[7] *https://public.tableau.com/views/InstalledCostComparison_2021/CompDash?:language=en-US&:embed=y&:embed_code_version=3&:loadOrderID=0&:display_count=y&:origin=viz_share_link*

SECURING YOUR ENERGY SUPPLY WITH SOLAR AND BATTERY ENERGY STORAGE SYSTEM

Youssef Ammar
VP Product Development
YELLOW DOOR ENERGY

MARKET OPPORTUNITIES: A BRIGHT FUTURE

There are 760 million people around the world without access to electricity, and 80% of these individuals are in Sub-Saharan Africa [1]. Even amongst those with access to electricity, frequent power outages continue to disrupt business operations and daily lives.

Compared to existing coal and gas power plants or diesel generators used in remote areas, new renewables are now the cheapest source of electricity generation [2].

Although renewables do have an intermittent challenge, a combination of solar photovoltaic (PV) and battery energy storage systems (BESS) could be a part of the solution to provide a stable and predictable electricity supply. The BESS market size is estimated to be at $5.4 billion globally, with significant growth expected in the next 5 years [3]. Moreover, in the past 10 years, the cost of batteries has dropped by 82% [1].

SOLAR PV AND BESS: A POWERFUL COMBINATION

Yellow Door Energy provides solar PV and BESS as part of its power purchase agreement (PPA). The businesses that are most suited for this solution in the Middle East and Africa are those operating off the grid, such as mining and oil and gas operations, farms, factories and hotels or resorts in remote locations.

Some of the benefits of combining solar PV and BESS are that they provide a secure energy supply, increased redundancy, higher cost savings on diesel, increased renewable energy penetration and of course 24/7 access to electricity.

There are different types of batteries on the market. Lead acid batteries are one of the oldest technologies that are still in use. They are more suitable for smaller applications because they have low energy density, requiring more space for the same amount of energy they can store. They also have low cyclic life, which means that they go through fewer cycles of charge and discharge, thus having a shorter lifespan.

In recent years, lithium batteries have become more affordable when compared to the total cost of ownership or the levelized cost of storage over the system's lifetime. Today, this technology is the most popular option due to its proven track record and cost-effectiveness.

Lastly, a new entrant into the market are flow batteries. They have low energy density, requiring space, but they have long lifespans. While they are gaining traction, they still require further development and more interest from manufacturers.

In the UAE, a large water management company is looking to decarbonize its operations with 24/7 clean electricity. The overall system encompasses a 2.2 MWp rooftop solar power plant and 1,500 kWh of BESS capacity, along with an existing 3,500 kVA capacity generator. Overall, the PPA brings significant cost savings, produces 4,700 megawatt-hours of clean electricity annually and has a 99.9% system availability guarantee.

References:

[1] *IEA (2023), SDG7: Data and Projections, IEA, Paris https://www.iea.org/reports/sdg7-data-and-projections, License: CC BY 4.0*

[2] *Bloomberg New Energy Finance, Liebriech Associates*

[3] *"Battery Energy Storage System Market - global size, share & industry analysis [latest]," MarketsandMarkets, https://www.marketsandmarkets.com/Market-Reports/battery-energy-storage-system-market-112809494.html?gclid=Cj0KCQjw06-oBhC6ARIsAGuzdw0uFWdFFGFddS0Z17cOFTd9X04-wh6Nwy1n1qVvb1PZ3ezmYydxQsoaAuQaEALw_wcB*

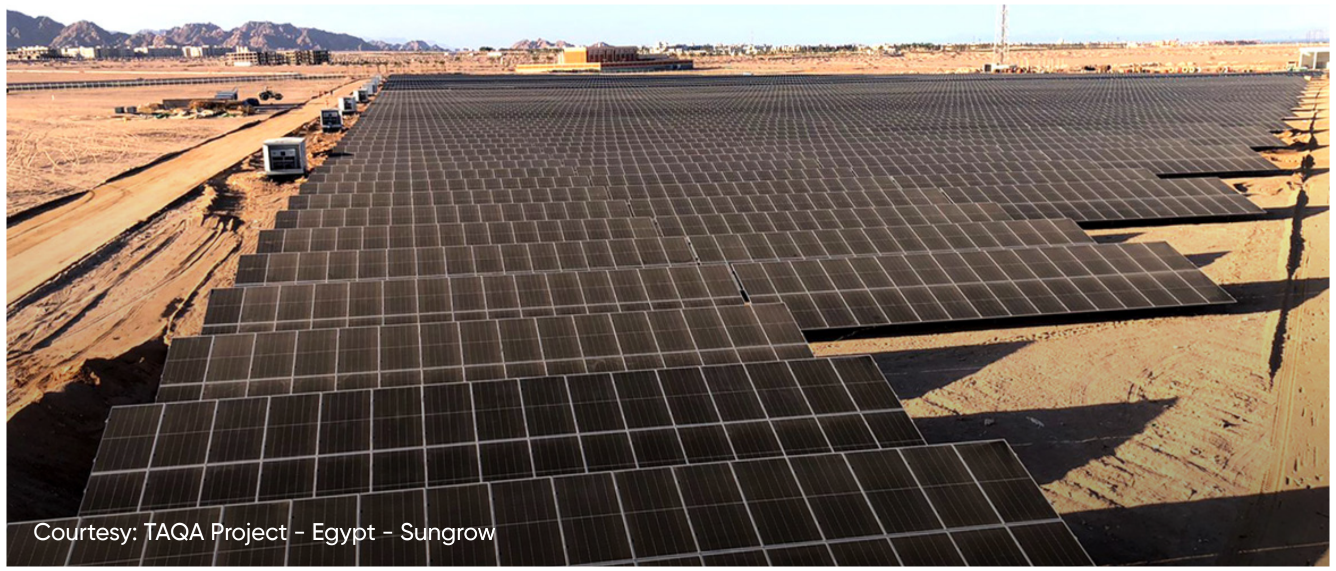
In the Kingdom of Saudi Arabia, a large manufacturer is aiming to procure more than half of its energy needs from solar PV and BESS. The ground-mounted solar power plant has a capacity of 5 MWp, and the BESS has a storage capacity of 8 MWh. Over 9 million kilowatt-hours of clean electricity are expected to be produced in the first year of operation, along with 45 million liters of diesel to be avoided over the 20-year tenure, contributing to 122,000 metric tons of avoided carbon emissions [4].

SAFETY AND MAINTENANCE BEST PRACTICES

When running a Battery Energy Storage System (BESS), cooling poses the biggest concern. In the hot climates of the Middle East, cooling challenges and fire hazards are easily managed with proper practices on safety and maintenance. These practices include but are not limited to, having an optimized cooling system that is suitable for the environment, providing an advanced monitoring system for the BESS, implementing a stringent fire-fighting system, allowing adequate space in and around the container, conducting regular checks on the condition of the power conversion system (PCS), ensuring the cables are in good condition and implementing frequent checks on the cooling system. Either the newer and more efficient liquid cooling system or the older air-cooled system would do the job, as long as they are sized to withstand the site condition and the end-user understands the different maintenance practices for the two systems.

AHEAD OF COP28: POWER FOR THE MASSES?

As world leaders convene at COP28 in the UAE in November, the aim is to witness a real, tangible move from promises to concrete actions. Solar PV and BESS are proven technologies; their impacts have been documented in the case mentioned above studies and many others. Access to electricity is a fundamental human right and it does not have to come at high environmental costs from traditional hydrocarbons. Through the effective implementation of solar PV and BESS, access to electricity can be provided in a distributed, reliable, and decarbonized manner. A just energy transition is around the corner, waiting for us.



Courtesy: TAQA Project - Egypt - Sungrow

References:

[4] *Greenhouse gases equivalencies calculator - calculations and references ..., https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.*

TOWARDS A NEW PV DESERT STANDARDS

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هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

The Middle East and North Africa (MENA) region is experiencing a pivotal shift towards sustainable energy, with solar power at the forefront. Abundant sunlight makes this region exceptionally attractive for solar energy production. As global awareness of climate change intensifies, governments and industries in MENA are investing heavily in solar infrastructure. However, ensuring the reliability of solar panels in the harsh, hot, and humid desert conditions unique to the region is paramount. The demand for robust solar panels has never been higher, as they form the bedrock of a greener, more sustainable energy future, positioning the MENA region as a global leader in solar energy innovation and implementation.

Current challenges in solar panel reliability stem from diverse environmental stressors. The harsh conditions such as high UV (Ultraviolet) irradiance, large differences in ambient (day and night) temperatures, humidity, and high soiling raise concerns about the long-term performance of PV modules in desert climates. A comparison of the environmental stressors in the desert region of UAE compared with a moderate region in Germany is shown in Figure 1. The defects observed in hot desert environments in different PV components include encapsulant discoloration, interconnect oxidation, back sheet chalking, delamination, finger breakages, wafer cracks and module anti-reflective coating (ARC) removal. The current environmental testing standards induce limited premature failures mostly found under moderate climate regions, which do not adequately represent degradation modes observed in desert regions. Therefore, we propose additions to existing tests and standard test protocols, such as the IEC 61215 series, to improve the overall durability of PV modules in such regions.

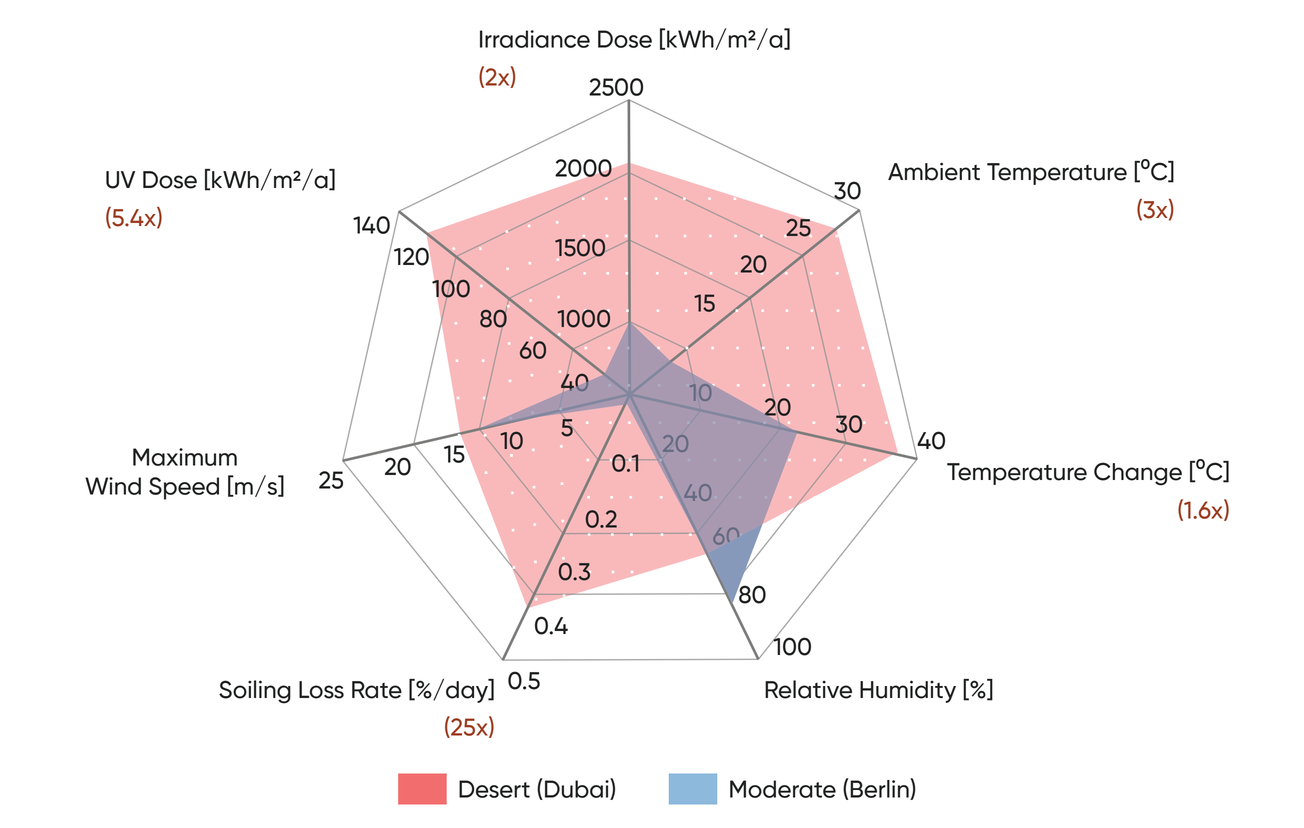

Figure 01: Dominant Environmental Stressors Operating in the Desert (Dubai, UAE) and Moderate (Berlin, Germany) Climates

The standard derating factor employed in Levelized Cost of Energy (LCOE) calculations for solar PV projects is typically set at approximately 0.5% per year [1] for solar PV projects in the MENA region. This implies that the rate of performance decline in PV modules should stay below this threshold. However, data from the Outdoor Test Facility (Figure 2) at Dubai's Electricity and Water Authority's R&D Centre indicates that numerous PV modules experience degradation rates above this limit. An accurate estimation of this degradation rate is a complex task and is prone to inaccuracies if all potential uncertainties are not meticulously considered. Figure 3 illustrates outcomes obtained through two distinct techniques for degradation rate assessment. The methodology employing RdTools [2] exhibits a comparatively higher degradation rate compared to indoor measurements. In the indoor assessments, PV modules are transported to a controlled environment and tested under Standard Test Conditions (STC), subsequently compared to the PV module's nominal value. Outdoor degradation rate assessment relies on the maximum power point data collected at 30-second intervals, making it susceptible to environmental influences like light-induced degradation, soiling, and potential errors in measurement instruments, including weather sensors.

Row	R1	R2	R3	R4
Tilt angle	5	25	25	90
Cleaning frequency	Monthly	Monthly	Weekly	Monthly

Figure 02: Image of Outdoor Test Facility (OTF) Operated by DEWA's R&D Center since 2016, Located at MBR Solar Park

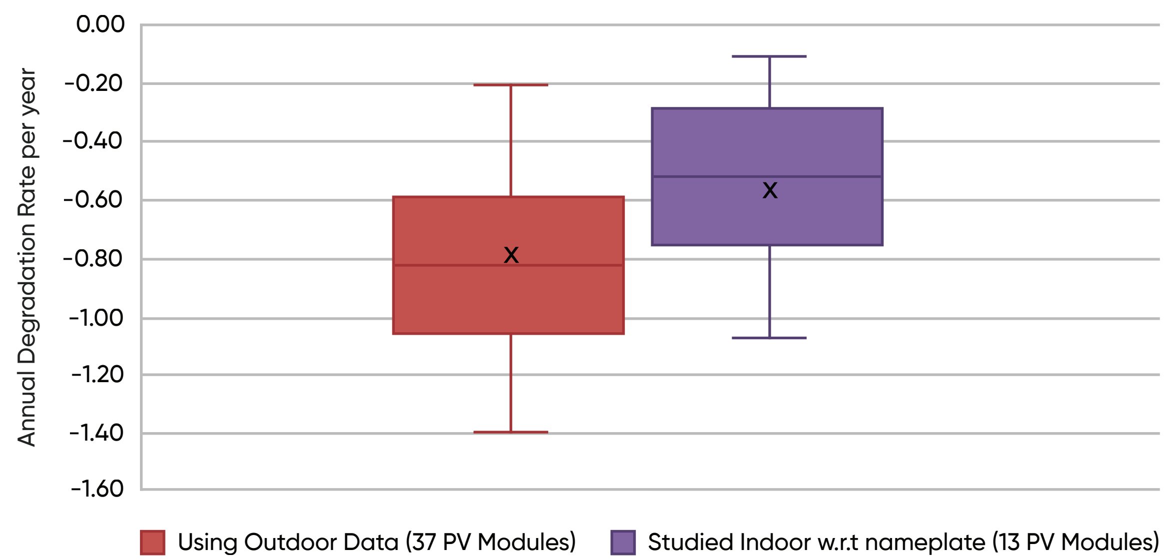

Figure 03: The Annual Degradation Rates of PV Modules that are Seven Years Old, Obtained from the Outdoor Test Facility (OTF)

09 SOLAR PANEL RELIABILITY

Degradation rates were assessed through two distinct methods: the first employs RdTools with outdoor data, while the second involves indoor testing under Standard Test Conditions (STC), followed by a comparison with the nameplate ratings.

The prevalent degradation mode observed in PV modules at the Outdoor Test Facility (OTF) is encapsulant discoloration. Modules operated in desert regions exhibit distinct discolouration patterns, specifically in terms of UV fluorescence (UV-f), evident across all modules in the field (Figure 4). The severity and formation of these patterns are contingent on the UV dosage and the type of bill of material (BOM) utilized in the PV modules. Additionally, back sheet defects were noted in modules exposed to the hot desert environment. While these defects primarily pose a safety concern rather than a reliability issue, chalking was identified as the predominant type of defect in nearly all back sheet-based modules. This phenomenon indicates the removal of TiO_2 additives incorporated into the back sheet during fabrication [3]. Although chalking and discolouration do not lead to immediate performance losses, they are early indicators of potential degradation modes like delamination, cracks, embrittlement, and discolouration. These, in turn, may result in insulation and eventually power loss [4].

Figure 04: The Outdoor Test Facility (OTF) Using UV Fluorescence Imaging at Night, Depicting Encapsulant Discoloration

A significant number of modules brought indoors for testing exhibited thermo-mechanical fatigue-induced defects. Among these, metallization issues accounted for 87%, followed by cell breakages at 62%. Interconnect breakages and warpages were less common. These defects notably impact the fill factor, contributing to performance degradation, and are visibly evident in Electroluminescence (EL) images. Weather-induced metallization breakages and cell cracks are distinctly observable in the EL images, as illustrated in Figure 5. Additionally, microscopic examination of outdoor modules reveals conspicuous glass abrasions. As depicted in Figure 6, there is nearly complete removal of the Anti-Reflective Coating (ARC) after just three years, potentially resulting in a performance loss ranging from 1-3%.

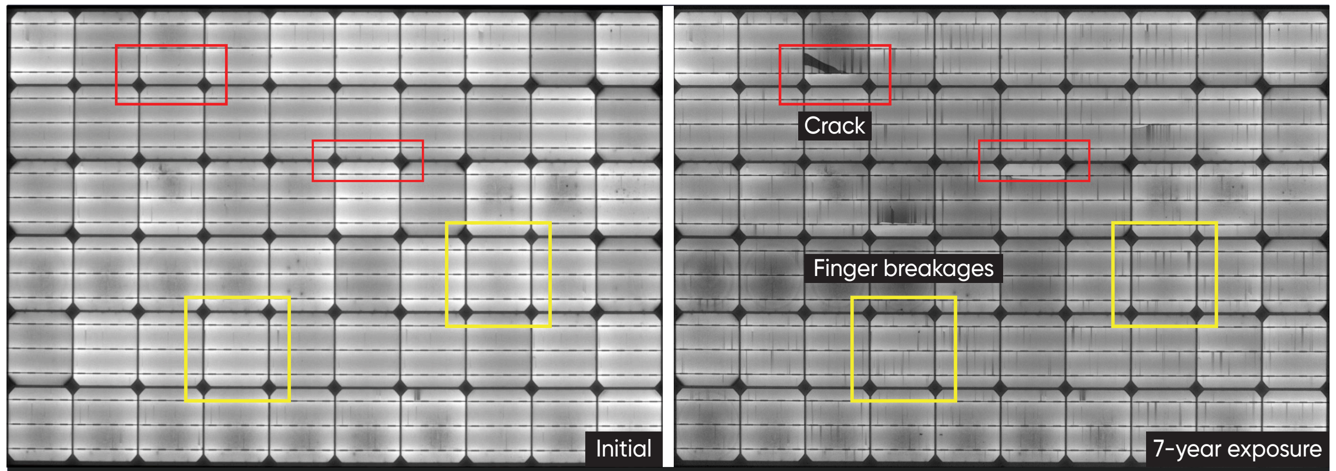

Figure 05: Comparing Electroluminescence (EL) Images of a PV Module at the Outdoor Test Facility (OTF) before Installation and After Seven Years Reveals Numerous Finger Breakages and Cell Cracks

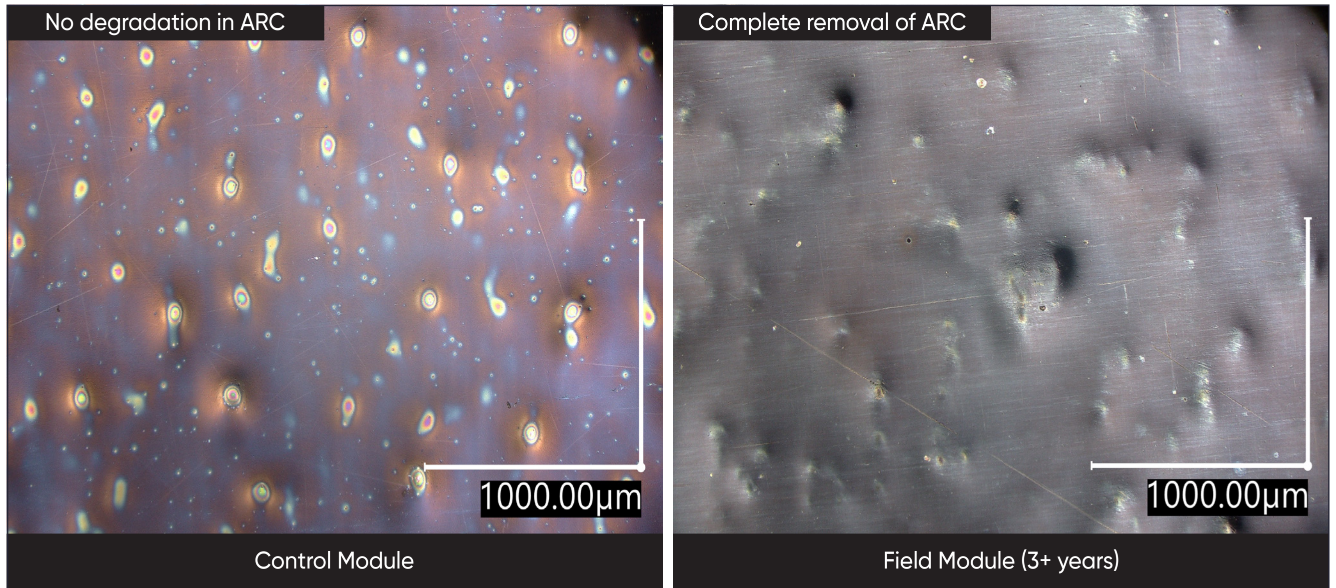

Figure 06: The Coaxial Microscope Images for the Surfaces of Two PV Modules

In Figure 6, the coaxial microscope images illustrate the surfaces of two PV modules. The first image depicts a control PV module stored indoors and not deployed in the field. In the second image, a predominantly grey hue indicates the near-complete removal of the Anti-Reflective Coating (ARC) in a PV module that has been in the field for 3+ years. In a microscopic view, the ARC coating is typically discernible in a distinct blue shade.

In outdoor-exposed solar modules, various degradation modes have been observed, including encapsulant discoloration, back sheet defects, metallization breakages, cracks, module warpages, and glass abrasions. To replicate these mechanisms in a controlled lab setting, a proposed test protocol called the Hot Desert Test Sequence (HDTS) has been developed using accelerated aging techniques. The HDTS, outlined in Figure 7, comprises three test sequences mirroring the reported degradation modes.

The Desert UV (DUV) test sequence consists of two legs, simulating encapsulant discoloration and back sheet defects. The first leg involves UV exposure of 60kWh/m2 at 80oC (±5°C), followed by 200 hours of damp heat testing (as per IEC 61215), repeated at least twice to replicate observed encapsulant discoloration. The second

leg entails damp heat preconditioning for 200 hours followed by UV exposure, followed by desert temperature cycling (-20 °C to 105 °C) for 400 cycles to mimic back sheet embrittlement. Intermediate measurements are proposed to assess module performance throughout the test sequence.

The desert mechanical stress (DMS) sequence comprises two legs. The first leg entails 400 cycles of desert temperature cycling to evaluate thermal fatigue. The second leg is a combined test sequence incorporating the combined effects of thermomechanical fatigue, UV stress for polymer softening, and mechanical load due to robot weight.

The sand and brush abrasion testing sequence also consists of two test sequences. The blowing sand test mimics the combined effects of sandstorms and high winds, employing specialized sand and dust chambers. Proposed parameters include a test time of 1.5 hours, wind speed of 20 m/s, chamber temperature of 60 °C, and relative humidity of ≤25% RH. Abrasions resulting from blowing sand testing have been reported, leading to reflectance losses in the module. Additionally, the motion of cleaning brushes on the module surface is considered. Standard IEC 62788-7-3 is followed to evaluate ARC material and coating wear and tear due to regular robotic cleaning.

The comprehensive test flow for durability testing of PV modules in desert regions is summarized in Figure 7 [5]. The complete test sequence involves six modules from the same batch, with defined test conditions and measurement requirements, as illustrated in the following figure.

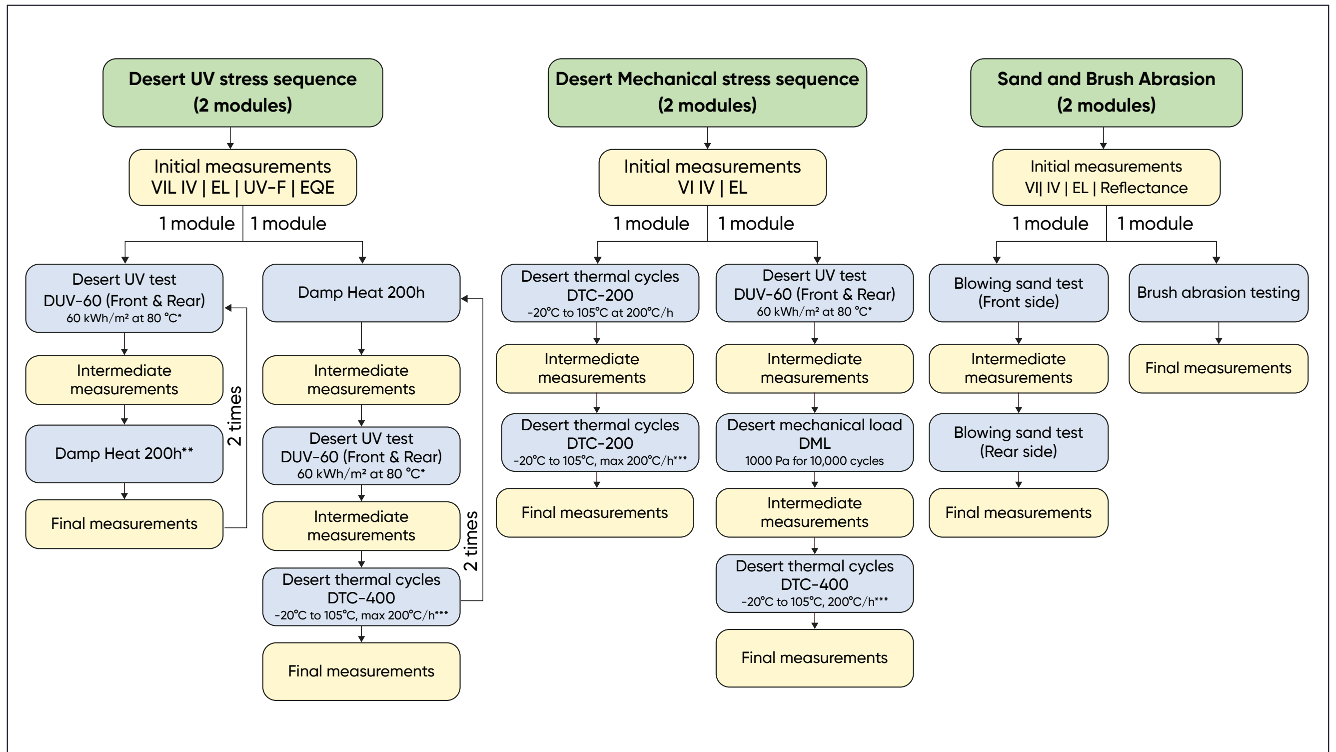

Figure 07: The Complete Testing Procedure for Qualifying Modules for Hot Desert Conditions, in accordance with the Hot Desert Test Sequence (HDTS), Comprises Three Sets of Sequences [5].

Integrating the hot desert test sequence necessitates specific adjustments and considerations to ensure consistent conditions, precise temperature regulation, and cost-effectiveness. By making these modifications, current standard chambers can effectively accommodate the HDTS, eliminating the need for new chamber designs. However, it's imperative to acknowledge the associated costs, particularly in the UV stress sequence. Testing five bifacial modules under the HDTS flow incurs nearly 80% higher costs compared to the complete IEC61215:2021 sequence for twelve modules. The UV stress sequence alone constitutes roughly 57% of the total expense. Considering test rates from an accredited PV module certification lab, it's evident that strategies to reduce costs are paramount. To address this disparity, exploring more economical UV test options, such as budget-friendly test conditions and cost-effective UV chambers, is recommended, without compromising the requisite test severity.

DEWA R&D invites global PV module manufacturers to join collaborative benchmark testing, including international partners.


Courtesy: Al Tajir - UAE - SirajPower

References:

[1] H. Apostoleris, S. Sgouridis, M. Stefancich, and M. Chiesa, 'Evaluating the factors that led to low-priced solar electricity projects in the Middle East', Nat Energy, vol. 3, no. 12, pp. 1109–1114, Dec. 2018, doi: 10.1038/s41560-018-0256-3.

[2] Dirk Jordan, Chris Deline, Sarah Kurtz, Gregory Kimball, Michael Anderson, "Robust PV Degradation Methodology and Application", IEEE Journal of Photovoltaics, 8(2) pp. 525-531, 2018, DOI: 10.1109/JPHOTOV.2017.2779779

[3] A. A. Suleske, G. Tamizhmani, B. Rogers, and N. Macia, 'Performance Degradation of Grid-Tied Photovoltaic Modules in a Desert Climatic Condition', Master's Thesis, Arizona State University, Arizona, 2010

[4] P. Gebhardt, Pitta L. Bauermann, and D. Philipp. "Backsheet Chalking - Theoretical Background and Relation to Backsheet Cracking and Insulation Failures," -1, 2018. https://publica.fraunhofer.de/handle/publica/404782

[5] S. Kumar, B. Adothu, J.J. John, G. Mathiak, B. Jaeckel, P. Gabbadi, M. Pander, R. Gottschalg, V. Alberts, "Proposal for hot desert test protocols for improved PV module durability", EPJ Photovoltaics 2023 (Under review)

ASSESSMENT OF THE EV MARKET WORLDWIDE AND INSIGHTS ON REGIONAL MARKET POTENTIAL

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Segment Manager
E-Mobility
Fronius

Renewably, Powered Electric Vehicles (EVs) offer significant advantages including energy efficiency, cost savings, and environmental sustainability – especially when combined with solar energy from one's own rooftop. While many countries are experiencing a surge in EV adoption, the e-mobility transition in the Middle East and other regions has not yet taken off to the same extent. Nonetheless, some signs suggest that e-mobility may soon gain momentum in the Middle East. This article explores global EV developments, particularly in battery – electric passenger cars, and assesses the prospects for e-mobility in the Middle East.

THE GLOBAL STAGE: FROM NICHE TO MEGATREND

Just a decade ago, the e-mobility transition was in its very initial stages. However, in recent years, the mobility landscape has undergone a remarkable transformation. The adoption of electric vehicles has accelerated, swiftly transitioning from niche to mainstream in the first markets, while others are rapidly catching up. In 2023, the global shift towards e-mobility continued to gather momentum, especially in the realm of new passenger car registrations. Approximately 6 million cars with electric drive systems were registered worldwide, including 4.27 million Battery-Electric (BEV) and 1.76 million Plug-in Hybrid (PHEV). A substantial increase of 40% compared to the previous year's record of 7.5 million units for the total year.

THE BIG PLAYERS – EUROPE, THE USA AND CHINA

The largest electric passenger car market in the first half of 2023 was once again China by a clear margin, where more than one in two e-cars were sold worldwide, with 3.4 million units (+37% compared to 2022). This is also due

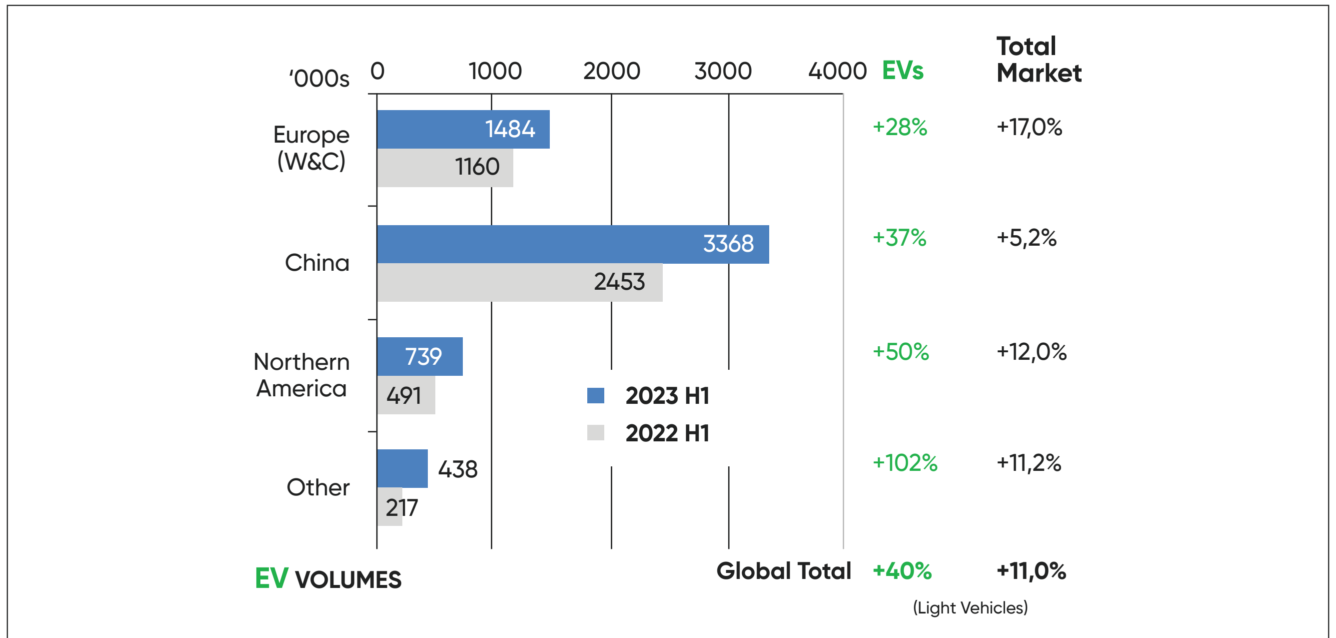

Figure 01: Numbers of EVs Sold in Thousands [2]

to the sheer size of the Chinese market. China is then followed by the US, with 739,000 (+50%) new electric cars registered in the same period. At Number 3 comes Germany. The German market accounted for nearly one in three e-cars sold in Europe, with roughly 300,000 BEVs and PHEVs sold. This means that in Germany, e-cars are already similar in popularity to diesel cars and have been the most popular type of engine in some months this year [1].

MIDDLE EAST AND OTHERS JUST STARTING OUT

The graph above illustrates that the remaining countries are only at the beginning of the e-mobility transition. Out of the total of 6 million battery-electric vehicles and plug-in hybrid electric vehicles sold in the first half of 2023, a mere 438,000 were sold in regions outside of Europe, Northern America, and China, including the Middle East.

PIONEER NORWAY: BATTERY – ELECTRICS OVERTAKING AT FULL SPEED

A particularly noteworthy example is Norway, Norway serves as a pioneer with its rapid EV transition. In just over a decade, they increased battery-electric vehicle market share from 1.4% in 2011 to an impressive 80% in 2022, making e-mobility the mainstream choice. With combustion cars at less than 6%, Norway has the world's highest EV market share, and its streets are to become predominantly electric in a matter of years.

Norway's example paints a picture that will likely be reflected in the future in other countries as well; the dominance of fully electric cars while plug-in hybrid vehicles decline. The Norwegian plug-in hybrid market share of new cars surged from 2.8% in 2011 to 31% in 2017, only to retreat to 15% by 2022. This confirms the idea that plug-in hybrids serve as a "bridge technology" in emerging EV markets. It is argued that once electromobility gains widespread acceptance in a country as is the case in Norway, battery-electric vehicles will surpass hybrids. Hybrid technology in turn will become more of a niche solution, suitable primarily for specific applications, especially in areas with limited overall infrastructure.

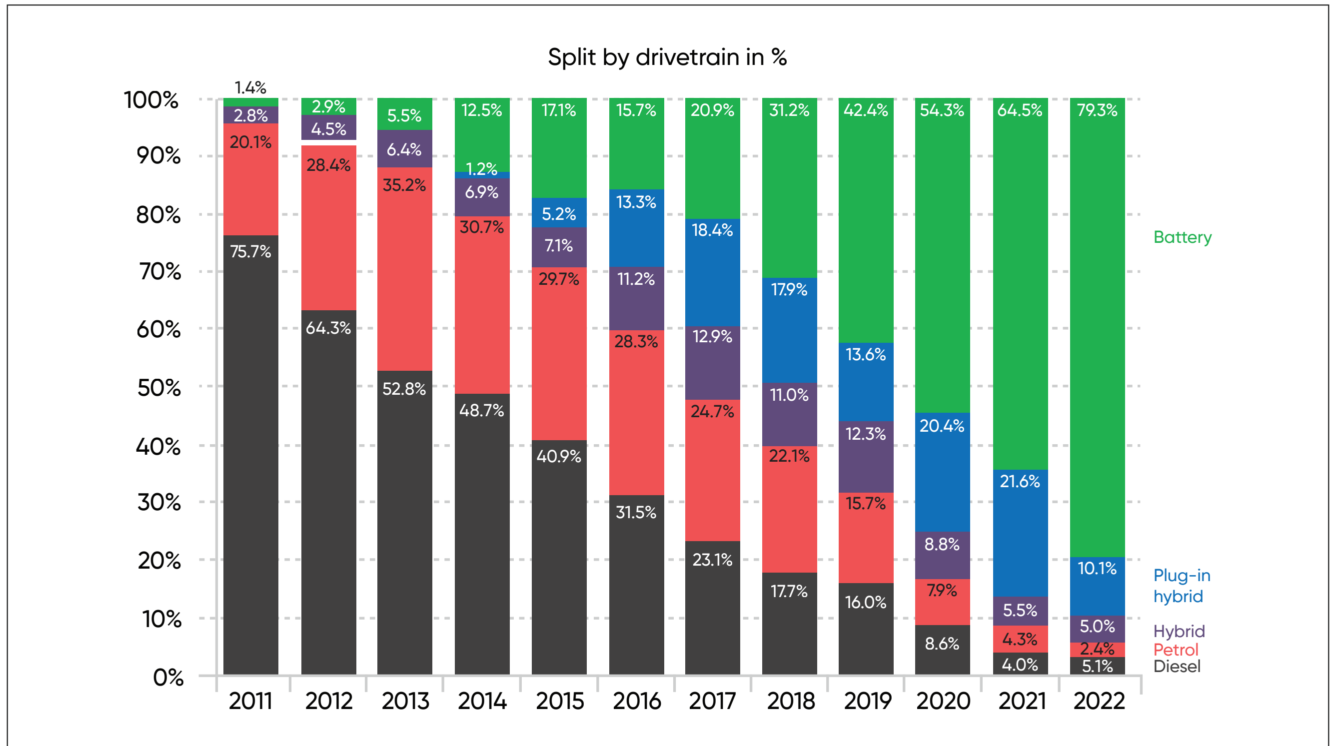

Figure 02: Norway Car Sales 2011 – 2022 [3]

EVs AND SOLAR – POWERFUL COMBINATION

Thanks to the direct use of electricity, electric vehicles avoid conversion losses altogether and combined with renewable sources like solar power, the highest efficiency is achieved. Drivers in advanced EV markets have recognized the advantages of directly powering their vehicles with rooftop solar panels: Solar and electromobility make for a perfect symbiosis in energy efficiency. In the future even more so, the possibility of bidirectional charging will allow EV batteries to store excess solar energy for night-time use. This will enable users to turn night into day and make the Fronius vision of 24 Hours of Sun become reality [4]–[6].

From a financial standpoint, the combination of solar power and EVs helps users save costs with every kilometer driven. This is especially true in regions with high solar irradiation such as the Middle East, where solar output is particularly high. In addition, grid operators also benefit from decentralized electricity generation and utilization, reducing strain on the grid and in turn the need for extensive infrastructure development.

THE MIDDLE EAST: WHAT TO EXPECT

Electric vehicle adoption in the Middle East has not yet happened to the same extent as in other regions. However, signs of change are emerging, as policymakers in the Gulf region are placing a stronger emphasis on e-mobility. Dubai with its Green Mobility Strategy, for instance, has set goals of achieving 10% electric car sales and making 30% of the public fleet electric by 2030 [7]. Saudi Arabia is also making strides with its own electric vehicle brand, CEER, scheduled to produce around 300,000 cars by 2030 and plans to install 5,000 EV fast-charging stations by 2025, as reported in Arab News in October [8], [9]. Government-industry partnerships are regularly announced in the media, and if these plans materialize, electromobility will soon become more established.

However, the most notable boost for e-mobility in the Middle East will be a global turning point; the moment EVs achieve price parity with traditional fuel-powered cars. Some analysts anticipate this happening as early as 2025. Once price parity is attained, the Middle East, like other regions, is likely to follow a similar trajectory in terms of EV adoption as seen today in Europe, China, or the United States.

OPPORTUNITIES AHEAD

What does the upcoming e-mobility transition mean for the solar and transport industries in the Middle East? To maximize the opportunities presented by this shift, governments and businesses are well-advised to invest in electromobility today. This will guarantee that they can position themselves ahead of the market, to be ready once increased demand for electromobility arrives.

Courtesy: Dubai Autodrome-UAE-SirajPower

References:

[1] *M. Rodríguez, "EV registrations in Europe in the first half of 2023," Electromaps. [Online]. Available: https://www.electromaps.com/en/blog/electric-vehicle-sales-europe-first-half-2023#:~:text=Passenger%20car%20registrations%20in%20Germany,15.8%25%20of%20the%20overall%20market.*

[2] *R. Irle, "Global EV Sales for 2023 H1," EV Volumes, the Electric Vehicles World Sales Database. [Online]. Available: https://www.ev-volumes.com/*

[3] *"OVF." [Online]. Available: https://ofv.no/*

[4] *Dr. J. Neuhausen and Dr. P. Rose, " Viewpoint: How The Diversification of Electric Platforms Will Determine the Next Phase In E-Mobility Transformation." [Online]. Available: https://www.strategyand.pwc.com/de/en/industries/automotive/powertrain-study.html*

[5] *A. Fritz, "E-Mobility Globally on the Rise." [Online]. Available: https://www.vda.de/en/topics/electromobility/market-developments-europe-international*

[6] *"Kraftfahrt - Bundesamt." [Online]. Available: https://www.kba.de/EN/Home/home_node.html;jsessionid=01A692C18956B6346FE02703FE65A454.live11294*

[7] *USA International Trade Administration, "United Arab Emirates Electric Vehicle Market," Jun. 2023. [Online]. Available: https://www.trade.gov/market-intelligence/united-arab-emirates-electric-vehicle-market#:~:text=This%20supports%20Dubai's%20Green%20Mobility,taxi%20fleet%20into%20hybrid%20vehicles.*

[8] *"Saudi Arabia Wants to Become a Force In Electric-Vehicle Manufacturing," The Economist Newspaper, Sep. 2023, [Online]. Available: https://www.economist.com/middle-east-and-africa/2023/09/28/saudi-arabia-wants-to-become-a-force-in-electric-vehicle-manufacturing*

[9] *"Saudi Arabia Forms Company to Develop EV Charging Infrastructure," Aug. 2023. [Online]. Available: https://www.arabnews.com/node/2397456/business-economy*

SOLAR–POWERED DESALINATION: TAPPING INTO RENEWABLE ENERGY FOR WATER SECURITY IN THE MENA REGION

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BUREAU VERITAS

In the arid landscapes of the MENA region, the confluence of escalating water scarcity and abundant solar energy finds a sustainable ally in solar-powered desalination technology. This burgeoning symbiotic relationship stands as a beacon of hope, potentially revolutionising the region's approach to water security.

THE MENA IMPERATIVE

Rapid urban expansion and population surge in the MENA region underline the increasing dependence on desalination as an integral strategy against imminent water shortages. In fact, the MENA region emerges as a veritable powerhouse in the world of desalination. It dominates the global scene, accounting for an impressive 53% of the desalinated water produced worldwide (Figure 1). Numerous plants, dispersed throughout the region, operate as lifelines, addressing these challenges head-on. However, many are anchored in fossil fuel consumption, casting shadows of environmental concern.

Traditional desalination, while crucial, brings along its baggage of environmental quandaries. Carbon emissions, habitat disruptions, and marine ecosystem imbalances are but a few of the negative externalities. The adoption of solar-driven processes presents an opportunity to recalibrate this balance, fostering a sustainable relationship between resource procurement and environmental preservation.

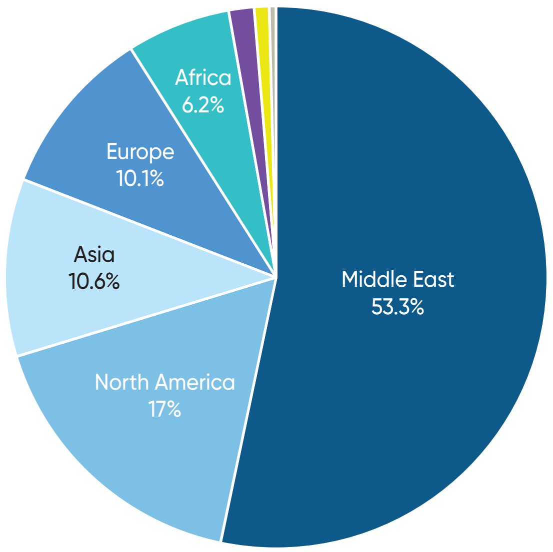

Figure 01: Distribution of Desalination Capacity Worldwide in 2022 by Region [1]

A CONFLUENCE OF INNOVATION

Recent technological advancements have seen the merger of solar energy and desalination techniques, sparking renewed enthusiasm for sustainable solutions. Among these, the advent of solar-driven reverse osmosis stands tall (figure 2), signalling a transformative era for water purification.

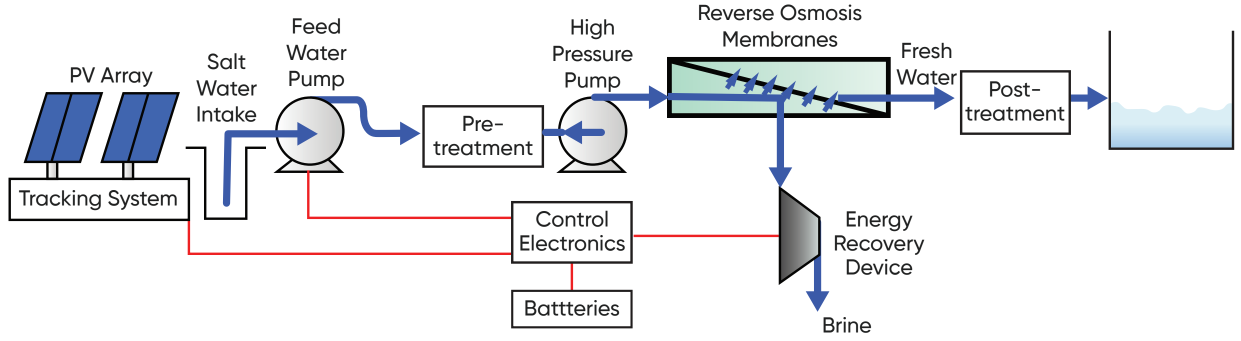

Figure 02: An Example of Solar PV Powered Reverse Osmosis Desalination System [2]

MENA's SOLAR DESALINATION VANGUARD

Acting as the crucible for sustainable innovations, the MENA region is witnessing the dawn of pioneering solar-powered desalination projects. These ventures, with their practical implementations, serve as testaments to the feasibility, scalability, and potential optimization of the technology.

Egypt: Blessed with an unparalleled solar resource, Egypt's landscape is an ideal playground for solar desalination. The government, tapping into this potential, has initiated tenders for five facilities along the northern coast. These structures, fortified by a 25-year BOO agreement, anticipate a substantive capital influx, together harnessing a combined energy output of 250 MWp. This, in turn, facilitates the desalination of over 400,000 cubic meters of water each day, marking a significant leap towards water sufficiency.

Saudi Arabia: The Jubail 3A Water Desalination Plant epitomizes Saudi Arabia's commitment to innovation. Slated to deliver a staggering 600,000 cubic meters of desalinated water daily, this initiative stands out. Furthermore, with an impressive solar array backing it, the plant signifies a noteworthy annual decrement in carbon emissions. Another facility, the Jubail 3B Desalination Plant, mirrors this commitment with a planned daily production of 570,000 cubic meters by 2024, undergirded by a solar infrastructure. Also in Saudi Arabia, the Shuaibah 3 transformation is in progress. Set near Jeddah and Makkah, it anticipates daily production of 600,000 m3 by Q2 2025, with up to 70% energy consumption savings. The Yanbu-4 Independent Water Producer Plant in Saudi Arabia, with a 450,000 cubic meters per day capacity, integrates 20 MWp of solar energy, making sizable dents in grid electricity needs.

Dubai: As a shining emblem of ambition and foresight, Dubai sets its sights on a transformative vision. Aiming to solar power a substantial segment of its desalination capacity by 2030, the region aspires to combine technological prowess with economic insight, heralding a new era of water management. The Dubai Electricity and Water Authority (DEWA) and ACWA Power have signed a 30-year water purchase agreement for the first phase of the Hassyan seawater desalination project. This project is notable for being the largest renewable energy Sea Water Reverse Osmosis (SWRO) plant. The facility will be powered by solar energy and have a capacity of 800,000 cubic meters per day. ACWA Power will invest AED3.357 billion ($914 million) in the project, which is expected to increase DEWA's water desalination capacity to 3.3 million cubic meters per day by 2030, from 2.2 million cubic meters per day at present. The Hassyan IWP will be the largest plant of its kind in the world, and it will desalinate water through reverse osmosis powered by solar energy.

For the MENA region, solar-powered desalination isn't merely a technological marvel; it's the dawning of a new era. By synergizing abundant solar resources with state-of-the-art desalination methodologies, the region embarks on a journey to ensure water security. With each solar panel installed and every droplet of purified water procured, the dream of relegating water scarcity to historical texts becomes not only imaginable but palpably attainable. As this journey unfolds, the MENA region, with its sun and sand, stands poised to chart a course for a "hydrated", hopeful future.

References:

[1] *Distribution of desalination capacity worldwide in 2022, by region, Statista*
[2] *Antar, M.A., Bilton, A., Blanco, J. and Zaragoza, G., 2012. Solar desalination. Annual review of heat transfer, 15*
[3] *Egypt launches a solar desalination tender for five CSP projects, SolarPaces*
[4] *Jubail 3A desalination plant's solar power station linked to the Saudi grid, Zawya*
[5] *Acciona commences energisation of Jubail 3B IWP in Saudi Arabia, Zawya*
[6] *SHUAIBAH 3 IWP, Acwa Power*
[7] *ENGIE in Saudi Arabia reaches financial close on Yanbu-4 IWP, Engie Middle East*
[8] DEWA picks ACWA Power to build Hassyan water desalination plant, Gulfbusiness

SOLAR ASSET INSPECTIONS WITH GLOBAL RANKING – NEW FRONTIERS!

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zeitview

Aircraft have been in use for a long time, serving various purposes and offering significant advantages for renewable energy sources. Drones have been employed in inspecting solar projects located in challenging areas, ensuring safety and saving time.

The logical progression now involves using manned aircraft for inspections due to their efficiency and extensive coverage. This article highlights the necessity to scale up asset management in response to the global surge in solar installations. It also emphasizes the importance of establishing a platform to assess the quality of solar assets.

It is crucial to recognize that saving power is tantamount to generating power. With the current solar installations amounting to a TW (1000 GW / 1,000,000 MW), even a 1% saving translates to 10 GW of solar assets, valued at approximately $5 billion. This signifies a substantial economic recovery by ensuring solar plants perform at their intended levels.

THE ROLE OF AERIAL INSPECTIONS: PLANES VS. DRONES

Aerial inspections with planes and drones are useful for identifying issues as well as maximizing the output and efficiency of commercial and utility-scale PV systems. Both aircrafts have their advantages and can be used for different purposes. Planes are better suited for large-scale projects and can cover wide areas quickly, while drones are more practical for on-demand inspections of small-to-mid-range solar plants.

In terms of data quality, both can provide accurate and detailed information about PV systems. However, the quality of the data may vary depending on the specific equipment used and the experience of the operator. To ensure the best results, it is important to carefully evaluate the capabilities of the aircraft and the operator before choosing which one to use for a particular project.

UTILIZING AI FOR THOROUGH PV SYSTEM ASSESSMENTS

Platforms used to analyze the anomalies are key in providing a holistic view of the performance and quality issues. Using Artificial Intelligence (AI) or Machine Learning (ML) to analyze thermographic images can help to identify these issues more quickly and accurately than if they were analyzed by a human. AI algorithms are trained to recognize patterns in the thermal data that may indicate a problem, and they can process the data much faster than a human could. This can help to minimize downtime and maximize the efficiency of the solar panel system.

In addition, using AI to analyze thermographic images can help to reduce the cost and time required for maintenance and repairs, as it can identify issues before they become more serious and costly to fix. Overall, using AI to analyze thermographic images can help to improve the reliability and performance of solar panel systems.

Also, an AI platform is considered to be the most suitable option; given the self-learning capacity of GW's, avoiding pitfalls of human error is a significant issue since it is not possible to avoid repetitive errors without the intervention of machine learning with GWs under its belt.

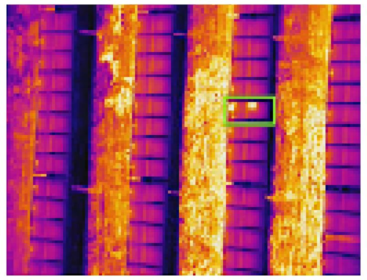
Overall, aerial inspections with planes and drones can be a valuable tool for optimizing the performance of commercial and utility-scale PV systems. By identifying and addressing issues early on, operators can prevent costly downtime and maximize their revenue from solar energy.

These geographical scans can then be used to a further advantage by creating a global solar asset quality ranking system which ranks assets based on performance garnered over a long period by inspecting a large base of such assets [1].

COMPARING UAV AND MANNED AIRCRAFT SCANS FOR SOLAR ASSET THERMOGRAPHY

By using data gathered by Zeitview, we've compared the benefits of UAV as well as the Manned Aircraft scans for solar assets thermography.

Problems detected through high-resolution photos and video	Problems detected through thermal sensing
• Soiling (drink, snow, dust)	• Hot spots
• Tracker issues (off-tilt or off-angle panels)	• Diode short-circuit or burnout
• Cracks and micro-cracks	• Reverse polarity (incorrect wining)
• Broken glass	• Fuse, junction box, array combiner, inverter failures
• Delamination	• Offline panel
• Snail trail (panel discoloration)	• Faulty cables
• Erosion at the base of mounts	• String outages
• Shadowing (vegetation, buildings)	• PID (potential induced degradation)
• Animal nests	



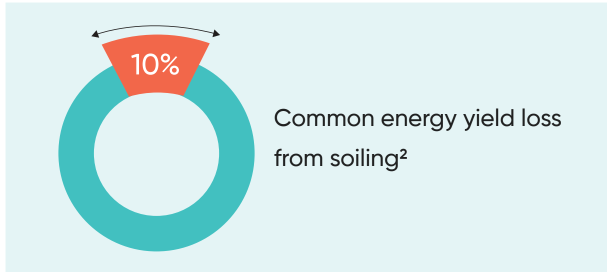


Table 01: Standard Issue Detection using RGB and Thermal Imagery

Drones are commonly used for aerial inspections of PV systems. Some models include the DJI M300, M2EA M600, M210, and M210 RTK, as well as the DJI Inspire 1. In general, any UAV capable of carrying an appropriate thermal sensor with a resolution of 640 x 512 and radiometric capability can be used for these inspections.

The aircraft payload should include an RGB camera with a minimum rating of 18 megapixels, or 12MP if using a dual-camera sensor. It should also include an infrared sensor, such as the H20T, Zenmuse XT2 R and XT R, FLIR Duo Pro R and Vue Pro R, Workswell Wiris, or Mavic 2 Enterprise.

Data analysis is an important part of aerial inspections of PV systems. Organizations can hire a data expert to review and interpret all the imagery collected, but this can become infeasible as the program scales. Alternatively, operators can build a custom AI platform to automate much of the analysis, or they can integrate a third-party solution designed specifically for aerial inspections.

	Manned Aircraft	Drone
Use cases	• Initial site surveys for a single or multiple large -scale prospective projects • Pre-construction planning and bid optimization • Verify construction and set performance baselines • Semi-annual inspections for a portfolio of facilities or plants spread across large swaths, to track against baselines, verify overall plant integrity and reduce performance degradation • For multiple large project sites in dispersed geographies • Pre-sale or acquisition inspections	• Initial site surveys for mid-or small-sized projects • Pre-construction planning and bid optimization • Construction progress tracking • Verify construction and set performance baselines • Semi-annual inspections of medium-to small-scale PV plants and commercial facilities, to track against baselines, verify overall plant integrity and reduce performance degradation • On-demand inspections and spot checks to assess areas of concern • Pre-sale or acquisition inspections
Maximum coverage area per day	• Typically 500 MW, 3,000 acres or as many as 60 rooftop installations • Can be as much as 1.7 GW	• Up to 30 MW or 100 acres
Lead time	• Requires advance scheduling, ranging typically between 2-4 weeks • Often scheduled spring and fall • May be performed on demand, depending on facility size and locale	• Standard lead times is 2 weeks, but DroneBase can often deploy within 48 hours • Expedited and on-demand projects possible

Table 02: Which Data Acquisition Method Works Best?

Courtesy: Shutterstock

	Manned Aircraft	Drone
Reporting delivery time	• Turnaround for processed data and reports approximately 5 days, depending on installation size.	• Turnaround for processed data and reports in approximately 5 days, depending on installation size.
RGB resolution for photos and videos	• 2.5 cm/pixel GSD[1] standard • 1 cm/pixel GSD optional	• 3 cm/pixel GSD standard • 1.5 cm/pixel GSD optional
Thermal imagery resolution	• 6.5 cm/pixel GSD standard • 3 cm/pixel GSD optional	• 5.5 cm/pixel GSD standard • 3 cm/pixel GSD optional
Accuracy	• For topographical surveys, +/-5cm • For thermographic surveys, individual panels • Mid-wave infrared technology used, allowing more sensitive and accurate temperature detection	• For topographical surveys, +/-5cm • For thermographic surveys, individual panels • Long-wave IR technology used, requiring closer poximity to achieve same temperature sensitivity
Locational factors	• In areas with busy airspace where drones aren't permitted • When wind presents a challenge for drone flights	• In areas with less air traffic • In stable weather without blustery winds

	UAV 3cm/px GSD	UAV 6.5cm/px GSD	Aircraft 6.5cm/px GSD
Single cell hotspot detection (2 examples)			

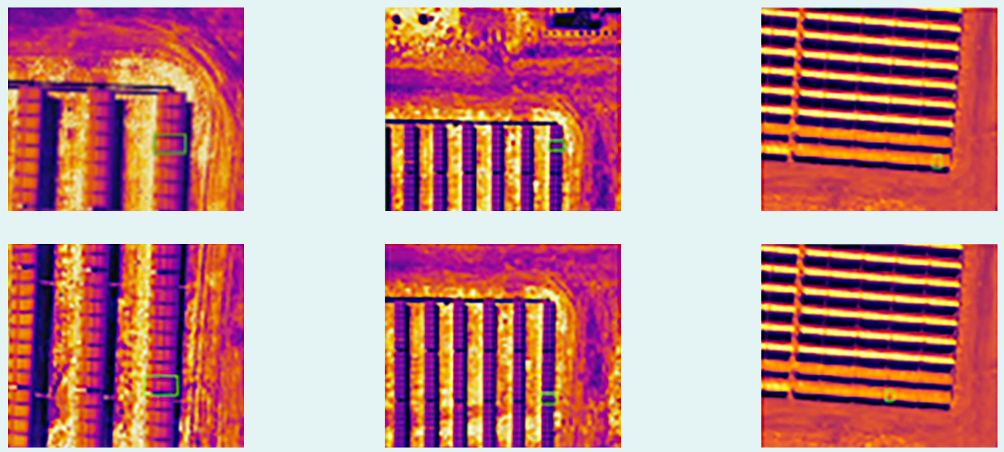


Table 03: Resolution Types

	Drone mission 1 3cm per pixel GSD	Drone mission 2 6.5cm per pixel GSD	Airplane mission 6.5cm per pixel GSD
Facility capacity	1.5MW	1.5MW	5MW
Thermal sensor and infrared imagery specs	• 13 mm or 19 mm focal length • 640 x 512 pixels resolution • 50Mk sensitivity[4] • Radiometric capability: LWR (long-wave infrared) sensor used requiring lower flight altitude to capture precise temperature data	• 13 mm or 19 mm focal length • 640 x 512 pixels resolution • 50Mk sensitivity • Radiometric capability: LWR (long-wave infrared) sensor used	• 100 mm focal length • 1280 x 720 pixels resolution • 20Mk sensitivity • Radiometric capability: MWR (mid-wave infrared) sensor used, temperature data captured in every pixel of images
RGB orthomosaic (high-res photography) specs	1.5 GSD	1.5 GSD	1.5 GSD

Table 05: Comparison of Specs Airplane Vs. Drones (Credit - Dronebase)

	Automated data collection time	Time on target[5]	Time on target	Time on target
	Data analysis time	100 minutes	85 minutes	45 minutes
Type and number of defects detected	Bypass-dioxide-activated module	66	59	66
	Isolated/underperforming module	73	73	73
	Missing module	4	4	4
	Multi-hotspot-affected module	1	1	3
	Single-hotspot-affected module	27	22	37

Table 06: Accuracy comparison of Drones vs. Airplanes

Comparing the cost and data granularity of aerial inspections using planes and drones at several mid-sized solar facilities, a study was conducted under similar weather conditions and a minimum solar irradiation level of 600 W/m2. Two drone missions and one airplane mission were flown to inspect the sites and identify any anomalies.

The study found that the detection of anomalies was high using both drones and an airplane. However, anomalies due to single-cell-affected modules were far more obvious in airplane imagery. This suggested that while both drones and planes are effective for detecting anomalies, planes may provide more detailed and accurate information in some cases.

Overall, the study highlights the tradeoffs between cost and data granularity in aerial inspections of PV systems. While drones are generally more cost-effective, planes may provide more detailed and accurate information in some cases. It is important for operators to carefully evaluate their specific needs and goals when deciding which type of aircraft to use for aerial inspections.

Construction

- High-resolution building progress imagery
- Equipment tracking
- Worker saftey checks
- Perimeter security
- As-built assessments

Commissioning

- Inspection of every panel to verify working order
- Detection of defects to be corrected by install team
- Capture of baseline performance for warranty purposes
- Orthomosaic maps portraying the full facility
- 3D models (digital twins) of projects

Operations and maintenance

- Soiling (dirt, snow, dust)
- Tracker issues (off-tilt or off-angle panels)
- Cracks and micro-cracks
- Broken glass
- Delamination
- Snail trail
- Erosion at the base of mounts
- Panel shading (vegetation, buildings)
- Hot spots
- Diode short-circuit or burnout
- Shorted cells
- Reverse polarity (incorrect wining)
- Fuse, junction box, array combiner, inverter failures
- Offline panel
- Faulty cables
- String outages
- PID (potential induced degradation)
- Cell browning/discoloring
- Transformer leaks
- Broken conduits
- Animal signs
- Vandalism
- Perimeter fence condition
- Power line condition

Sale

- Performance assessment of every panel (not just a sampling)
- Detection of defects
- Orthomosaic site maps
- 3D models (digital twins) of full facility

Decommissioning

- Imagery to prove out completion of site restoration

Table 07: Aerial Imagery Usages for Solar Assets

The need for accurate and timely results is a global ongoing requirement where regular inspections of solar panel assets are needed to ensure the continued performance and efficiency of the PV system. Over time, exposure to solar radiation, weather, and environmental conditions degrade components especially Solar PV Panels, leading to reduced output and increased risk of downtime. By conducting regular inspections, operators identify and address issues early on, preventing costly repairs and maximizing revenue from solar energy.

Regular inspections at different GSD based on the required can identify different anomalies and also help operators detect potential induced degradation (PID), a common issue in PV systems that can significantly reduce the performance of the panels. PID is caused by electrical currents that are induced in the modules, leading to power loss and reduced efficiency. By identifying and addressing PID early on, operators can prevent further degradation and maximize the output of their PV systems. These are just some of the warranty conditions that regular inspections can provide.

Overall, regular inspections are an essential part of maintaining the performance and efficiency of PV systems. By identifying and addressing issues early on, operators can prevent costly downtime and maximize their revenue from solar energy.

References:

[1] *L. Lovely , "First Standardized Solar Asset Ratings Introduced," Electrical Contractor Magazine, https://www.ecmag.com/magazine/articles/article-detail/first-standardized-solar-asset-ratings-introduced.*

THE EVOLVING RENEWABLE ENERGY LANDSCAPE IN THE MENA REGION

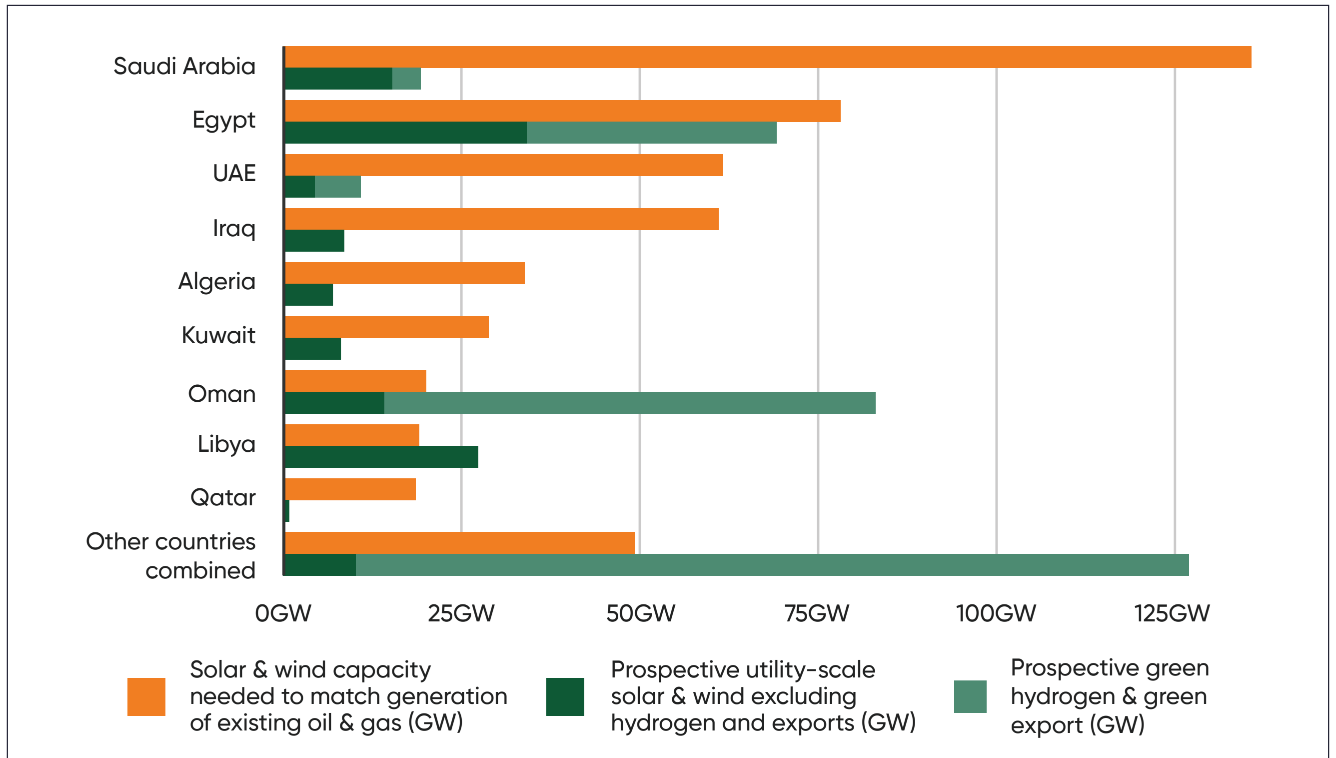
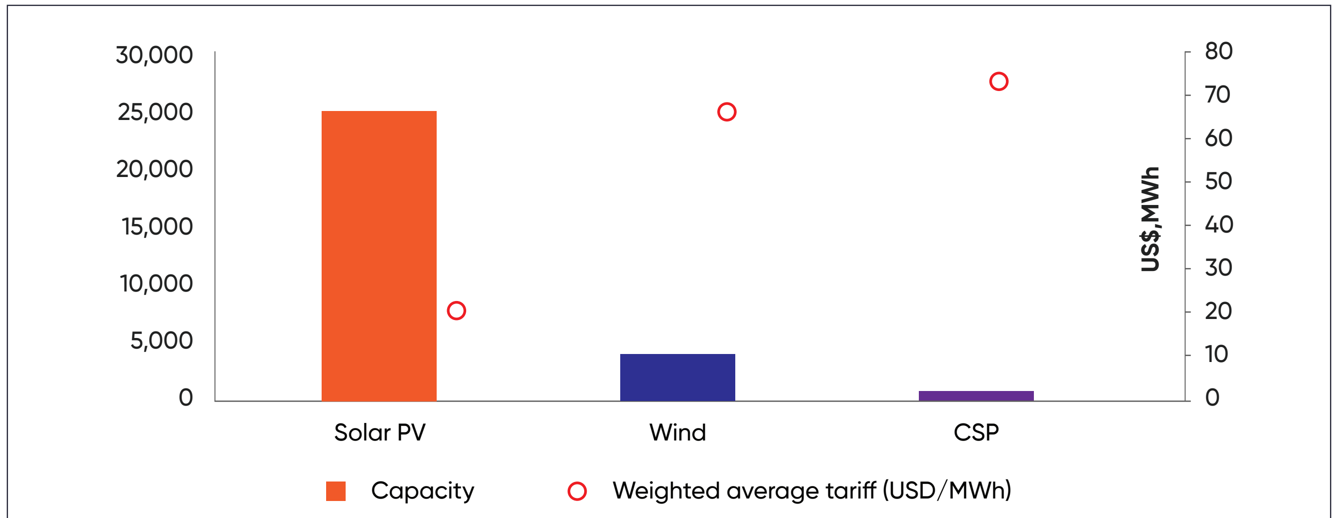


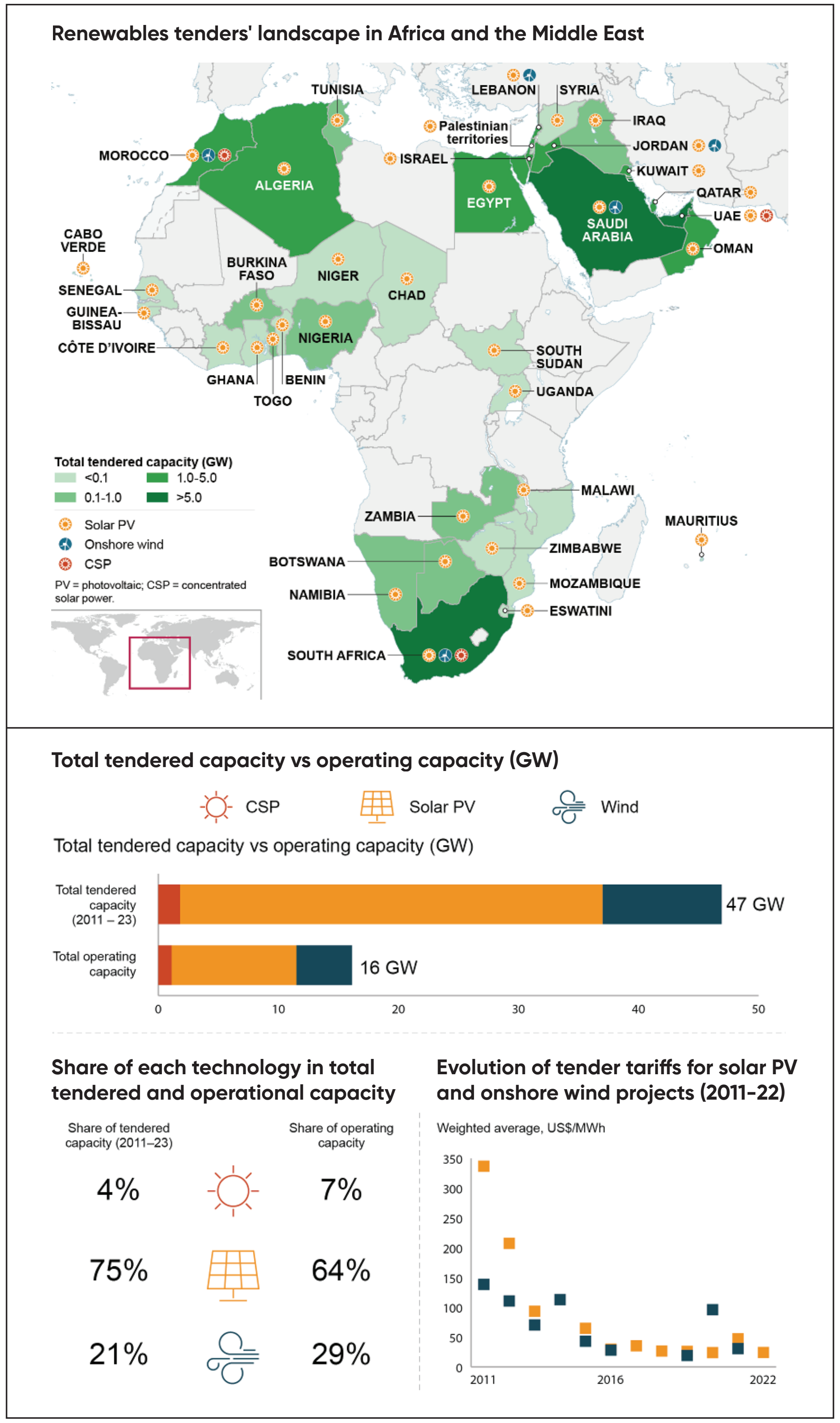
Figure 01: Solar & Wind Capacity Required to Generate Equivalent Amount of Power as Existing Oil & Gas Power Plants in MENA Countries, in Gigawatts (GW)

Note: Values are Global Energy Monitor calculations based on data from the Global Solar Power Tracker, Global Wind Power Tracker and Global Oil and Gas Plant Tracker. Source: Global Energy Monitor



In the Middle East, more than half of the total tendered capacity is concentrated in Saudi Arabia and the UAE, with solar PV dominating procurement. Source: S&P Global Commodity Insights

Figure 02: Fast Deployment Times, Lower Costs and Abundant Resources Lead to Solar Overshadowing Other Renewables in the Middle East



Source: S&P Global Commodity Insights

Figure 03: Overview of Renewables Tenders in Africa and the Middle East

Country	Operating solar	Prospective solar	Operating wind	Prospective wind	Operating solar & wind	Prospective solar & wind
Algeria	454	7,002	10	0	464	7,002
Bahrain	0	191	0	0	0	191
Comoros	0	0	0	0	0	0
Djbouti	0	5,030	0	5,059	0	10,089
Egypt	2,089	20,620	1,641	48,575	3,730	69,195
Iraq	0	8,460	0	100	0	8,560
Jordan	1,141	1,163	621	0	1,762	1,163
Kuwait	70	8,010	10	100	80	8,110
Lebanon	0	165	0	220	0	385
Libya	500	27,350	0	0	500	27,350
Mauritania	65	22,134	130	28,100	195	50,234
Morocco	740	29,050	1,291	25,971	2,031	55,021
Oman	1,288	46,464	50	36,600	1,338	83,064
Palestine	0	70	0	0	0	70
Qatar	800	875	0	0	800	875
Saudi Arabia	776	14,972	400	4,300	1,176	19,272
Somalia	10	92	0	0	10	92
Sudan	0	0	0	284	0	284
Syria	52	516	0	0	52	516
Tunisia	50	6,512	253	630	303	7,142
UAE	5,616	10,852	0	58	5,616	10,910
Western Sahara*	455	0	553	1,520	1,008	1,520
Yemen	0	190	0	77	0	267

Country-level total operating and prospective utility-scale solar & wind power capacity in the Middle East and North Arica (MENA), in megawatts (MW)

Global Solar Power Tracker, Global Wind Power Tracker, Global Energy Monitor. Data includes only project phases with a capacity of 10 MW or More

*Global Energy Monitor tracks projects located in non-self-governing territories, including Western Sahara, separately. Areas of western Sahara are administered by Morocco.

Source: Global Energy Monitor

Figure 04: Utility-Scale Solar & Wind Power in the MENA Region

Country	Operating	Construction	Pre-Construction	Announced	Prospective (Sum of Construction, Pre-Construction, Announced)
Regional Total	14,106	16,545	92,249	100,924	209,718
Algeria	454	21	1,000	5,981	7,002
Bahrain	0	119	72	0	191
Comoros	0	0	0	0	0
Djbouti	0	0	30	5,000	5,030
Egypt	2,089	1,430	14,090	5,100	20,620
Iraq	0	1,875	6,135	450	8,460
Jordan	1,141	0	0	1,163	1,163
Kuwait	70	0	6,590	1,420	8,010
Lebanon	0	0	165	0	165
Libya	500	100	250	27,000	27,350
Mauritania	65	34	0	22,100	22,134
Morocco	740	1,321	15,229	12,500	29,050
Oman	1,288	1,853	32,461	12,150	46,464
Palestine	0	35	35	0	70
Qatar	800	875	0	0	875
Saudi Arabia	776	6,752	4,660	3,560	14,972
Somalia	10	0	0	92	92
Sudan	0	0	0	0	0
Syria	52	158	20	338	516
Tunisia	50	420	5,292	800	6,512
UAE	5,616	1,552	6,100	3,200	10,852
Western Sahara*	455	0	0	0	0
Yemen	0	0	120	70	190

Global Solar Power Tracker, Global Wind Power Tracker, Global Energy Monitor. Data includes only project phases with a capacity of 10 MW or More

*Global Energy Monitor tracks projects located in non-self-governing territories, including Western Sahara, separately. Areas of western Sahara are administered by Morocco.

Source: Global Energy Monitor

Figure 05: Large Utility-Scale Solar Capacity in Megawatts (MW)

Country	Operating	Construction	Pre-Construction	Announced	Prospective (Sum of Construction, Pre-Construction, Announced)
Regional Total	4,959	6,173	78,641	66,780	151,594
Algeria	10	0	0	0	0
Bahrain	0	0	0	0	0
Comoros	0	0	0	0	0
Djbouti	0	59	0	5,000	5,059
Egypt	1,641	2,512	36,063	10,000	48,575
Iraq	0	0	0	100	100
Jordan	621	0	0	0	0
Kuwait	10	0	100	0	100
Lebanon	0	0	220	0	220
Libya	0	0	0	0	0
Mauritania	130	0	0	28,100	28,100
Morocco	1,291	778	7,693	17,500	25,971
Oman	50	300	33,150	3,150	36,600
Palestine	0	0	0	0	0
Qatar	0	0	0	0	0
Saudi Arabia	400	2,000	0	2,300	4,300
Somalia	0	0	0	0	0
Sudan	0	84	200	0	284
Syria	0	0	0	0	0
Tunisia	253	30	75	525	630
UAE	0	30	0	28	58
Western Sahara*	553	380	1,140	0	1,520
Yemen	0	0	0	77	77

Global Solar Power Tracker, Global Wind Power Tracker, Global Energy Monitor. Data includes only project phases with a capacity of 10 MW or More

*Global Energy Monitor tracks projects located in non-self-governing territories, including Western Sahara, separately. Areas of western Sahara are administered by Morocco.

Source: Global Energy Monitor

Figure 06: Wind Capacity in Megawatts (MW)

Country	Operating	Construction	Pre-Construction	Announced	Prospective (Sum of Construction, Pre-Construction, Announced)
Regional Total	**19,065**	**22,718**	**170,890**	**167,704**	**361,312**
Algeria	464	21	1,000	5,981	7,002
Bahrain	0	119	72	0	191
Comoros	0	0	0	0	0
Djbouti	0	59	30	10,000	10,089
Egypt	3,730	3,942	50,153	15,100	69,195
Iraq	0	1,875	6,135	550	8,560
Jordan	1,762	0	0	1,163	1,163
Kuwait	80	0	6,690	1,420	8,110
Lebanon	0	0	385	0	385
Libya	500	100	250	27,000	27,350
Mauritania	195	34	0	50,200	50,234
Morocco	2,031	2,099	22,922	30,000	55,021
Oman	1,338	2,153	65,611	15,300	83,064
Palestine	0	35	35	0	70
Qatar	800	875	0	0	875
Saudi Arabia	1,176	8,752	4,660	5,860	19,272
Somalia	10	0	0	92	92
Sudan	0	84	200	0	284
Syria	52	158	20	338	516
Tunisia	303	450	5,367	1,325	7,142
UAE	5,616	1,582	6,100	3,228	10,910
Western Sahara*	1,008	380	1,140	0	1,520
Yemen	0	0	120	147	267

Global Solar Power Tracker, Global Wind Power Tracker, Global Energy Monitor. Data includes only project phases with a capacity of 10 MW or More

*Global Energy Monitor tracks projects located in non-self-governing territories, including Western Sahara, separately. Areas of western Sahara are administered by Morocco.

Source: Global Energy Monitor

Figure 07: Large Utility-Scale Solar and Wind Capacity in Megawatts (MW)

A. AFGHANISTAN

RE Target by 2032	Renewable Energy Share of the Total Installed Capacity by 2022	Solar Installed Capacity by 2022
40%	**62%**	**33 MW**

Source: IRENA, Ministry of Energy and Water

I. CURRENT SITUATION:

Afghanistan's energy sector heavily relies on imports, with approximately 73% of its energy sourced from neighbouring countries such as Iran, Tajikistan, Turkmenistan, and Uzbekistan. However, the country has set an ambitious target to generate 40% of its electricity from solar energy by 2032 as part of its long-term vision and commitment to establishing a thriving and sustainable solar energy market.

The distributed generation (DG) market in Afghanistan has a high demand for solar energy due to the low electrification rate in rural areas. where less than 11% of the population has access to grid-connected power. In contrast, over 90% of the urban population in cities like Kabul and Herat enjoy access to grid electricity.

II. UPDATES ON REGULATIONS AND FRAMEWORKS:

Afghanistan has adopted solar regulations and schemes to promote renewable energy, such as Feed-in Tariffs, Power Purchase Agreements, and Net-Metering. It also released a renewable energy roadmap in 2017, with the support of the Asian Development Bank, the Ministry of Energy and Water, and the national power utility.

The roadmap assesses the potential of various renewable energy sources in Afghanistan, including solar, wind, hydro, biomass, and geothermal. It also examines the technical, economic, environmental, and social aspects of renewable energy development. The roadmap suggests actions and recommendations to address the barriers and challenges that impede the growth of renewable energy in the country.

However, the current political situation in the country has stalled the progress of these regulations and the roadmap.

III. PROJECTS:

Several solar projects have been planned or initiated in Afghanistan:

400 MW Herat Solar Project:

Another interesting application of ML in the solar industry is resource forecasting. Various providers can predict irradiance from multiple sources, including geostationary weather satellites and weather models, a process that is known as numerical weather prediction (NWP). These models primarily differ according to how they combine and interpret various sources of data; this difference also has a significant impact on their accuracy.

50 MW in Herat (Guzara):

This solar PV project in Herat has a capacity of 25 MW. It was in the pre-construction phase but is currently on hold due to bankability issues.

3000 MW AB PAL 4 Solar Energy:

The AB PAL 4 Solar Energy Solar PV Park is a significant solar project with a capacity of 3000 MW. It was developed by Da Afghanistan Breshna Sherkat and Pal 4 Energie Solaire,The project was in the announced stage. And It was expected to enter commercial operation in 2026.

**Please note that all these projects are facing delays due to bankability issues that have affected their progress and development.*

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IV. CHALLENGES AND OUTLOOK

The US withdrawal from Afghanistan, the political turmoil, and the Taliban takeover have led to the suspension of all utility-scale solar projects in the country while also creating uncertainty about the regulatory environment and their overall prospects. Moreover, these projects face bankability issues that hinder their progress.

However, there is still a growing demand for solar energy in the distributed generation (DG) market, especially in the commercial and industrial (C&I) sector.

The C&I sector dominates the DG market, as hospitals and schools need backup power solutions.

The future of utility-scale projects and regulatory updates is unclear, but the DG market has potential for growth, driven by the demand for solar energy in the health and education sectors. The DG market is expected to grow at a compound annual growth rate (CAGR) of 17% until 2032. However, this projection is subject to change depending on various factors such as political stability, financing availability, and regulatory frameworks.

Source: Solarabic Database

B. EGYPT

RE capacity by 2022	RE Share in Electricity Generation by 2022 (Excluding Hydropower)	RE target by 2035
8,778 MW	14.4%	50%

Source: IRENA, Solarabic Database

I. CURRENT SITUATION:

Egypt is facing the challenge of balancing its state budget and meeting its energy demand amid rising global oil prices. The government started reducing electricity loads this year to one hour per day but then extended it to two hours in some areas. This measure is expected to continue until July 2023, when the government plans to lift subsidies on electricity as part of the economic reform program supervised by the IMF.

The program aims to improve Egypt's fiscal and monetary situation, but it also imposes some conditions and challenges, such as removing support for the electricity sector, which consumes a large amount of the $12 billion loan that Egypt obtained from the IMF in 2016.

Despite the domestic electricity crisis, Egypt has maintained its electricity exports to Jordan and Sudan, which amount to 150-180 MW per day. On the other hand, the renewable energy sector has witnessed a recovery this year, with a total production of nearly 6,000 MW, half of which comes from hydropower and the other half from solar and wind energy. Egypt has also launched an ambitious plan to increase the share of renewable energies and to use hydrogen mixtures as an alternative fuel in power plants. The national strategy for green hydrogen includes several projects that rely on renewable energy sources.

Moreover, financial data revealed that Egyptians borrowed 341 million pounds (more than $11 million) from companies to purchase solar photovoltaic energy systems for their homes during the first half of 2023. This represents 1.66% of the total consumer financing activity.

This is in line with an incentive package offered by the Egyptian government to encourage citizens to switch to clean energy by supporting and facilitating projects that produce electrical energy from solar energy with net metering and self-consumption systems.

II. UPDATES ON REGULATIONS AND FRAMEWORKS:

On September 25, Egypt announced several measures to encourage investment in the sector of renewable and new energy, such as:

1. Amending the rules and laws governing electricity activities to unify the procedures and transactions for both public and private sectors, based on the principle of competitive neutrality.

2. Reducing the time for issuing and renewing permits and licenses by 50% compared to the previous legal period.

3. Exempting all solar energy projects with a net metering system connected to the national grid from the integration fee, up to 10 megawatts.

4. Solving the problem of investors in the Industrial Developers Zone on the 6th of October City by adopting urgent measures.

5. Issuing 31 permits and licenses to the private sector for investing in electricity production and distribution.

6. Establishing rules for the work of private companies in setting up electric vehicle charging stations and granting them a 10-year exemption from paying fees for permits and licenses issued by the agency.

7. Changing the method of paying consumption insurance for subscribers by allowing them to pay in instalments for one year without interest.

8. Developing standard contracts for investors to establish facilities that produce power from waste

9. Issuing rules for setting up electric power production stations with a self-consumption system.

10. Issuing the necessary rules and contract forms to enable consumers who want to switch their electricity consumption to renewable sources affiliated with the New Energy Production and Development Authority.

III. PROJECTS

Fars Solar Power Station 500 MW

This project, located in the desert back of the village of Fares in the Kom Ombo centre, aims to build the largest solar station in Africa with a capacity of 500 MW. The project is carried out by a specialized Chinese company and covers an area of 10,000 square meters. It is expected to be completed and to start supplying electricity to the national grid in September 2024. The project created about 2,000 job opportunities.

Solar Energy Projects in Sharm El Sheikh 40 MW

These projects are part of the government's commitment to transform Sharm El Sheikh into a green city by using renewable energy sources that will involve installing solar panels on rooftops, public buildings, and street lighting.

Four Renewable Energy Projects with a Capacity of 3,700 MW

On the 27th of June, the Egyptian Ministry of International Cooperation announced the signing of financial closure agreements for four renewable energy projects with a total capacity of 3,700 MW within the framework of the Integration of Water, Food, and Energy (NWFE) program. The projects include wind farms, solar plants, and hydropower stations.

Com Ompo Solar Project and 250 MW

This project is a joint venture between the public and private sectors to establish a new solar station in Kom Ombo with a capacity of 250 MW. On the 14th of August, an official source in the Ministry of Electricity and Renewable Energy announced that the project is currently under construction and expected to be completed by next January.

Zaafarana Solar Project, 50 MW

A new 50 MW project in the Zafarana area of the Suez Governorate, worth up to 38 million euros, was announced on August 14 by an official from Egypt's Ministry of Electricity and Renewable Energy.

IV. CHALLENGES AND OUTLOOK

Egypt is the largest operator of renewable energy in Africa, according to a report by Environment+Energy Leader. The country has huge areas that can be used to establish electricity generation plants from the sun and wind, with a potential capacity of up to 997 GW.

The government is granting tax incentives and preferences to green hydrogen projects, this policy aims to expand these projects in the Egyptian market and support the country's energy transition.

However, Egypt is also facing some challenges in meeting its growing electricity demand, especially during periods of extreme heat that increase consumption and cause power cuts. The government has resorted to reducing loads and extending the periods of power cuts in some areas.

One of the possible solutions to the electricity crisis is to further increase distributed generation market size, which has already increased this year, due to the heat waves and the power outage crisis. The relative decline in solar panel prices has also encouraged more people to switch to clean energy, despite the scarcity of the dollar, which affects the import of solar panels.

Source: Solarabic Database

C. INDIA

RE Capacity by 2030	RE Target by 2030	Renewable Energy Share of Electricity Capacity by 2022
500 GW	**50%**	**33.7%**

Sources: MNRE, and IRENA

I. CURRENT SITUATION:

In recent years, the Indian government has been actively promoting the use of solar energy. This initiative aims to reduce India's dependence on traditional energy sources and mitigate the impact of climate change. With a population of 1.4 billion, India has a significant demand for energy to fuel its rapidly growing economy.

From being a power-deficit nation at the time of Independence, India has made continuous efforts over seven decades to become energy-independent. Today, India is a power surplus nation with a total installed electricity capacity of over four lakh MW.

Keeping in mind the sustainable development goals, India's power generation mix is rapidly shifting towards a more significant share of renewable energy. Today, India is a global leader in renewable energy with the third-largest production of renewable energy in the world, fourth-largest installed wind power capacity, and fifth-largest installed solar power capacity.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

India has emerged as the world's largest market for renewable energy auctions. The transparent mechanisms and ambitious targets set by the government have attracted a multitude of domestic and international players. This influx of competition has significantly driven down the cost of clean power in the country.

Here are some of the key regulations that India has adopted to promote renewable energy:

- Renewable Energy Auction
- Feed-in Tariff
- Net Metering
- Renewable Energy Target

The Energy Conservation (Amendment)

At the beginning of the year, the Indian government notified the Energy Conservation (Amendment) Act, of 2022. This act empowers the central government to specify a carbon credit trading scheme.

It aims to incentivize businesses to reduce their carbon emissions by allowing them to trade their surplus carbon credits. This act represents a significant step towards achieving India's climate goals.

The Union Cabinet approved the National Green Hydrogen Mission

India's MNRE revealed on January 4, 2023, that the Union Cabinet had given the green light to the National Green Hydrogen Mission NGHM. The ministry, which is the main agency for this mission, will oversee and execute it. The ultimate goal is to turn India into a world leader in GH and its related products, both as a producer, user, and exporter. This will help India gain a prominent position in the global GH scene in terms of technology and market share.

Review of the Competitive Bidding Mechanism for Procurement of Power from Wind Power Projects

The MNRE issued a notification on January 9, 2023, to announce its decision on the competitive bidding mechanism for wind power projects. The decision was based on a report by a committee that examined how to increase wind energy capacity in India. The notification stated that:

- From 2023 to 2030, bids for 8 GW of wind power capacity would be issued every year.
- The bids would be composite, meaning that they would include sub-bids for each of the eight windy states in India.
- The power generated from the sub-bids would follow the Electricity (Amendment) Rules.
- The Wind Bidding Guidelines would be amended accordingly and notified separately.

Draft Guidelines to Promote the Development of Pump Storage Projects

According to a notification dated January 15, 2023, The MoP and the MNRE issued draft guidelines to promote pump storage projects PSP, a technology that can store renewable energy and provide grid services. The guidelines were open for comments from stakeholders.

The motivation for the guidelines was to support India's energy transition and address the challenges of variable and intermittent renewable energy sources. PSP was chosen as a suitable, reliable, and clean technology that can stabilize the grid and meet peak power demands.

Necessary Frameworks

To support the GH ecosystem, the government will create a policy framework that enables its development. It will also soon set up strong standards and regulations. Moreover, it will promote PPP for R&D under NGHM and SHIP.

NGHM will lead R&D projects and scale them up continuously to develop world-class technologies. It will also run a skill development program for GH. All government entities will work together to follow NGHM's goals, as India is focused on GH.

III. PROJECTS

NTPC Renewable Energy Invites Bids for 1 GW Solar Projects in Gujarat

NTPC Renewable Energy, a subsidiary of NTPC, is looking for bidders to implement land and EHV transmission system packages for ISTS-connected solar power projects of up to 1 GW in the Bhuj region of Gujarat.

The deadline for bid submission is November 28, 2023. The bidders have to meet certain eligibility criteria such as track record, land acquisition, technical feasibility, financial threshold, and net worth. The minimum bid capacity is 300 MW and the maximum is 1 GW.

SJVN Launches 1.5 GW Solar Tender

SJVN, a government-owned thermal energy producer, has launched a 1.5 GW solar project developing tender for ISTS-connected projects in India. The bidding deadline is Dec. 15 and the PPA duration is 25 years. The minimum project capacity is 50 MW, except for special category states where it is 30 MW. The tender also allows existing projects that are not under any scheme and are selling power on a short-term basis.


Courtesy: Shutterstock

NHPC Invites Bids for 1.5 GW Renewable Power Supply from ISTS-Connected Projects

In October, last month, the National Hydroelectric Power Corporation (NHPC) announced that it was inviting bids for the supply of 1.5 GW of renewable power from ISTS-connected projects. The projects will be developed on a build-own-operate (BOO) basis, and the deadline for bids is November 17, 2023.

NLC Launches 200 MW Solar EPC Tender

NLC India Ltd. launched a 200 MW solar EPC tender and invited bids to install and commission a solar plant of 200 MW capacity that was connected to the ISTS. The solar plant could be located anywhere in India and the bidding had closed on May 9.

The contractor who had won the bid had been responsible for the design, engineering, site development, manufacture, inspection, supply, storage, erection, testing, and commissioning of the 200 MW solar power project and its delivery point evacuation system. The contractor had also provided operation and maintenance of the entire solar project at no cost for 12 months after it had declared commercial operation and at a charge for the next three years.

South Eastern Railway Invites Bids for 13.54 MW Solar Rooftop Projects

In May, the South Eastern Railway (SER) announced its invitation for bids on 13.54 MW solar rooftop projects. The projects will be developed across various railway stations and other facilities in the SER jurisdiction.

The projects will be developed on a Design, Build, Finance, Operate, and Transfer basis.
The select bidder will be required to operate and maintain the rooftop solar projects for 25 years.

Gensol Secures ₹3 Billion Solar EPC Contract in Maharashtra

last month Gensol Energy Private Limited announced that it had secured a ₹3 billion (~$36.3 million) solar EPC contract in Maharashtra. The contract is for the development of a 62 MW solar power plant. The project is expected to be completed by 2024.

IV. CHALLENGES AND OUTLOOK

India has a huge potential for solar energy, However, the solar sector in India faces several challenges that need to be overcome to realize this potential.

One of the main challenges is to enhance the research and development, modern facilities, and manufacturing infrastructure in the solar sector. This will reduce the dependence on imports from other countries, especially China, and lower the cost of solar systems. Another challenge is to make the initial investment in solar systems more affordable and attractive for customers.

Moreover, there is a need to increase the awareness and acceptance of solar energy among the people, especially in rural areas. This can be done by improving the education levels, infrastructure, and grid supply. There are also some administrative hurdles, such as land acquisition and government approvals, that need to be streamlined for faster implementation of solar projects.

However, there are also many positive signs for the solar sector in India. The government has revised its target to achieve 500 GW of renewable energy capacity by 2030, out of which 280 GW is expected to come from solar energy. The cost of solar panels and systems has also been declining steadily, making them more affordable and attractive for customers.

Furthermore, many initiatives and innovations are promoting solar energy in India. For instance, India has distributed millions of solar lanterns and home lighting systems in rural areas. Many social enterprises and NGOs are providing solar solutions to rural communities. India has also launched the International Solar Alliance (ISA), a global platform to foster cooperation and innovation in solar energy.

In conclusion, the solar sector in India has a great opportunity to transform the country's energy scenario. However, to achieve this goal, the challenges mentioned above need to be addressed. The government, industry, and other stakeholders need to work together to create a conducive environment for the growth and adoption of solar energy in India.

Source: Solarabic Database

D. KINGDOM OF SAUDI ARABIA

Target by 2060	RE Target by 2030	RE Capacity by 2023	RE Capacity by 2030
Net Zero Carbon Emissions by 2060	**50% by 2030**	**9.5 GW by 2023**	**58.7 GW by 2030**

Sources: Vision 2030 & Solarabic Database

I. CURRENT SITUATION:

Saudi Arabia is making steady progress in developing solar energy in the country, to reach 7 GW of solar power in the total energy mix by 2023 and 40 GW by 2030.

The distributed generation (DG) market in Saudi Arabia is booming, especially in the commercial and industrial sectors. This is due to the government's recent decision to raise the self-consumption capacity limit from 2 MW to 30 MW. This opens up new opportunities for large-scale renewable energy projects, which can help to reduce the country's reliance on fossil fuels and support its sustainability goals.

The DG market has been experiencing a revival in recent years, thanks to government policies that support the development of renewable energy. The new decision is expected to pave the way for even more DG projects to be developed, as it will allow larger-scale projects to be implemented.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Regulatory Framework for Renewable Energy for Self-Consumption Amended

Last July, the Water and Electricity Regulatory Authority (WERA) in Saudi Arabia announced that its Board of Directors had approved several amendments to the regulatory framework for renewable energy for self-consumption. The amendments aim to clarify the rules and procedures for facilities that want to generate electricity from renewable energy systems for their use, whether they are connected to the grid or not.

According to the amended regulatory framework, facilities that wish to install renewable energy systems for self-consumption must obtain a study permit from WERA before starting any preparatory work, such as studies, planning, offering, or advertising. The study permit will specify the maximum capacity of the renewable energy system, which cannot exceed 30 MW.

III. PROJECTS

Fourth Phase of Solar Energy Projects in Saudi Arabia: List of Candidates Announced

The Saudi Energy Procurement Company (SEPCO) revealed in August the names of the alliances that are qualified for the fourth phase of solar photovoltaic (PV) projects under the National Renewable Energy Program (NREP). The fourth phase consists of two projects: Al-Hanakiya with a capacity of 1,100 MW and Tubarjal with a capacity of 400 MW. The total investment value of these projects is estimated at around 4 billion Saudi riyals (1.06 billion US dollars).

ACWA Power Secures Financing for Two Solar PV Projects in Saudi Arabia

ACWA Power announced in July the signing of financing agreements for the Shuaibiyah 1 and 2 solar PV projects. The projects will have a combined capacity of 2,630 MW, The total cost of these projects is 8.3 billion Saudi riyals (more than $2.216 billion).

The financing agreements were signed with a consortium of investors that includes Saudi Aramco, the national oil company, and Badil Electricity Holding Company, a subsidiary of the Public Investment Fund (PIF), the sovereign wealth fund of Saudi Arabia. The consortium will provide equity and long-term debt for the projects.

Wadi Al-Dawasir Solar Power Plant: Consortium Completes Financing for 119-MW Project

In July, a consortium of three companies, namely Total Energies, Toyota Tsusho, and Saudi Renewable Energy Company (Zahid Group), has achieved financial close for the development of a 119-MW solar power plant in Wadi Al-Dawasir, Saudi Arabia. The project is part of the third round of the National Renewable Energy Program (NREP).

The consortium secured financing from local lenders, APICORP and Riyad Bank, after making the final investment decision. The consortium also signed a power purchase agreement with the Saudi Electricity Supply Company, which will buy the electricity generated by the solar power plant for 25 years.

The solar power plant will be constructed by SEPCO (China) and is expected to start operation by early 2025.

Jubail Solar Water Desalination Project 45.5 MW

In June, Saudi Arabia launched the first large-scale solar water desalination project in the country. The project, located in Jubail City in the eastern region, has a capacity of 45.5 MW. The project can produce 600,000 cubic meters of desalinated water per day, meeting 20% of the plant's daily consumption.

The project is valued at $650 million and has set a world record in efficiency and cost. The project uses only one-kilowatt hour of electricity to produce one cubic meter of water from the Arabian Gulf Sea. The project also offers a world-record tariff level of $0.41 per cubic meter of water, which is significantly lower than the average cost of conventional desalination methods.

Three New Solar PV Projects in Saudi Arabia: SEPCO Signs PPA with ACWA Power and Badil

The Saudi Energy Procurement Company (SEPCO) signed in May a power purchase agreements (PPA) with a consortium of ACWA Power and the Water and Electricity Holding Company (Badil) for three new solar photovoltaic (PV) projects in Saudi Arabia.

The three projects are Al-Rass 2, Saad 2, and Al-Kahfah, with capacities of 2,000 MW, 1,125 MW, and 1,425 MW respectively. The total capacity of the projects is 4,550 MW.

Al Jouf Cement Company and Engie Partner to Build a 30-MW Solar PV Plant in Saudi Arabia

Al Jouf Cement Company signed an agreement last March with Engie to build a 30-MW solar photovoltaic (PV) plant in the Kingdom. The plant will provide clean and renewable energy to the cement company's operations and reduce its carbon footprint.

The agreement stipulates that the solar PV plant will be constructed in three phases, each with a capacity of 10 MW. The plant will be located near the cement company's factory in the Al Jouf region, in the north of Saudi Arabia.

IV. CHALLENGES AND OUTLOOK

Saudi Arabia has set ambitious goals to increase the share of renewable energy in its power energy mix, as part of its economic diversification, emissions reduction, and liquid fuels substitution strategies. The government has committed to achieving net-zero carbon emissions by 2060. The country also aims to become the global leader in low-cost renewable energy production and to optimize its oil and gas exports in a high-price environment.

However, the development of solar energy in Saudi Arabia faces several challenges, such as the low penetration of solar energy in the residential sector due to the low electricity tariffs that make net billing unattractive. On the other hand, solar energy is expanding rapidly in the industrial and commercial sectors, and utility-scale projects are among the largest in the region.

Source: Solarabic Database


Courtesy: Red Sea Project - KSA- Sunpure

E. KUWAIT		
RE Target by 2030	Solar Energy Share of the Total Installed Capacity by 2022	Solar Installed Capacity by 2022
15%	**0.4%**	**85 MW**

Source: Solarabic Database

I. CURRENT SITUATION:

The development of utility-scale solar energy in Kuwait has been slow and limited due to various challenges, including the lack of supportive policies and regulations. According to the International Renewable Energy Agency (IRENA), Kuwait's renewable energy share in total final energy consumption was only 1% in 2019, which is far below its target of 15% by 2030.

On the other hand, the Kuwaiti government has taken several steps to encourage the expansion of renewable energy sources in the distributed generation sector. These steps include preparing electricity purchase agreements with the private sector and supplying government buildings with 10% clean electricity.

Furthermore, the government has announced a group of solar energy projects to supply government sector buildings under construction and water desalination plants with photovoltaic energy with a capacity of 500 MW during the next phase. Additionally, it has planned several solar stations on a limited scale with a capacity of 1 GW.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

PPA Regulations Amendments

Recently, Kuwait has made some important changes in its regulatory framework for renewable energy projects. Previously, the only body that was authorized to regulate electricity purchase agreements was the Kuwait Authority for Partnership Projects: KAPP, which oversees the development and implementation of public-private partnership projects in Kuwait.

However, by the end of 2022, an amendment was introduced to allow the Ministry of Electricity and Water (MEW) to sign direct power purchase agreements PPA outside the scope of the KAPP Authority. This amendment represents a significant legal shift for signing future renewable energy projects, as it gives more flexibility and autonomy to the MEW to negotiate and finalize the contracts.

Net Metering

There is no official legislation or regulation for net metering in Kuwait. However, the Ministry of Electricity and Water (MEW) has been working on drafting a net metering policy since 2019. According to some sources, the MEW is expected to issue the net metering legislation by the end of this year or early next year.

III. PROJECTS

The development of utility-scale solar PV projects in Kuwait was halted in 2020 due to legislative issues. However, after resolving these issues, Kuwait resumed its efforts to expand its solar PV capacity, launching several new projects, such as

Al Shagaya Project (4,500 MW)

After the cancellation of the 1,500 MW Al-Dabdaba project (Shagaya phase two), The second and third phases of the Shagaya project have been merged into one phase, which will have a total capacity of 4,500 MW.

The new merged stage of the Al Shagaya project will be divided into four phases, which are planned to be completed in 2027 and 2028.

The 5,000 MW Solar Complex

A group of companies announced their plans in December 2021 to build a large-scale solar energy complex in northern Kuwait, with a total capacity of 5 GW. The complex will include several solar PV stations, with an investment of $3.5 billion.

The Sabiya Solar Project

A 30 MW solar PV plant for water storage and desalination services in Jahra. The project was inaugurated in February 2022 and is expected to be operational by 2025.

IV. CHALLENGES AND OUTLOOK

Kuwait has great potential and opportunity to expand its solar energy sector and achieve its renewable energy strategy. The country needs to add about 5 GW of solar energy plants by 2030 to meet the increasing demand and diversify its energy sources. Solar energy can also help Kuwait reduce its dependence on fossil fuels, which are heavily subsidized by the government and constitute a major economic burden on the country. Solar energy can also enhance Kuwait's environmental sustainability and reduce its carbon footprint.

Kuwait faces several challenges in achieving its renewable energy goals. One of the main challenges is the lack of supportive policies and regulations for solar energy development, which has been slow and limited. The process of making amendments to existing regulations can be time-consuming, which can hinder the growth of renewable energy in the country. To further accelerate the growth of renewable energy in Kuwait, the country must develop its solar regulations more efficiently and expedite the process of making amendments. This will help create a favorable environment for investment and innovation in the solar energy sector, leading to faster adoption and deployment of renewable energy technologies.

Source: Solarabic Database

Courtesy: Shutterstock

13 HIGHLIGHTS IN SELECTED SOLAR PV MESA MARKETS

F. SYRIA

RE Target by 2030	Solar Capacity by 2022	Renewable Energy Share of Electricity Capacity by 2022
30%	**60 MW**	**15.3%**

Sources: IRENA, RCREEE

I. CURRENT SITUATION:

Syria is facing a severe electricity crisis that has affected its economic and social development. The country suffers from frequent power outages that can last up to 22 hours a day in some areas. This has forced many Syrians to resort to using solar energy as an alternative source of power if they can afford it.

The electricity crisis in Syria is mainly caused by the lack of fuel supply, the damage to the transmission and distribution networks, and the sanctions imposed by the US and its allies on the Syrian oil and gas sector. According to the Syrian government, the daily demand for electricity in Syria is about 6,000 MW, while the available supply since the beginning of 2023 was about 2,000 to 2,100 MW, and it recently rose at the end of September to 2,500 or 2,600 MW. The Syrian government blames the electricity crisis on the US presence in lands containing oil and gas sources in the northeast of the country.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Syria Genies Imposing Fees on Solar Energy Users

In mid-2023, the Syrian government denied that there was a plan to impose new financial fees on users of solar PV panels. The government clarified that it supports and encourages the use of solar energy and does not take any decision against it. The government also stated that the committees that were formed to monitor residential buildings with solar PV panels were only for safety and quality purposes, after the earthquake that hit the country, not for taxation.

The Amendments to the Renewable Energy Loan

The Ministry of Internal Trade and Consumer Protection announced in early February 2023 the increase of the loan ceiling from 5 million Syrian pounds ($700) (1$ = 14000SYP) to 10 million Syrian pounds ($1,400). It extended the repayment period from 5 years to 10 years.

The loan is interest-free for state workers and retirees, as its interests are covered by the Renewable Energy Consumption Support Fund, which was established in 2022. The loan is allocated to install photovoltaic systems in the form of "two panels and a lithium battery," to serve the needs of citizens, such as lighting and charging in homes. The loan is also available for other consumers who work in the public or private sectors, or owners of industrial, commercial, and service activities, except for the agricultural sector. However, they have to pay interest on the loan.

III. PROJECTS

The Adra Industrial City Project - 100 MW

After the cancellation of the 1,500 MW Al-Dabdaba project (Shagaya phase two), The second and third phases of the Shagaya project have been merged into one phase, which will have a total capacity of 4,500 MW.

The new merged stage of the Al Shagaya project will be divided into four phases, which are planned to be completed in 2027 and 2028.

The Hasiya Solar Project - 3 MW

The station was inaugurated by the Syrian Minister of Electricity on May 22, 2023. The station has a capacity of 3 MW and was installed on the roofs of hangars in the industrial city of Hasiya in Homs Governorate.

The station cost about 12 billion SYP ($ 857 thousand) and aims to reduce the pressure on the national grid and provide backup power for the industrial city.

Wind Energy Project – 110 MW

A future project that is expected to boost the renewable energy sector in Syria is the wind station project, which will be the first and largest wind power plant in Syria.

The project has completed its electrical and civil studies and is expected to start implementation before the end of 2023. With a 110 MW capacity, the project will be connected to the national grid gradually in the first half of 2024.

IV. CHALLENGES AND OUTLOOK

Solar energy has emerged as an excellent solution to the electricity crisis in Syria, which has affected the economic and social development of the country. The Syrian market is one of the largest markets for the distributed generation (DG) of solar energy in the region, despite the many political crises and problems that come due to the sanctions imposed on the country. The distributed generation market for solar energy is growing exponentially in Syria, as more citizens and businesses are opting for solar photovoltaic (PV) systems to meet their power needs.

However, the solar energy sector in Syria also faces some challenges and limitations that need to be addressed. One of the most important challenges is the stifling economic crisis that citizens are exposed to, as workers in the public sector receive less than $10 per month. This affects the affordability and accessibility of solar energy for many people, especially those who live in rural or remote areas. The high initial investment and technical expertise required to install and operate solar PV systems also pose a barrier for many potential users.

Another challenge is the lack of skill and training in the workforce in the Syrian market, with the presence of high demand. This leads to many faulty or incorrect installations, which can reduce the efficiency and performance of solar PV systems. Moreover, there is a risk of counterfeit or low-quality products entering the market, which can compromise the safety and durability of solar PV systems.

The outlook for the solar energy sector in Syria, however, is not entirely bleak. There are some positive developments and opportunities that can enhance the potential and performance of solar energy in Syria. One of these developments is the political reconciliation that took place between Syria and the rest of the Arab countries this year, which is expected to have a positive impact on the utility-scale market. This means that large-scale solar projects can be implemented with more support and cooperation from regional partners, which can increase the supply and diversity of solar energy in Syria.

Source: Solarabic Database

Courtesy: H4 Robotic Cleaning Solution - Ecoppia

G. UNITED ARAB EMIRATES

RE Target by 2030	Installed Solar Capacity by 2022	RE Target by 2030
30% by 2030	**2,940 MW**	**14,000 MW**

Sources: IRENA, Solarbic Database

I. CURRENT SITUATION:

The UAE has made significant progress in developing its solar energy sector in recent years. In 2012, the country had only 12 MW of solar capacity, but that number has risen to about 3,040 MW in 2022, an increase of 25,000%.

The UAE government has set ambitious targets for renewable energy development and has implemented a number of policies to support the growth of the solar energy sector, such as offering generous subsidies for solar energy projects or creating a number of financial incentives for businesses and individuals to invest in solar energy. The UAE is well-positioned to become a major player in the global renewable energy market.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Financing Programmes

Emirates Development Bank (EDB): On the 10th of September, The EDB launched a new program to finance solar energy projects with up to 100 million UAE dirhams. The program is open to small, medium, and micro enterprises in various sectors, as well as technology providers, equipment suppliers, and energy consumers in various sectors. The program offers medium and long-term loans as well as working capital while also supporting projects related to hydrogen production and use, waste management orwater plants.

Commercial Bank of Dubai (CBD): CBD launched a new green home loan with easy facilities. The loan is available for properties with a platinum or gold LEED certificate, which is an internationally recognized standard for designing, constructing, and operating environmentally friendly buildings. CBD offers a processing fee of 0.25% of the loan amount, fixed interest rates for 1, 3, or 5 years, and an exclusive interest rate of 4.79% fixed for 5 years.

Adoption of National Hydrogen Strategy

In early June, the UAE Cabinet approved a new national hydrogen strategy, which aims to position the country as a producer and exporter of low-emission hydrogen over the next eight years. The strategy includes developing supply chains, creating hydrogen oases, and establishing a national centre for research and development.

Updated National Energy Strategy

Along with the Adoption of a National Hydrogen Strategy, The UAE Cabinet approved an updated national energy strategy, which aims to triple the contribution of renewable energy over the next seven years and invest between 150 and 200 billion dirhams in the renewable energy sector.

III. PROJECTS

Al Khazna Solar PV Project (1,500 MW)

Emirates Water and Electricity Company (EWEC) invited developers, in early September, to submit requests for expressions of interest in developing a new solar photovoltaic energy plant in the Al Khazna area in Abu Dhabi. The plant will have a capacity of 1,500 MW and will be similar in size and production capacity to the Al Dhafra and Al Ajban solar power stations.

Financing of 31 Solar Energy Plants (39 MW)

Earlier this year, the National Bank of Fujairah (NBF) signed an agreement with Yellow Door Energy to finance 31 solar energy plants with a capacity of 39 MW in the UAE.

Update On Al Dhafra Solar Project Construction (2,000 MW):

Last month, Abu Dhabi Future Energy Company Masdar completed the installation of the last solar panels at the Al Dhafra plant, which is the largest independent solar power plant on a single site in the world with a capacity of 2,000 MW.

Al Ajban Solar PV Project (1,500 MW)

EWEC received four bids in July, to develop the Al Ajban Independent Solar Photovoltaic Power Plant project. The bids came from ACWA Power, EDF Renewable Energy, Marubeni Corporation, and the consortium of Jinko Power and JERA.

World's Largest Water Desalination Project Using Solar Energy (180 MGD)

ACWA Power was selected in August, to implement and operate the first phase of the Hassyan water desalination project using solar energy in Dubai. The project will have a production capacity of 180 million gallons of desalinated water per day using reverse osmosis technology and is expected to be the lowest-cost desalination project in the world, with a price of 0.36536 USD per cubic meter of desalinated water.

Courtesy: Kingsx -UAE-Siraj Power

IV. CHALLENGES AND OUTLOOK

The UAE is targeting a total solar capacity of 7.3 GW by 2030, and the adoption of the National Hydrogen Strategy and Updated National Energy Strategy will further accelerate the growth of the solar energy sector. The hydrogen strategy aims to position the UAE as a producer and exporter of low-emission hydrogen, and the updated energy strategy aims to triple the contribution of renewable energy to the country's energy mix by 2030.

The outlook for solar and hydrogen energy in the UAE is very positive.\ The development of these sectors will create jobs, reduce pollution, and help the UAE achieve its climate goals.

Here are some specific ways in which the adoption of the National Hydrogen Strategy and Updated National Energy Strategy will support the growth of the solar energy sector:

- The hydrogen strategy will create demand for solar energy to produce hydrogen.
- The updated energy strategy will provide financial incentives for solar energy projects.
- The development of the solar and hydrogen sectors will be complementary. Solar energy can be used to produce hydrogen, and hydrogen can be used to store solar energy. This will help to make solar energy more reliable and affordable.

The outlook for solar energy in the UAE is very positive, and the adoption of the National Hydrogen Strategy and Updated National Energy Strategy will further accelerate the growth of the sector.

Source: Solarabic Database

H. YEMEN

RE Target by 2025	Solar Installed Capacity by 2022	Solar Pump's Market Share of the Pump's Market in 2020
15%	2,100 MW	31%

Source: Solarabic Database

I. CURRENT SITUATION:

Yemen's electrical network has been deteriorating since the political crisis began in 2011. This crisis has not only impacted the electrical infrastructure but has also led to significant damage. Even in areas covered by the network, residents face persistent power outages, causing them to rely less on it as a dependable energy source.

Instead, Yemenis now depend on private diesel generators to obtain their electricity. The cost of this electricity varies depending on the governing authority in the region, due to political divisions. Each region has its own pricing structure and exchange rate against the dollar. The Yemeni energy market is quite complex and fragmented because different authorities control various regions, each implementing its own energy policies and regulations.

Yemen holds great potential for the development of solar photovoltaic (PV) energy in the Middle East. This is due to the country's ongoing electricity crisis. Solar PV systems offer a reliable and cost-effective energy source for millions of Yemenis living in rural and peri-urban areas, where access to the traditional grid is limited or unavailable. For example, the use of solar energy in agriculture has increased from 0% in 2013 to 31% in 2020, highlighting the substantial growth of the distributed generation market in Yemen. In fact, Yemen is considered one of the fastest-growing distributed generation DG markets in the Middle East.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

The political crisis in Yemen has stalled the development of the legislative structure for renewable energy. However, there is still legislation related to project auctions, which has remained unchanged in recent years.

III. PROJECTS

For the past decade, the distributed generation sector of solar energy has been the exclusive driver of the solar energy market in Yemen. However, this year marks a significant shift in this trend, with the emergence of several utility-scale projects that have either constructed or are currently in development. These projects include:

120 MW Solar PV Project:

Developed by Masdar Company and situated in Aden, the temporary capital of Yemen, this project, funded by the Emirates, utilizes Jinko Solar PV panels. The project was supposed to commence operations in October of this year.

Power outage is a major challenge in Yemen, especially in Aden, where it has sparked many demonstrations and exacerbated the humanitarian crisis. This project aims to restore and expand electricity access in rural and peri-urban areas, and to plan for the recovery and reform of the power sector. By doing so, it hopes to alleviate some of the suffering of the Yemeni people.

185 MW Solar PV Projects:

Consisting of Four utility-scale projects with a combined capacity of 145 MW, these projects are currently in the development phase, overseen by different entities. Construction is slated to commence next year, and they are poised to contribute significantly to the diversification and stability of Yemen's energy supply.

IV. CHALLENGES AND OUTLOOK

Yemen has a huge potential and demand for solar energy, especially in the distributed generation sector, which has been the main driver of the solar energy market in the country. The utility-scale sector is also expected to grow significantly in the near future, as several large projects have started or are under development.

However, the solar energy market in Yemen faces some challenges that may hinder its development and performance. One of these challenges is the prevalence of counterfeit products or the lack of skills of some installers, which may result in poor quality and safety standards. Another challenge is the political instability and conflict that affect the legislative structure and the overall environment for the solar energy sector.

Despite these challenges, Yemen has a great opportunity to harness its abundant solar resources and to benefit from the environmental, economic, and social advantages of solar energy. The solar energy market in Yemen needs more support and investment from the government, the private sector, and the international community to overcome the obstacles and achieve its full potential.

Source: Solarabic Database


Courtesy: Shutterstock

The eyes of the world will be focused on COP28 in those two weeks which is expected to be a turning point for the renewable industry with solar playing a main role! The focus will be on how to progress in limiting climate change and the urgency of the situation faced to slow down global warming. One of the main elements that is expected to be the focal point of the discussion is accelerating and increasing the fund deployment needed. This is targeted to be around $1.5 trillion per year and the assembly will have to decide on an amount with this number in mind. It is also expected that global warming Relief and recovery reduction funds will be discussed to allow for affected countries to be compensated!

Hassan Qasem - CEO
Alternative Energy Company (AEPCo)

In recent years, Earth has faced an unprecedented climate crisis, causing daily challenges for the majority of the world's population and raising serious concerns for future generations. Global collaboration, evident through COP summits and entrepreneurial-led green initiatives, provides hope amidst these challenges. The Middle East and North Africa, profoundly affected and unprepared for climate change, grapple with rapid population growth, urban expansion, resource depletion, and economic diversification issues, especially in oil-dependent nations. To lead effectively, the region must surpass climate commitments, adopt new policies for increased climate financing, and embrace green finance for a gradual shift toward a sustainable economy. The upcoming COP28 conference holds immense significance, shaping global climate actions and promoting sustainable solutions.

Mohammed Shakir Aldulaimi - President
Baghdad Renewable Energy
and Sustainability Center

As the MENA region gears up for COP28, Jinko Power anticipates a transformative boost for renewable energy. COP28's spotlight on sustainability aligns perfectly with our mission to harness the sun's power for a greener future. We foresee collaborative agreements and strategic investments driving the development of solar energy infrastructure across MENA. This conference is poised to catapult our region into a global solar hub, capitalizing on abundant sunlight. Jinko Power is enthusiastic about the opportunities emerging from COP28, propelling us to the forefront of the green energy revolution. Together, we illuminate a path towards cleaner, more sustainable power, shaping a radiant tomorrow for the MENA region.

Mothana Qteishat - VP - International Tendering Head
Jinko Power

I approach COP28 with great anticipation and optimism. We view this conference as an important opportunity to strengthen international collaboration and accelerate the global transition to renewable energy. Our expectations are high; we look forward to strengthening partnerships, securing investments, and sharing Jordan's success stories in renewable energy adoption and energy efficiency projects.

We do, however, face many challenges on our path to energy transition in Jordan. When heading towards our goal to decrease greenhouse gas emissions to limit global warming, we can't forget about vulnerable communities who might not have the financial resources to react to increasing energy costs and invest in renewable energies. It is therefore crucial to find solutions, that are both green and social. Energy transition is too complex to only look at one side of the journey. We must find the balance between environmental sustainability, social equity, and economic growth.

Rasmi Hamzeh - Director
JREEEF

I see COP28 as a critical turning point in the climate crisis. The collective commitment will propel the much-needed fast-track espousal of renewable energy across the world. The ME region endowed with abundant solar energy is fast becoming a shining example with their solar capacity installation and adoption of new technologies. Solar trackers have become indispensable for optimizing energy efficiency, paving the path toward a more sustainable future in global energy production. As the world's leading provider of intelligent, integrated solar tracker and software solutions, Nextracker can play a key role in generating up to 20% more energy, in addition to accelerating construction schedules, minimizing environmental impact, and reducing project risks.

Hemanshu Sugandhi - Sr. Director - Business Development and Sales (MEIAT Region)
Nextracker

Climate change is an existential global challenge for all of humanity, and COP28 presents a unique opportunity to organize and accelerate climate action.

It is essential that we set ambitious targets and define the playbook to be used by all nations to achieve such targets, to limit global warming to well below 2 degrees Celsius above pre-industrial levels and strive for a 1.5-degree target. Concrete measures and policies that drive the transition to renewable energy, reduce carbon emissions, and promote sustainable practices should be at the core of the conference's outcomes.

The impacts of climate change disproportionately affect vulnerable communities and nations. It is crucial that any agreements reached at the conference consider the need for climate justice, ensuring that resources, technology, and support are provided to those most affected by climate change.
I hope that COP28 promotes transparency and accountability. Tracking progress towards climate goals is essential, and I expect the conference to establish robust monitoring mechanisms and ensure that participating nations adhere to their commitments.

Lastly, I hope that COP28 will build on the work started in previous COPs around making serious commitments towards climate finance, adaptation and resilience and loss and damage mechanisms.

Dr Raed Bkayrat - Senior Advisor
Sunergy Advisory

Beyond aspirations for successful negotiations, we should remain determined to drive decarbonisation and just energy transition across sectors. The use of clean technologies and innovations should be scaled up to close the emissions gap as soon as possible.

Green energy plays a significant role in the Middle East and North Africa region with proven success in advancing energy security and climate action while enhancing quality of life and breeding new market opportunities for businesses and youth to embark on. COP28 offers another momentous opportunity to actionise mitigation pledges and channel more climate finance to strengthen resilience and adaptation within fragile and conflict-affected communities.

Ruba AlZubi - Levant Climate, Energy and Environment Lead
UK Foreign, Commonwealth and Development Office (FCDO)

Climate change is the biggest crisis of our generation. As world leaders convene for COP28 this November, it is important to remember that global business leaders wield immense power and influence over the future of our planet. The private sector plays a pivotal role in decarbonizing economies. By choosing clean, green and distributed energy, we can actively steer our economies towards a future that is prosperous, resilient and sustainable.

Jeremy Crane - CEO
Yellow Door Energy

Head of COP28 UAE, let's translate the motion into action! The decisions that world leaders are going make now will have an important impact and a massive effect on our generation, our children's generation and generations to come.

I would really like to see supportive and transparent regulations on the real cost of energy. This would enable businesses to utilize clean, distributed, reliable and affordable energy that can power a low-carbon future.

Rory McCarthy - Chief Operating Officer
Yellow Door Energy

- **AI** Artificial Intelligence
- **ARC** Anti-Reflective Coating
- **BEV** Battery-Electric Vehicle
- **BESS** Battery Energy Storage Systems
- **BOO** Build, Own, Operate
- **CAISO** California Independent System Operator
- **CBD** Commercial Bank of Dubai
- **CO2** Carbon Dioxide
- **COP27** Conference of the Parties 27
- **COP28** Conference of the Parties 28
- **DEWA** Dubai Electricity and Water Authority
- **DG** Distributed Generation
- **DMS** Desert Mechanical Stress
- **DU** Desert UV
- **DNI** Direct Normal Irradiation
- **EDB** Emirates Develop-ment Bank
- **EDF** Électricité de France
- **EDS** Electrodynamic Cleaning System
- **EPC** Engineering, Procurement, and Construction
- **EPRI** Electric Power Research Institute
- **ESS** Energy Storage Systems
- **EUR** Euro (currency)
- **EVs** Electric Vehicles
- **FPV** Floating Photovoltaic
- **GREGY** Green Energy Interconnector
- **GW** Gigawatt
- **HDTS** Hot Desert Test Sequence

- **HECO** Hawaiian Electric Company
- **HJT** Heterojunction Technology
- **IEC** International Electrotechnical Commission
- **IEC-61724** International Electrotechnical Commission standard
- **IEEE** Institute of Electrical and Electronics Engineers
- **IEA** International Energy Agency
- **IRENA** International Renewable Energy Agency
- **IRR** Internal Rate of Return
- **ISFH** German Institute for Solar Energy Research
- **IWP** Independent Water Producer
- **KSA** Kingdom of Saudi Arabia
- **kWh** Kilowatt-hour
- **kW** Kilowatt
- **kWp** Kilowatt-peak
- **LEED** Leadership in Energy and Environmental Design
- **LCOE** Levelized Cost of Energy
- **M2EA** Matrice 2 Enterprise Advanced
- **M210** Matrice 210
- **M600** Matrice 600
- **MASDAR** Abu Dhabi Future Energy Company
- **MEW** Ministry of Elec-tricity and Water
- **MENA** Middle East and North Africa
- **MGD** Million Gallons per Day
- **ML** Machine Learning
- **MW** Megawatt
- **MWp** Megawatt-peak
- **NWP** Numerical Weather Prediction

GLOSSARY OF TERMS

PIF Public Investment Fund

PID Potential Induced Degradation

PPA Power Purchase Agreement

PR Performance Ratio

PV Photovoltaic

RE Renewable Energy

RGB Red Green Blue

RH Relative Humidity

SEPCO Saudi Energy Procurement Company

SPPC Saudi Power Procurement Company

SWRO Sea Water Reverse Osmosis

TOPCon Tunnel Oxide Passivated Contact

TWh Terawatt-hour

TW Terawatt

UAE United Arab Emirates

UV Ultraviolet

WERA Water and Electricity Regu-latory Authority

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