جمعية الشرق الأوسط لصناعات الطاقة الشمسية

MESIA Middle East Solar Industry Association

SOLAR OUTLOOK REPORT 2023

Exclusive Partner

WORLD FUTURE ENERGY SUMMIT

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What is MESIA?

The Middle East Solar Industry Association is the only non for profit, solar association covering and bringing together the whole of the solar sector across the entire Middle East and North Africa (MENA) region. Our aim is to:

1. Create business opportunities for our members
2. Organize educational webinars, events, and networking opportunities for solar professionals
3. Produce reports on market trends, latest technologies, standards, and best practices
4. Assist in the development of policies intended to strengthen the local solar industry
5. Support our members and partners through various physical and digital activities

The Middle East Solar Industry Association has over 80 local, regional and international company members from the entire solar value chain: EPCs, integrators, subcontractors, technical advisors, law firms, components manufacturers, Investors/lenders/funds, components suppliers/components agents, or distributors.

Any company involved in the MENA solar and broader renewable energy industry is welcome to join MESIA.

Founders & Partners

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Foreword

Denisa Fainis
Secretary General
MESIA

2022 ended at last. Following a challenging couple of years, one might have presumed, we would collectively finally catch our breath and see world returning back to a semi-normalcy. Yet, Europe's political challenges and subsequent energy crisis have taken a front seat in the third quarter of the year. As mentioned by S&P Global Commodity Insights, restrictions of "gas supplies to Europe have triggered a 565% increase in prices year-on year" with both US and Europe applying sanctions to the biggest producer of oil and gas in the world. Compared to previous years, the Middle East has reported little disruptions targeting the energy infrastructure, which shifted the spotlight on Saudi Arabia and the UAE alone, to play a critical role as a supplying region to the rest of the world.

As first-time host of the Conference of the Parties (COP27), Egypt gathered heads of states and delegates from over 192 countries that reached a 'breakthrough agreement" on a New "Loss and Damage" fund for Vulnerable Countries, as described by the United Nations Climate Change Conference. The package of decisions urges countries to "boost the support of finance, technology and capacity building needed by developing countries" in matters related to climate change. There is room for improvement, however. we can only be hopeful that this year's UAE based COP28 will elaborate on a more focused approach and implementation plan on cutting underlying greenhouse gas emissions.

Which brings us to one the first few topics of this year's report, where we will be elaborating on the topic of carbon credits and the COP proceedings. Although the Middle East does not particularly have the infrastructure to capture and monetize carbon credits at a regional level, the expectation remains that COP28 will address the need to incentivize developers and regulators to create the framework required to monitor environmental attributes, and tackle climate change at all levels.

Green hydrogen, sustainably sourced through solar energy, is set to turn the MENA region into the second-largest electrolyser installer by 2040, with green hydrogen producing plants set for Egypt, Morocco, Oman, Saudi Arabia, and the UAE accounting for close to 20% of the world production. Given its geographical position in relation to both Asia and Europe, the MENA is set to become an important supply chain hub.

Although the Middle East is gifted with summertime year-round, one of the main energy consumers and contributors to CO2 emissions is cooling. The demand for cooling is expected to triple by 2050, with cooling technological innovations being considered one of the main drivers in achieving an efficient cooling scenario. To achieve a competitive tariff, both solar PV developers and business owners need to evaluate ways in which they can lower their consumption, by increasing their energy efficiency and implementing Building Management Systems.

While the adoption of Electronic Vehicles in the Middle East is still a challenge in terms of infrastructure and testing in the hot climate, it is expected that 60% of all vehicles sold globally will be represented by EV's by 2023; A decade long leap from the 9% global supply recorded in 2021. Ambitions plans from Saudi Arabia based manufacturing companies estimate a capacity of close to 350,000 EV's, which will ignite the creation of an industry, with a goal of creating jobs and diversifying the economy. We can only hope for a world where businesses and residences are powered by solar PV energy, and each carpark is fitted with EV chargers that are solar powered.

The report is also addressing the topics of Asset Management, via Drone Surveying, Robot cleaning, O&M digitalization, followed by country specific highlights, showcasing many experts' opinions on both opportunities and challenges for their countries. Our friends from Solarabic help us take a quick dive into the map of countries with electricity shortages and showcase figures and pain points that could pose an opportunity for businesses with a high risk appetite.

The MESIA Solar Outlook Report has reached its 10th edition, and our aim remains to consistently provide our members, global collaborators, solar energy professionals and passionate industry readers, with topics featuring expert contributors while showcasing region specific technology and solutions.

We would like to extend special thanks to this year's contributors and dedicated individuals that drive the industry forward and break the mould, and we would like to thank all our supported, members and non-members for supporting MESIA and being part of a dynamic and interactive platform. We welcome new members for entrusting us on their growth journey to the Middle East solar industry.

01. Introduction

We are at the dawn of a new growth phase in solar energy. This exciting new phase is unshackled by the past decade of vacillation about the viability of solar energy. Equally important is the fact that solar energy is competitive in cost & electricity price against other energy products and solutions. Which has been the underlying factor for its resilience and unimpeded growth during the sustained low oil & gas prices and recent volatile energy market conditions. Solar energy has always been unique amongst other technologies, being able to be scaled to fit any need, from residential applications to utility-scale developments. This unique flexibility has resulted in solar energy being applied to related energy requirements such as electrified transportation and green hydrogen production. Electrified transportation and the growth of battery storage solutions offer unique symbiotic solutions with solar energy, which, if implemented correctly, could hasten us towards our destination of a net-zero future.

We see that the collective experience gained in MENA by installing and using solar has led to a drive to achieve greater energy yields and higher efficiencies in operations. The nascent but important aspect of solar energy production has brought in new applications of, Robotics, AI, Drones and Imaging Technologies, all aimed at improving the effectiveness of solar energy. Solar photovoltaic technology continues to find better efficiencies at both the cell and module levels. New technologies such as Hetero Junction Technologies and Perovskites are yet to become mainstream, but the industry watches these developments closely to gauge the future trajectories these potentially higher-efficiency cells can create. Further evidence of the industry's increasing maturity and viability of solar energy.

The developments in Green Hydrogen, Energy Storage and Electrified Transportation are ancillary to the solar industry. Green hydrogen, for example, has the potential to change erstwhile energy importing countries to energy exporters by capitalising on their abundant solar resources to electrolyse hydrogen. Similarly, in underserved regions where the supply of electricity is intermittent or insufficient, battery storage in tandem with solar can provide a cost effective solution. In our report, we have drawn attention to these developments and highlighted the relevance of solar growth for the growth of electrified transportation. The growth of electric vehicles in middle east countries is evident, and the start of manufacturing of electric vehicles in the region furthers the impact the electric vehicles sector will have in a region famous for its affinity for cars. Carbon offsetting technologies and their relevance to the solar industry is a topic we have highlighted, particularly methods to achieve carbon neutrality goals, with attention to the cost associated with implementing these technologies.

In our report, we have explored the market conditions and ambitions of the nations that comprise the Middle East and North African region. We deemed it important to particularly highlight countries in the MENA neighbourhood that continue to face shortages in electricity supply. It is clear that each country has ambitious goals and a path to these goals that are unique to their prevailing market forces. It is equally clear that most countries have an overwhelming and as yet unmet demand for solar solutions to solve fundamental energy needs. On the other hand, countries with abundant oil & gas resources view solar as an important method to diversify their energy generation mix, reduce carbon emissions and achieve net-zero goals.

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Courtesy: 10MW TAQA Project - Egypt - SUNGROW

COP 27 & COP 28, IMPACT, EXPECTATIONS AND CLIMATE CHANGE MITIGATION

S&P Global Commodity Insights
Miguel Barros Brito Low Carbon Electricity Analyst

- The very well attended COP27 proved historic in its ground-breaking language on "loss and damage" - having those developed nations responsible for historic emissions agree to help compensate vulnerable nations for their climate-change induced costs.
- While the gap between the status quo and the needed incremental emissions reductions to achieve 1.5-degree targets remains daunting, COP27 did not signal much increased progress. Relatively few countries communicated increased ambition, and the language on limiting fossil fuels did not move beyond what had been announced in Glasgow.
- More meaningful climate actions in 2022 have come through country policies and smaller scale efforts, such as those flowing from the G20 meetings.

The world gathered in force at Sharm El Sheikh, with official figures showing COP27 was the second largest to date, second only to Glasgow last year. The energy and fossil fuels industries also showed a strong showing, potentially offering a preview of COP28 in Dubai.

COP27 led to a global agreement featuring historic language on loss and damage. For the first time, developed nations have agreed to establish a fund for the costs of climate change for the most vulnerable emerging and developing economies. To take this forward, parties decided to set up a committee tasked with making recommendations regarding institutional arrangements, structure, governance, terms and sources of funding, which will be presented in Dubai in 2023. Although this is a significant achievement, the details are still to be decided, and the effectiveness and goodwill generated will depend on the generosity of donors, which has been limited to date.

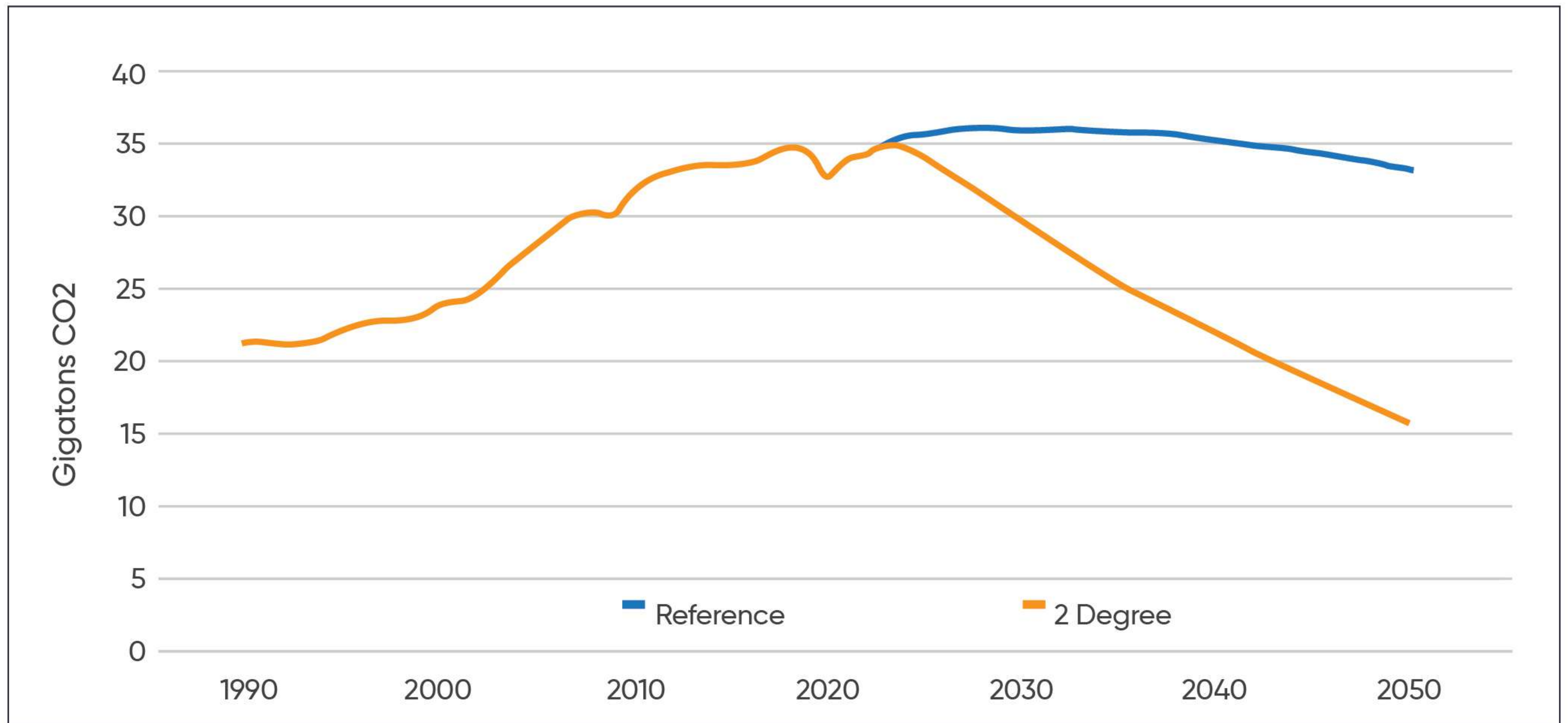

Figure 1: Projected Global Emissions and 2050 Generation in Reference (top) and 2 Degree

Parties also acknowledged the lack of progress on the collective climate finance pledge (made originally at COP15 in 2009) and urged developed countries to meet the annual goal of $100 billion. This largely unfulfilled promise has raised concerns about the feasibility of conditional emissions-mitigation targets and the ability of developed countries to follow through on the new funding pledges under loss and damage. Nevertheless, Adaptation Fund recorded $230 million in new pledges and contributions, with Germany and the United States leading the way with $60 and $50 million in new pledges, respectively.

As expected, there was minimal progress at Sharm El Sheikh on getting the emissions reduction needed to keep any hope of limiting warming to 1.5 degrees.

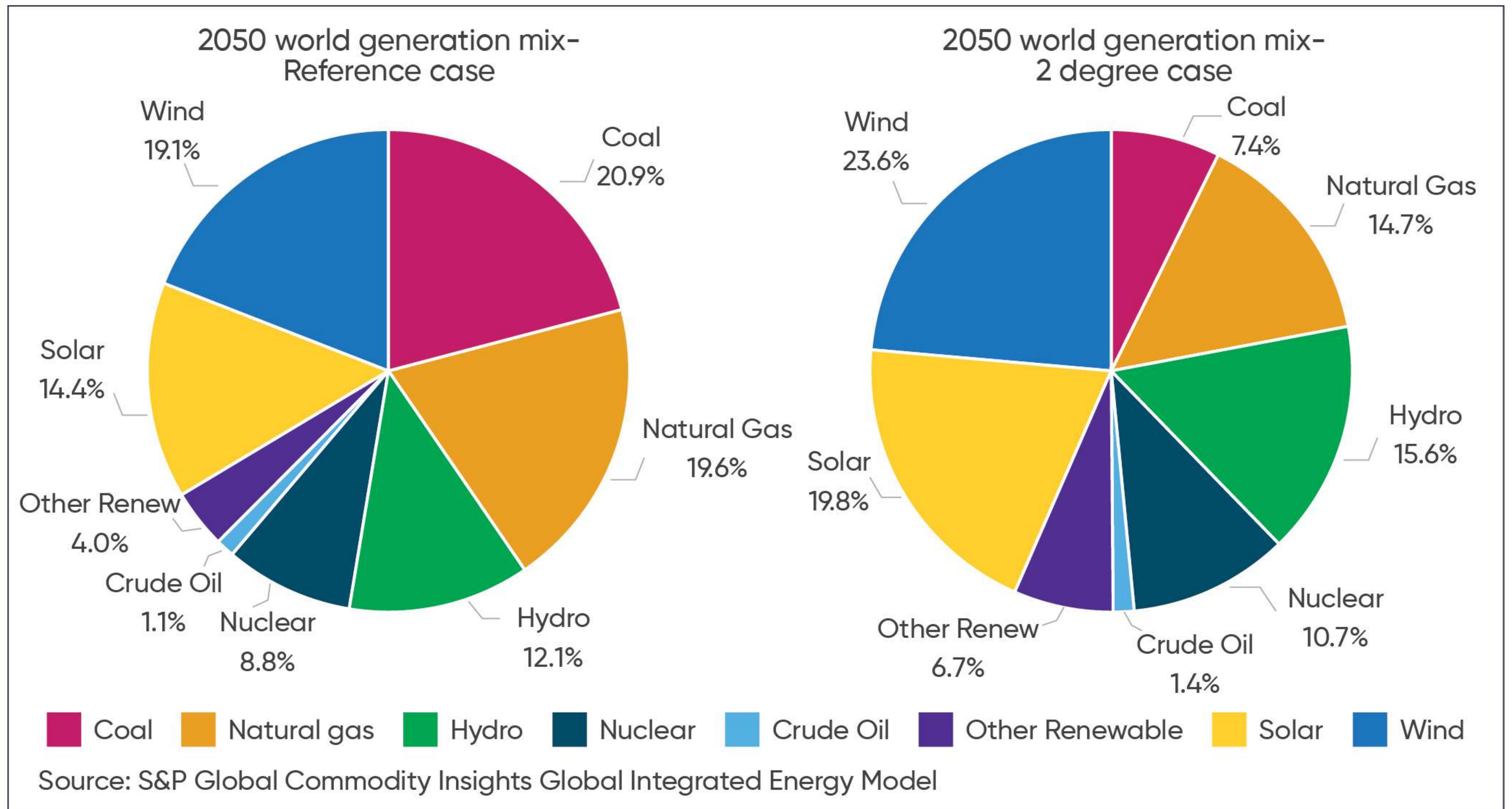

Figure 2: 2050 World Generation Mix

Despite a call at COP26 for countries to update their ambitions, only 35 countries have released new or updated Nationally Determined Contributions (NDCs) through 2030. These included several G20 countries, specifically Australia, Brazil, India, Indonesia, South Korea, Mexico and Turkey, but emissions trajectories remain far from 1.5 degrees target levels. The current set of NDCs would only reduce emissions by approximately 2% in 2030 relative to 2019 levels, compared with the 23% reduction that the Intergovernmental Panel on Climate Change (IPCC) states is needed to align with a 1.5°C pathway. Meanwhile, the Global Methane Pledge unveiled in Glasgow saw its total membership grow from 100 to more than 150, but still does not include major emitters China and India.

Given energy supply issues and concerns around inflation and the global economy this year, some considered it a success that official language on fossil fuels did not roll back what had been proclaimed in Glasgow. However, there was no building upon the "phasing down of coal" from last year - no "phase out" of coal, no statements directly limiting oil or natural gas - despite efforts by India and others to expand

Courtesy: COP27 - Egypt - Longi

02. Conference of the Parties COP27, COP28

the ambition. The inclusion of language of support for "low-emission energy" might be interpreted as allowing continued use of natural gas given individual country circumstances.

Interestingly, 2022 has seen significant policy progress on the energy transition but done through national and regional initiatives outside of COP, such as the Five Year Plans (China), Fit for 55 policies (EU), and the Inflation Reduction Act (US). After a year of geopolitical tensions and a global energy crisis, where energy security concerns have reemerged to the fore, key energy transition outcomes in terms of financing and investment are more likely to be driven through domestic policies, bilateral agreements, or ties among smaller groups of stakeholders. It was at the G20, not at COP27, that the leaders of the US and China finally met and agreed to restart bilateral climate talks. It was at the G20 that a more targeted climate effort like the Indonesia Just Energy Transition Partnership was announced, with real emissions commitments by parties and implications for a leading global coal producer.

Negotiations at COP and interim UNFCCC sessions are the key venues for progress regarding Paris Rulebook efforts, such as Article 6 global carbon trading. Sharm El Sheikh provided for those discussions, making progress on a number of fronts but also dealing with other efforts that may have added more confusion than clarity, such as the Energy Transition Accelerator program. As it is, these discussions to date are focusing more on approaches around nature-based solutions and forestry, and less on having these mechanisms drive the transition of the energy sector.

Ultimately, while COP27 broke new ground in seeking to address the costs of climate change, it did little in also addressing the need to dramatically cut underlying greenhouse gas emissions, which will hopefully return to the forefront of discussions at COP28 in Dubai.

03. Carbon Credits

FUTURE OF CARBON CREDIT AND CARBON OFFSETTING IN MENA

Yvonne Lam
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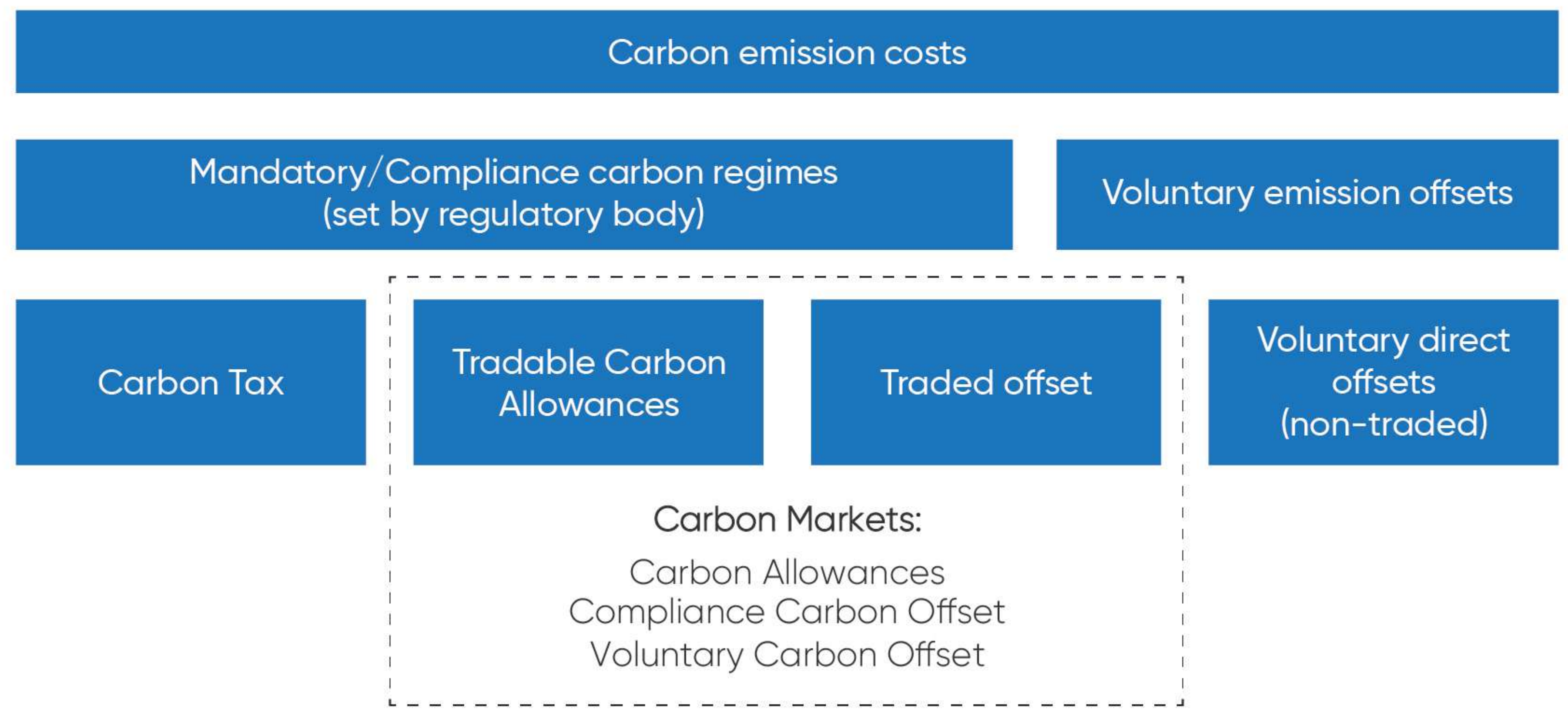
RYSTAD ENERGY

Carbon markets could be broadly defined as systems for carbon trading, making CO2 a commodity that could be traded on the market. However, as opposed to usual trade markets, the carbon market trades in allowances or credits instead of actual goods. In other words, it is putting a price on carbon emissions. Carbon markets can be broadly divided into mandatory, also known as compliance carbon markets, and voluntary carbon markets. Figure 1 illustrates the different types of carbon emissions costs and how carbon markets fit. The emissions trading system (ETS), commonly known as cap-and-trade, is a system that trades carbon allowances, which means permission to emit for companies. Carbon tax and cap-and-trade systems are the mandatory carbon pricing mechanisms for CO2 emissions, which companies that fall under the jurisdiction are obliged to pay.



*Allowance or permission to emit on ton of CO2 within a regulated/ market like ETS. Allocation and volume of credits set by regulator (governmental body) but traded between companies within the ETS

**Compliance offset market credits may in some instances be purchased by voluntary, non-regulated entities, but voluntary offset market credits, unless explicitly accepted into the compliance regime, are not allowed to fulfil compliance market demand.

Source: Rystad Energy research and analysis

Figure 1: Carbon Market and Types of Carbon Emissions Costs

In some of the regulated markets, carbon offsets are also allowed to be used to offset companies' emissions to comply with the regulation in a limited percentage. The current carbon pricing implemented globally covered only close to 11.9 gigatonnes (Gt) of CO2e, which is approximately 23% of the world's greenhouse gas emissions. Companies that do not fall under the jurisdiction of carbon pricing can choose to participate in the Voluntary Carbon Market (VCM). The use of carbon offset mechanisms is a controversial topic, primarily due to the integrity of the issued carbon credits. However, for some companies, the use of carbon credits in their decarbonisation strategies is essential to deal with remaining unabated emissions. As companies aim to align with country climates targets and the terms of the Paris Agreement, strategies must be developed for decarbonisation. Carbon offsetting essentially ensures that companies' unabated emissions are dealt with in some manner. One way to offset emissions is by purchasing carbon credits. Carbon credits can be purchased through mandatory or voluntary markets, where one carbon credit equates to 1 tonne of CO2 that

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the purchasing company will emit. Mandatory markets, such as the Alberta Emission Offset System, are used by companies and governments that are legally mandated to offset part of their emissions, whereas voluntary markets, such as the Australian Carbon Credit Unit (ACCU), allow private companies and individuals to purchase carbon credits on a voluntary basis. The money accumulated from the buying of carbon credits is used by the seller to finance the project that is offsetting carbon emissions either by reduction or direct removal. Reduction projects are those that reduce the production of CO2 emissions by displacing a process that does emit – mainly renewables projects such as solar and wind. Removal projects are those that directly remove CO2 that has already been emitted – direct air capture (DAC), reforestation, and enhanced weathering, for example.

Although there are many different types of credits for companies to choose from, some credits are better than others. This is primarily due to the four pillars – additionality, tangibility, measurability, and permanence; illustrated in Figure 2. Essentially, carbon credits need to be well-vetted and verified before companies have the opportunity to purchase them.

The first pillar – additionality – refers to whether or not the project is additional in its removal or reduction of emissions and is a defining characteristic of carbon offset projects. This means that if a removal or reduction project would have taken place regardless of the revenue provided by the selling of carbon credits, then the project cannot generate carbon credits. However, if projects are not well-vetted and have other sources of funding, the clause of additionality may be compromised. Projects that are not additional do not actually compensate for the purchaser's emissions. Any project, whether it be DAC, solar, or reforestation, could be additional or not, making it difficult to determine the integrity of a credit without some means of vetting and verification.

The second pillar – tangibility – indicates that the project providing carbon offsets is an actual project that does intend to remove or reduce CO2 in some manner. This can be more difficult to verify, as this requires the selling company to do what they claim to be doing. Some projects may not be removing/reducing as much CO2 as they claim, overall reducing the quality and credibility of the carbon credit they are selling. This can also fall on the integrity of the purchasing company. The

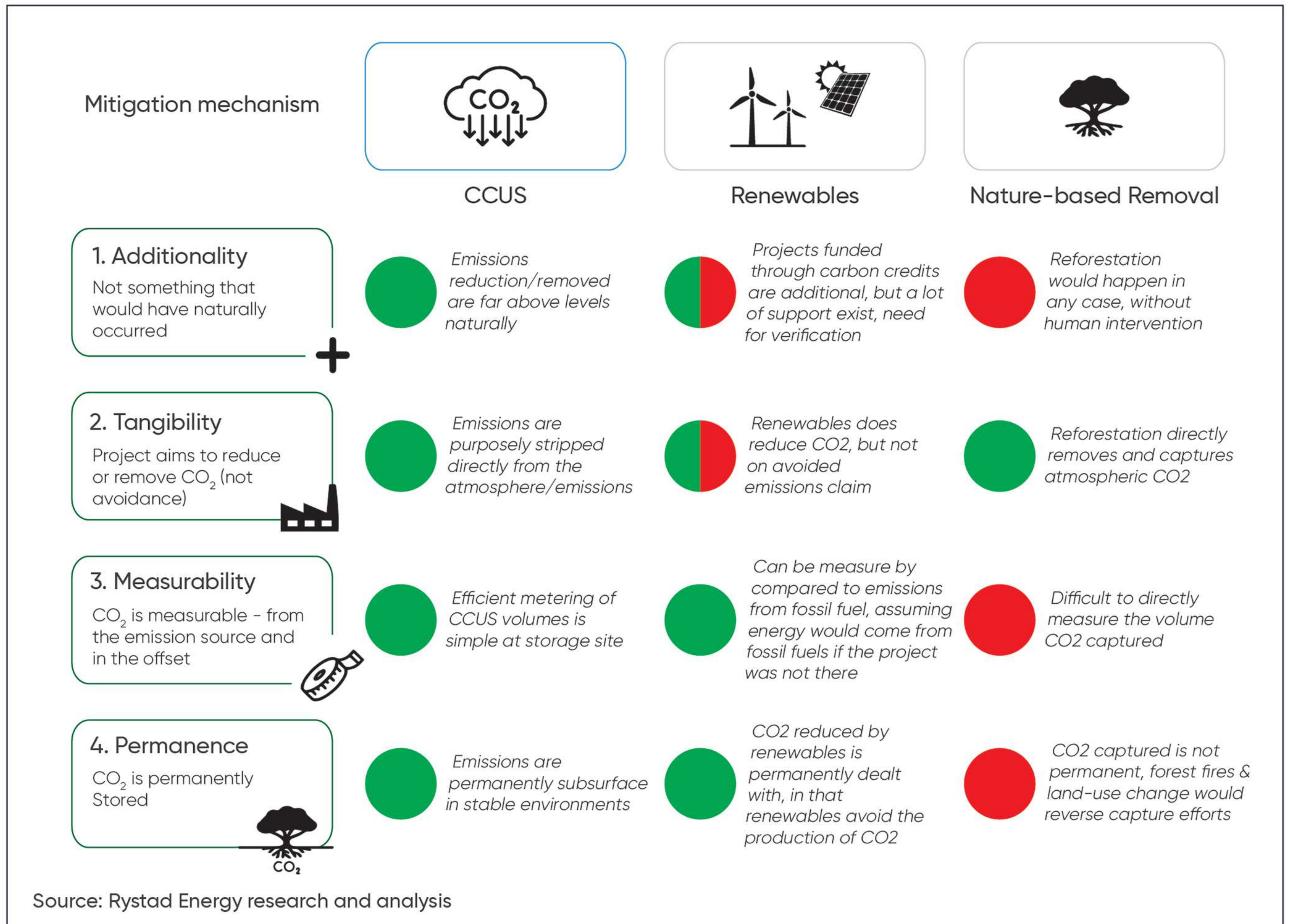


Figure 2: Carbon Offset Mechanisms

03. Carbon Credits

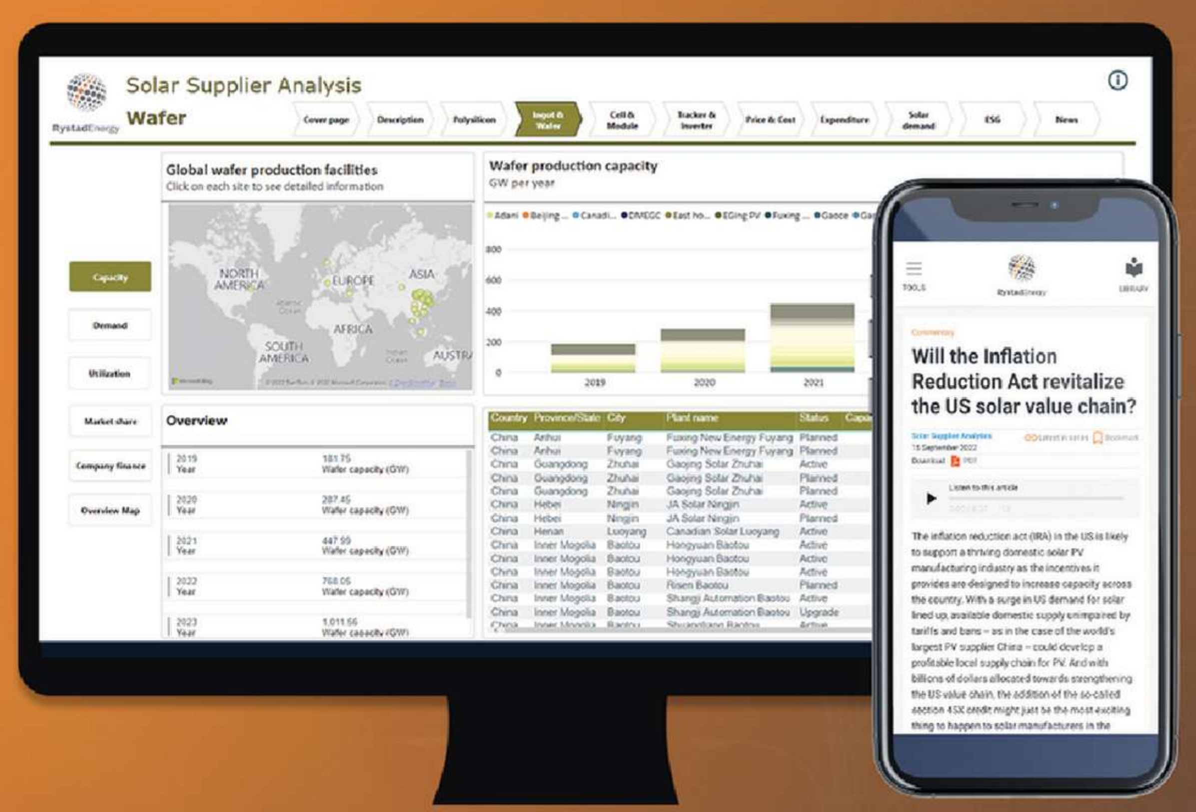
tangibility of a project can also be questionable if the project is not removing/reducing the present emissions of the buying company – meaning that the project will avoid future emissions rather than removing/reducing present-day emissions.

The third pillar – measurability – refers to the accounting of CO2, both the amount being offset and the amount the purchaser is emitting. This is to ensure that the purchaser is, in fact, buying the correct amount of credits, as well as the seller offsetting the same amount of CO2. More often than not, this becomes an issue where the seller is not actually offsetting the amount of CO2 that the purchaser is paying for.

The fourth pillar – permanence – indicates that the CO2 being offset is permanently dealt with. For some credits, like reforestation projects, this qualification is questionable. For instance, consider California's forest carbon offset program; although this project does plant trees as advertised, hundreds of thousands of acres of trees that were planted and sold as offsets burned in the California and Oregon 2021 wildfires, completely negating the CO2 offsets.

As illustrated, the four pillars provide a baseline to evaluate credits in varying situations for their credibility, providing governments with a means of creating policy frameworks regarding carbon offsets and applicable uses. As policymakers gain more experience setting rules and regulations on CO2 emissions, some loopholes in current carbon offset deals will soon be regulated. With some companies relying on carbon offset mechanisms to fully decarbonise, this will become increasingly important going forward.

Investments in the solar industry have hit an all-time high in MENA. However, with the record low electricity tariffs for Solar Power Purchase Agreements, some projects might not be profitable under the current situation. An alternative to funding solar projects or attaining revenue growth for projects could be the sale of carbon offset. A renewables carbon offset is of relatively high quality compared to nature-based carbon offsets, as seen in the previous chart. With more companies seeking or willing to pay for high-quality offset, the demand is set to increase exponentially, especially after details on Article 6 of the Paris Agreement are concluded between different countries.



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Currently, there is no link between Article 6 and the various carbon offset markets, including the very fragmented VCM. Market attention has been put on Article 6.4 as it will outline how and what needs to be fulfilled for the current market to be used for emissions trading. The outcome of the rulebook from COP 26 was deemed as a major milestone for Article 6, but the rules agreed upon were ambiguous and risk including projects that do not contribute to the mitigation of climate change. While momentum on Article 6 has slowed down this year, placing a firm 2023 deadline for discussions in Dubai next year would help kickstart it again. There is a pressing need to agree on details as these credits are crucial to helping companies and countries set more aggressive targets for meeting climate goals.

HOW MACC CAN REDUCE CARBON FOOTPRINT TODAY

Amer Arafat
Partner
ElementSix

A lot of companies today are under the spotlight to find ways to reduce their carbon emissions or even reach their net-zero targets. According to the Paris Agreement, the global greenhouse gas (GHG) emissions must be halved by 2030 and reduced to net-zero by 2050. This is assumed to be the only way to limit the global rise in temperature to 2.0 degrees Celsius above preindustrial levels, or ideally to 1.5 degrees Celsius.

In order to meet those stringent targets, it is important for companies to understand their environmental impacts by first measuring their overall carbon footprint. The management guru Peter Drucker once said, "if you can't measure it, you can't manage it." Measuring a company's carbon footprint will help them understand not only the sources of their emissions, but also how carbon intensive their operation is. This is crucial to help them set that measurement as baseline and start planning how they can reduce those emissions in a way that is in line with the Paris Agreement targets and the latest in climate science.

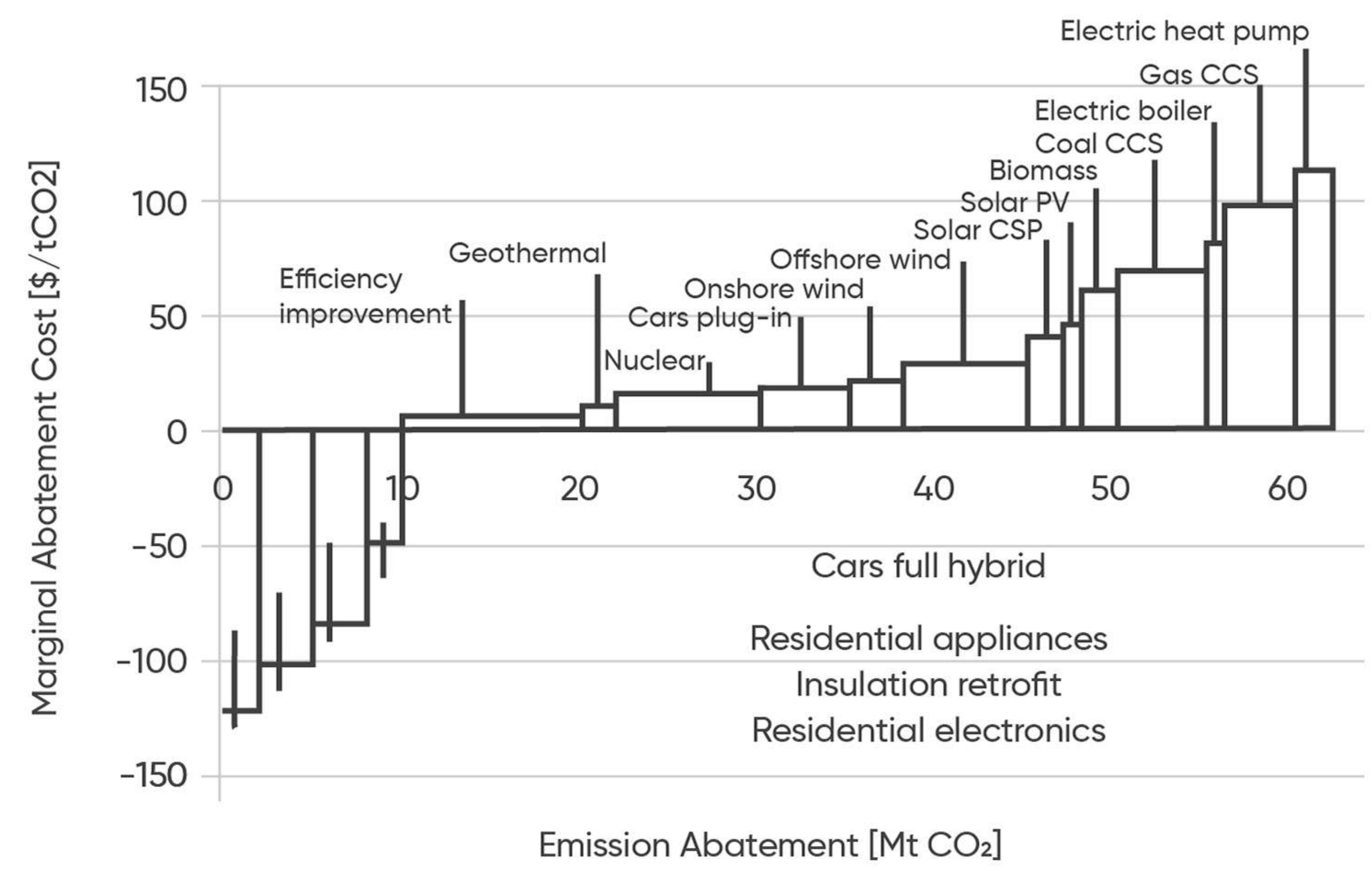

Figure 1: Example on a Marginal Abatement Cost Curve – Fabien Kesicki

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Marginal Abatement Cost Curve

Setting emission reduction targets through carbon abatement strategies and roadmaps is the ideal next step to measuring the company's carbon footprint. One of the ways that help companies understand not only the emission reduction measures they can take, but also the costs and savings involved is through the development of a Marginal Abatement Cost Curve (MACC).

A marginal abatement cost curve is defined as a graph that indicates the cost, associated with the last unit (the marginal cost) of emission abatement for varying amounts of emission reduction (in general in thousand tons of CO2)[1].

MACCs rank the emission reduction opportunities starting from the cheapest to the most expensive, as shown in the graph above, and can be used for setting not only the short-term and long-term emission reduction targets, but can also help meet the company's net-zero targets.

Net-Zero Targets and MACC

The width of each opportunity (box) shows the potential emission reductions that may possibly be achieved provided that opportunity is taken compared to the set baseline, and the height shows the associated costs or savings. The boxes that appear under the curve show that there will be financial savings achieved from taking those opportunities.

Being easy to read and simple in their representation, MACCs are popular with decision makers as they show the economics associated with the emission reduction and climate mitigation measures proposed, helping them prioritise the mitigation options and focus on what is important for them in the short-term and long-term.

Depending on the industry, MACCs can provide valuable information for investment decisions in terms of the costs and the emission reduction potential perceived from those measures. The development of such MACCs for specific industries or companies will result in immediate actionable steps to reduce their overall carbon footprint without causing a major dent in their budget.

When it comes to offsets, they are not usually included in MACCs, but including them can be of great benefit, especially for companies with net-zero targets. This allows the decision makers to understand what percentage of the total emissions the company intends to reduce using offsets. Furthermore, suppose the company is committed to following the Science-Based Targets initiative (SBTi) in its emission reduction strategy. In that case, they're allowed to offset no more than 10% of their overall carbon footprint, and one of the best ways to visualise how to do that is by including those offsets in MACCs.

It is important, however, to pay attention to the details while reading a MACC and understand all the assumptions made while preparing it. The reason is that the costs assumed might be dependent on certain market conditions that were present at the time the MACC was prepared. Therefore, it might be wise to consider revisiting the costs stipulated in the MACC to make sure that the assumptions are still valid or need to be revised.

Conclusion

Even though MACCs have certain limitations and cannot be solely used as the magic tool that develops a robust emission reduction strategy, we still recommend including them in the toolkit of the carbon abatement strategy for medium and large companies. This is mainly because of the fact that all the emission reduction measures and opportunities can be represented in the same format, that is, $/tCO2, which simplifies the complexity of such topics to the decision makers.

1 *Fabian Kesicki - Marginal abatement cost curves for policy making – expert-based vs. model-derived curves*

Courtesy: Hassan Allam - Egypt - SUNGROW

GREEN HYDROGEN: THE NEXT GREAT OPPORTUNITY IN MENA

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With new announcements, this November from the Suez Canal Economic Zone (SCZone) in Egypt, the Middle East and North African (MENA) region is set to become the second-largest green hydrogen electrolyser installer in 2040. The MENA region has ambitions to install over 28 GW by the end of 2030. Capacity is then set to grow at a compound annual growth rate (CAGR) of 8.9% to reach 68.3 GW by 2040. Based on the currently announced projects pipeline, installations are lined up in Egypt, Morocco, Oman, Saudi Arabia, and the UAE (see figure 1).

Close to 155 gigawatts (GW) of electrolyser capacity is lined up for installation worldwide by this decade's end based on announcements as of November 2022, 19% of which will be in the MENA region. This installed global capacity is expected to more than double in the following decade, with nearly 353 GW in 2040[1]. MENA is still set to account for about 20% of the global electrolyser capacity at this time, second only to Europe, which is projected to account for 30% of the global electrolyser capacity[1].

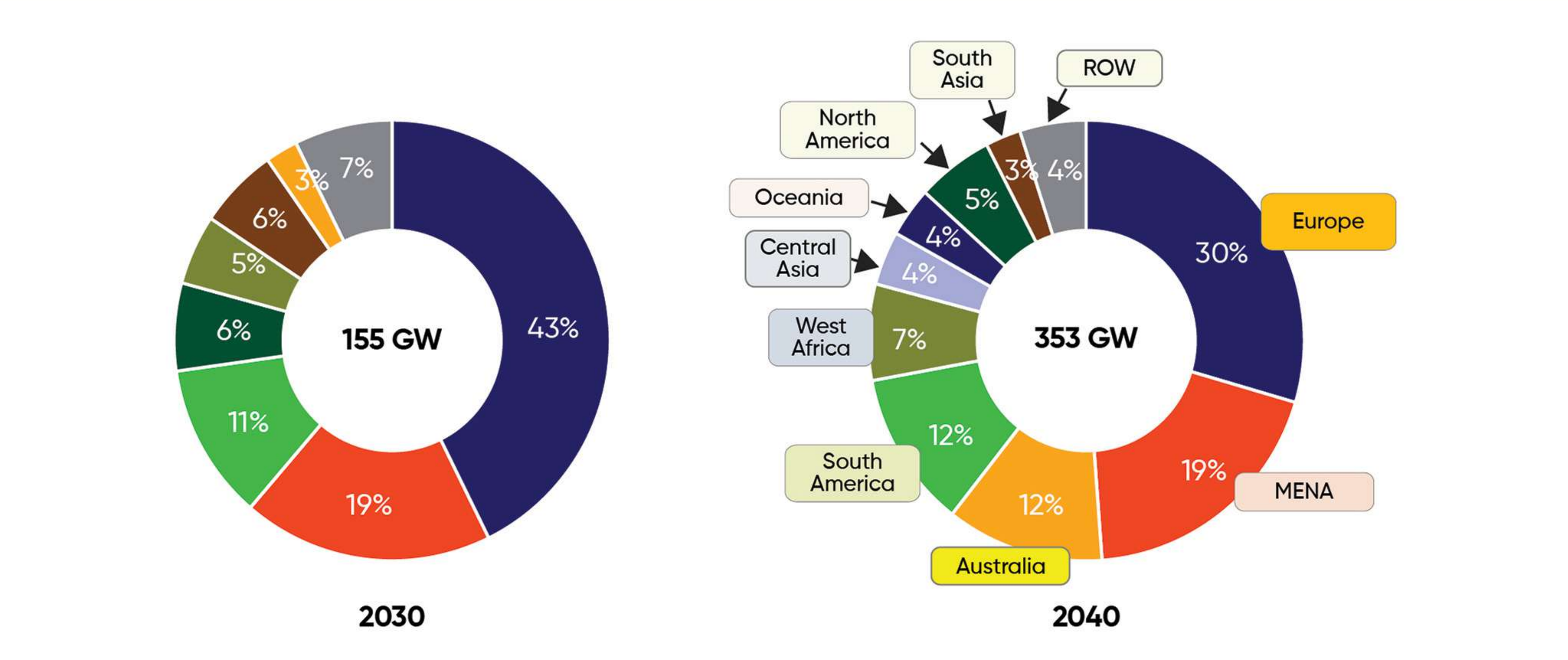
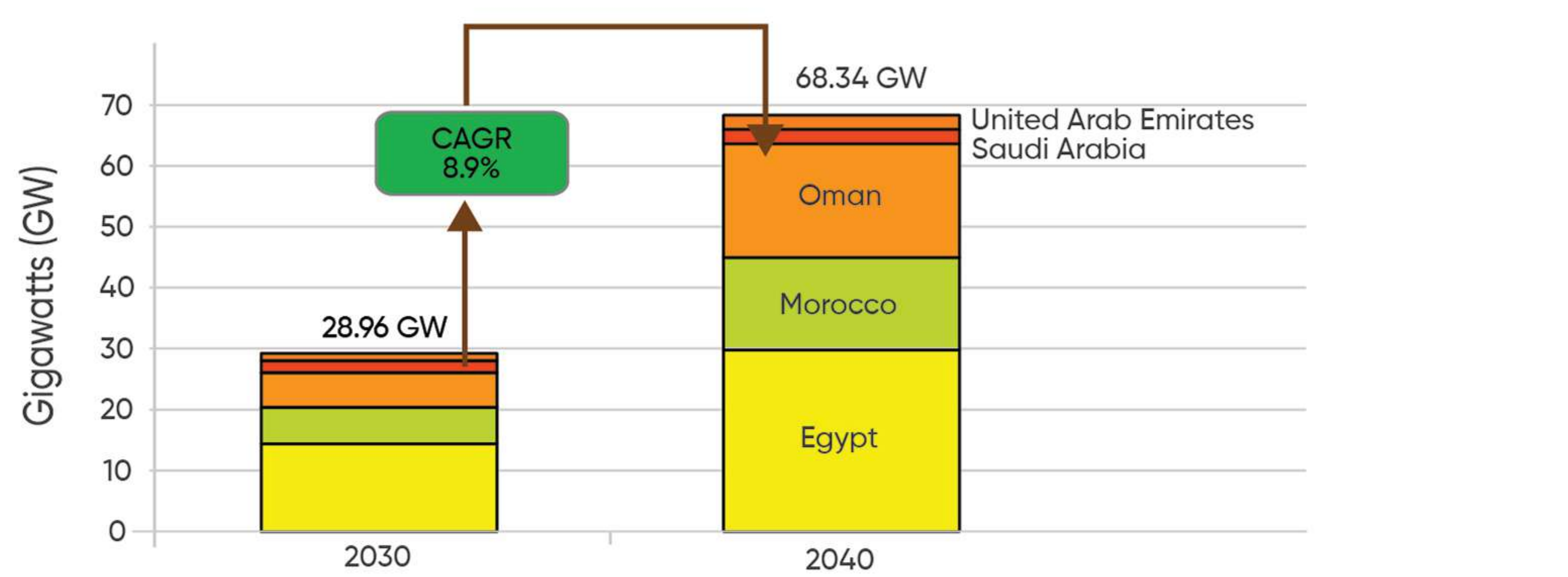


Figure 1: a. Global Green Hydrogen Installed Capacity* Outlook

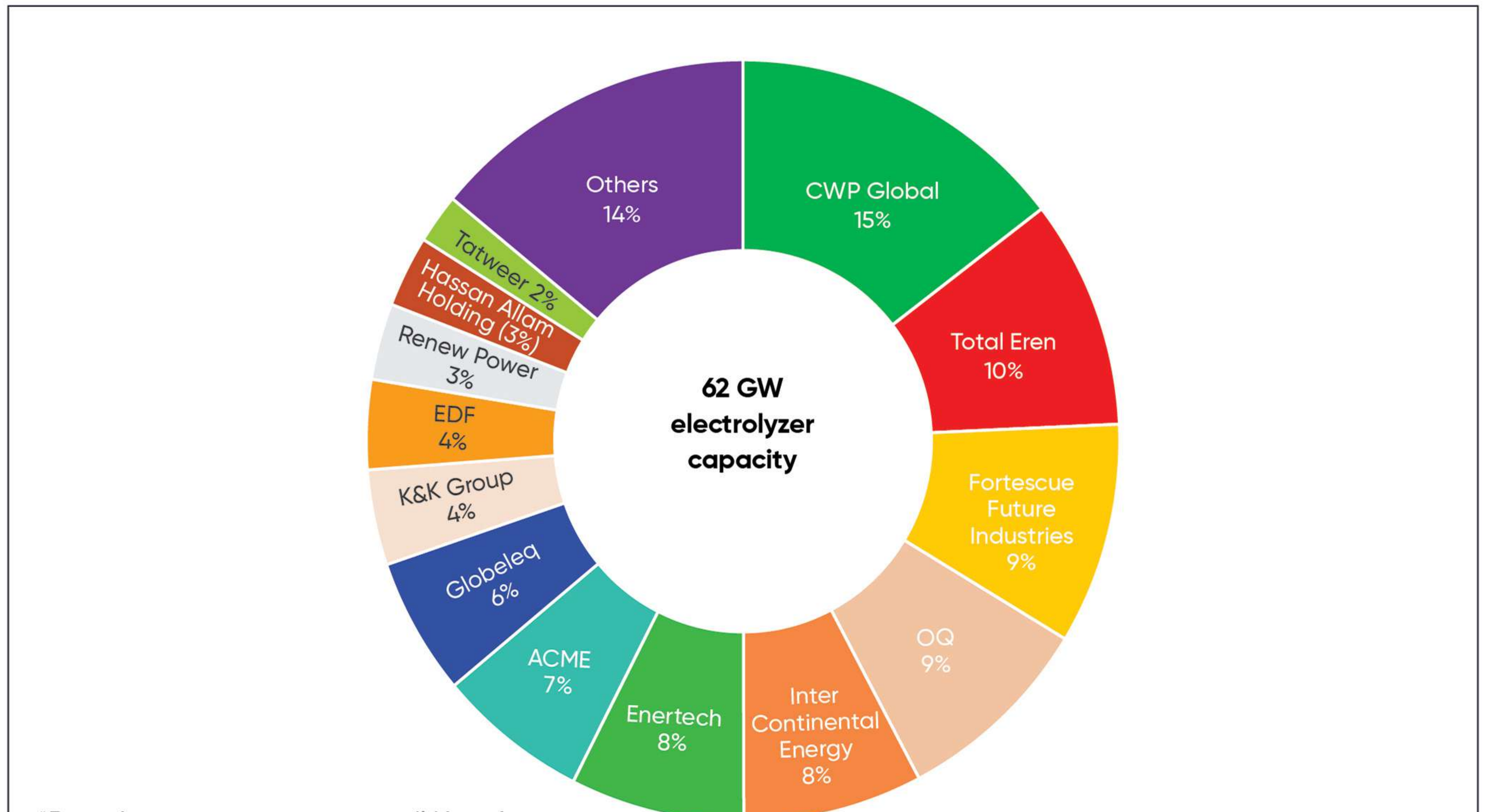


*Capacity based on announcements until Nov-22. Source: Rystad Energy RenewableCube

Figure 1: b. MENA Region Green Hydrogen Electrolyzer Outlook

1 Based on rystad energy research and analysis

CWP Global is projected to be the most significant green hydrogen developer in the MENA region with a 15% market share by 2040, meaning an estimated electrolyser capacity of 9 GW, followed by Total Eren, which will account for 10% (see figure 2). Furthermore, Fortescue Future Industries and OQ will have a market share of 9%, each followed by InterContinental Energy, and Enertech. Other prominent developers in the region are expected to be ACME (7%), Globeleq (6%), K&K Group (4%), EDF (4%), Renew power (3%), Hassan Allam Holding (3%), and Tatweer (2%).



*Based on announcements until Nov-4
Source: Rystad Energy RenewableCube and Hydrogen Cube

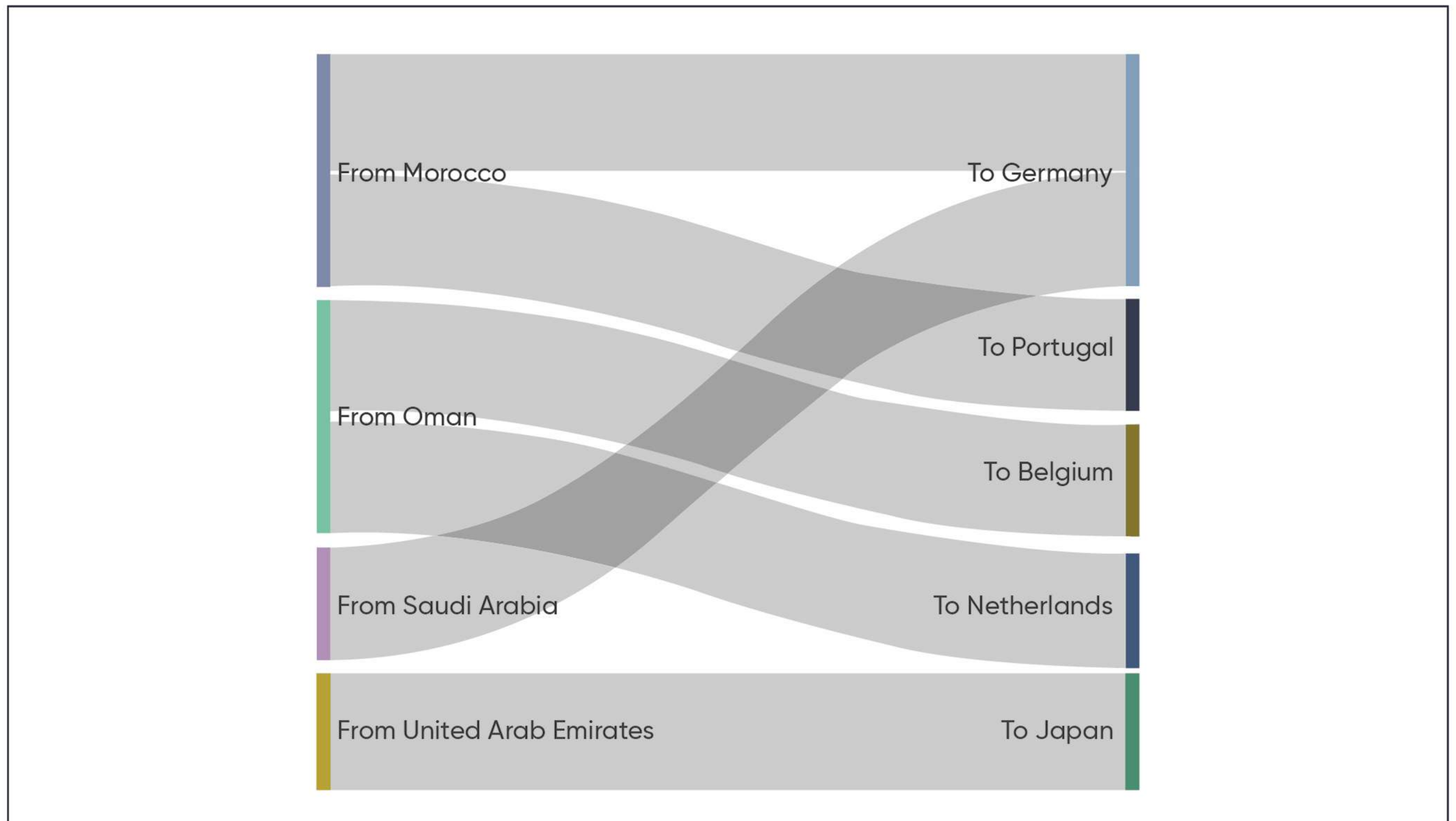
Figure 2: Top Green Hydrogen Developers in the MENA Region 2040

Ammonia is a common end-product in most of these announced projects suggesting that the companies view ammonia as an export medium for inter-continental trade. Ammonia, primarily because of its well-established shipping infrastructure compared to hydrogen, is becoming an effective medium to transport hydrogen from green and blue hydrogen projects. Although ammonia is already a globally traded commodity, there will be a need to increase the ammonia-oriented infrastructure to support the increased demand for shipping capacity. Presently, the MENA region has an ammonia shipping terminal capacity of 1.1 million tonnes which is set to increase further as the pipeline grows and more export agreements materialise (see figure 4).

ADNOC recently announced its first shipment of low-carbon ammonia that left from UAE for Hamburg, Germany. The first of these several cargoes is produced by Abu Dhabi's Ruwais Industrial Complex and will be sold to German off-takers. Several bilateral hydrogen agreements have been signed between countries in the MENA region and Europe and Japan for the export of hydrogen and its derivatives (see Figure 3). Saudi Arabia and Germany have signed an agreement to cooperate on the production, processing, and transporting hydrogen from renewable sources. Similarly, UAE and Japan signed a bilateral agreement on the cooperation on technology development, regulatory frameworks, and standards to create an international hydrogen supply chain.

Courtesy: 800MW Solar PV Project - Al-Kharsaa, Qatar - LONGi

04. Green Hydrogen



Source: Rystad Energy RenewableCube

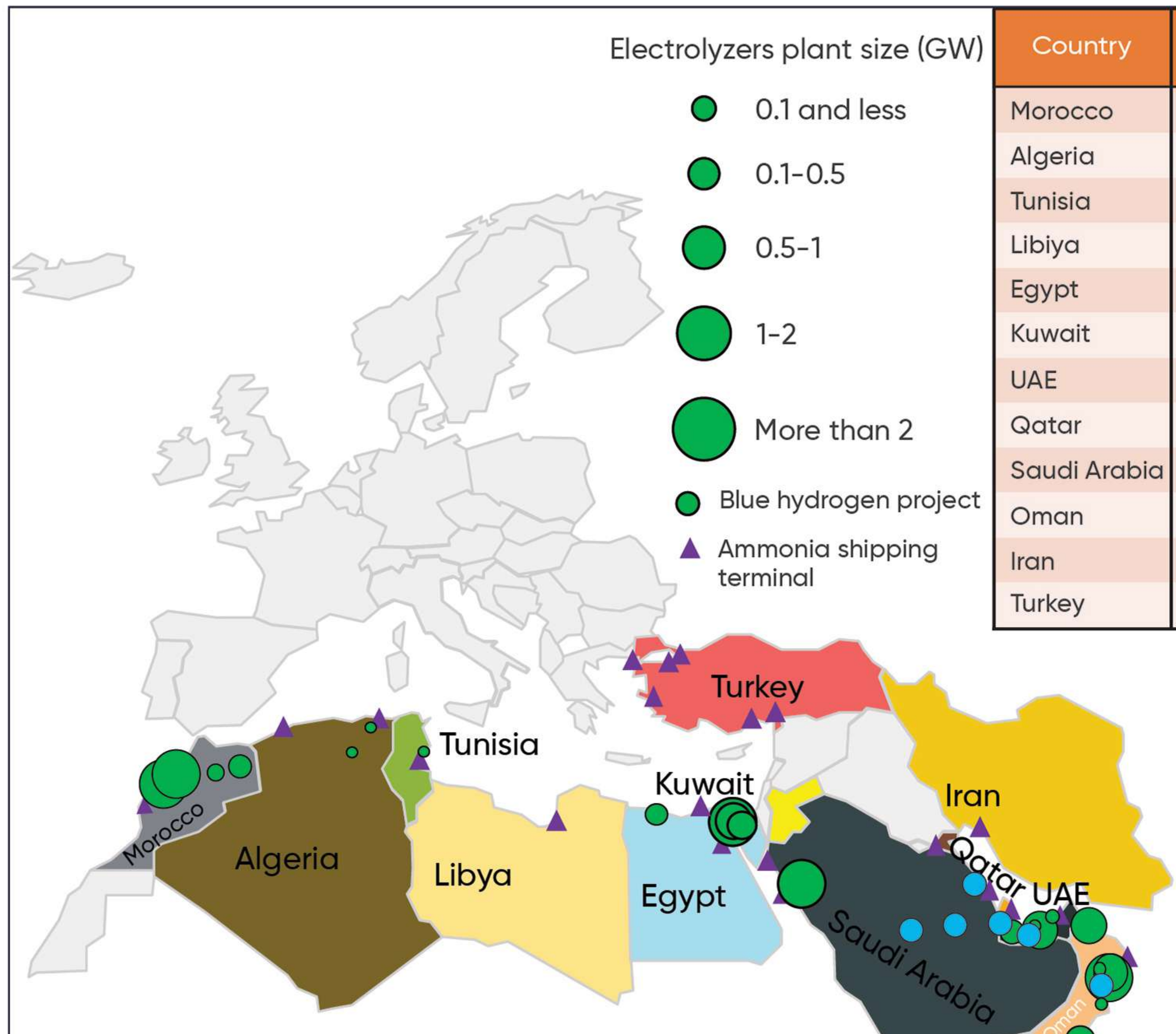
Figure 3: Bilaterals Hydrogen Agreements in MENA Region

Among the countries, Egypt is well on its way to being a hydrogen powerhouse. A swathe of project announcements has pushed estimated investments in the North African country's sector past $100 billion. Some 70% of these investments are linked to projects unveiled since May this year. Since then, Egypt has seen nine project announcements with a combined annual hydrogen production capacity of 2.1 million tonnes (Mt), pushing the nation's total hydrogen production to 3.3 Mt – third only to Australia with 9.2 Mt and the United States with 3.8 Mt (see fig. 5). Investments in Egypt's hydrogen sector have come from far afield, led by players in the Middle East and Europe, with Indian and Australian companies also pitching in significantly.

Australia's Fortescue Future Industries is the latest to announce an investment in Egypt's hydrogen sector. The company in mid-August signed a memorandum of understanding (MoU) with Egyptian authorities and followed this up with talks in October involving President Abdel Fattah el-Sisi on plans to explore the development of a green hydrogen production project with 7.6 gigawatts (GW) of installed renewable capacity. August also saw seven new announcements from international players of hydrogen schemes in Egypt, with India-headquartered ACME Group announcing a project capable of producing 390,000 tonnes per annum (tpa) of green hydrogen from 4GW of electrolysers and committing $13 billion to the development. Africa-focused developer Globeleq signed an MoU for 350,000 tpa of green hydrogen production from 3.6 GW of electrolysers with an $11 billion commitment. Other project announcements included those from UAE-based KK Power (230,000 tpa of green hydrogen and $10.5 billion of investment), Alfanar (100,000 tpa of green hydrogen and $10.5 billion of investment), Alcazar Energy (40,000 tpa of green hydrogen and a $2 billion investment), Actis (36,000 tpa of green hydrogen and a $10.5 billion investment), and MEP (20,000 tpa of green hydrogen and a $250 million investment). India's ReNew Power announced a project with annual hydrogen production of 220,000 tpa and pledged an investment of $8 billion.

Net hydrogen production from the nine project announcements mentioned above and previous announcements is 3.3 Mtpa using more than 30 GW of hydrogen electrolysers, with total estimated pledged investments pegged at around $100 billion. The current pipeline capacity of MENA stands at around 70 GW by 2040, making up 20% of the world capacity. We expect the region to be a major powerhouse in hydrogen production space with more projects addition in the future as it utilize the enormous solar and wind potential available.

04. Green Hydrogen



Country	Present Capacity (tonnes)	Total pipeline (Million tonnes)
Morocco	230,000	1.1
Algeria	135,000	2.45
Tunisia	55,000	0.2
Libiya	40,000	0.2
Egypt	115,000	5.65
Kuwait	46,000	0.48
UAE	40,000	5.65
Qatar	165,000	5.54
Saudi Arabia	100,000	4.07
Oman	60,000	11.82
Iran	120,000	3.5
Turkey	164,000	0.89

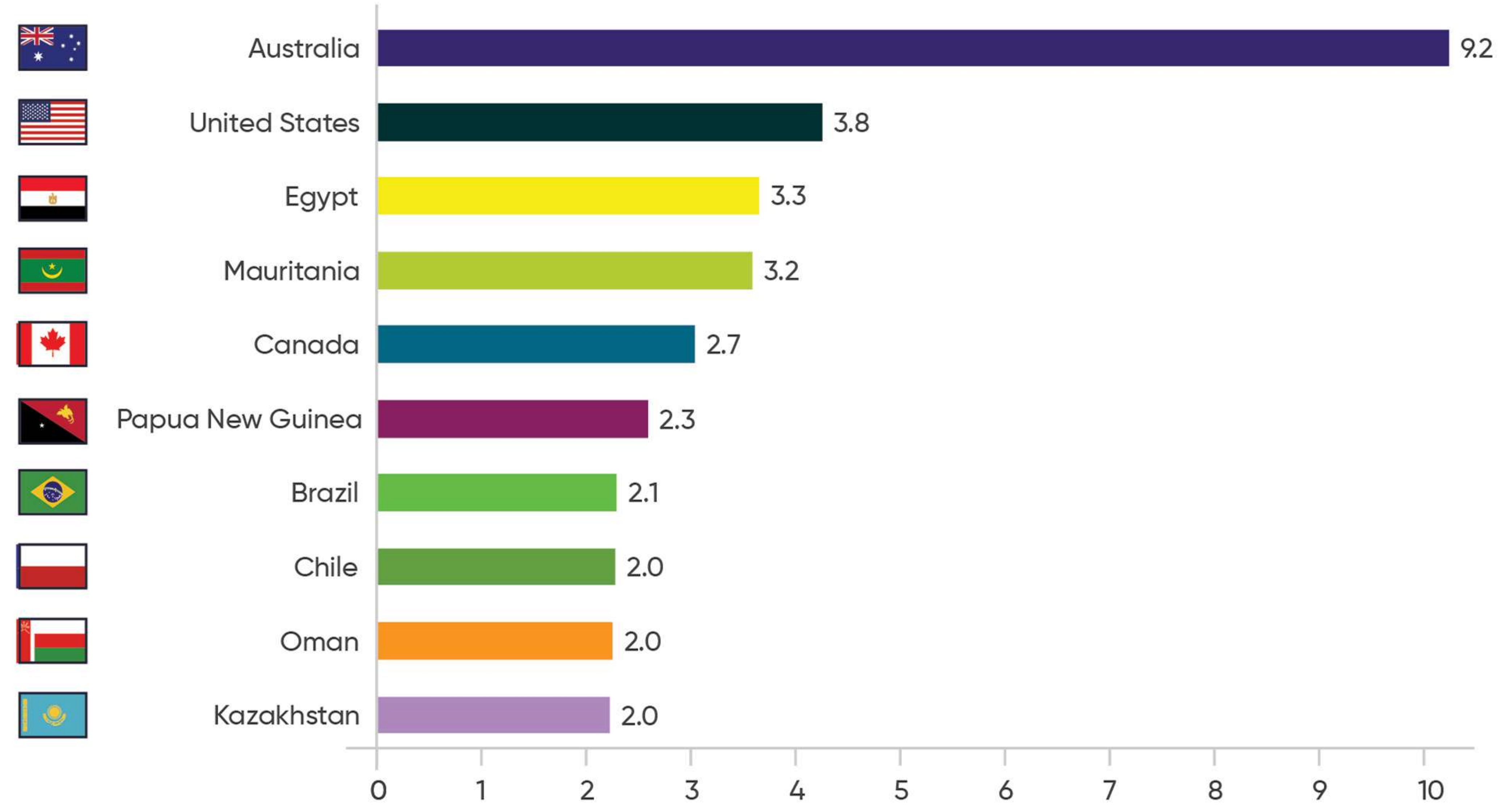
*Based on announcements until Aug-22
Source: Rystad Energy HydrogenCub

Figure 4: Announced Hydrogen Projects in MENA Region and Ammonia Terminals

In conclusion, Egypt is clearly establishing a lead in the production of green hydrogen; the Suez Canal offers Egypt a clear logistical advantage to supply European & American markets as well as Asian & African markets. However, given the preferences for Ammonia as a medium of transport, the GCC nations, with their oil & gas infrastructure, are perhaps better placed to satisfy market demands. From all points of view, the future is certain; the production of green hydrogen with electrolysers and power supplied by solar energy can extend the energy exporting credentials of MENA for several more decades.

Courtesy: 10MW TAQA Project - Egypt - SUNGROW

04. Green Hydrogen



Source: Rystad Energy Hydrogen Cube

Figure 5: Top 10 Countries Based on Green Hydrogen Production Announcements

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04. Green Hydrogen

CENTRALISED AND OPEX'S BASED COOLING FOR MENA

Mustapha Aanzi
Board member
Clean Energy Business Council

In several industries, we have seen that "as a service" models have changed the market dynamics drastically. So what if this "as a service" model was rolled out in the MENA region for one of the main energy consumers and contributors to CO2 emissions, cooling?

In 2022 the International Energy Agency published a report that shows a staggering increase in energy consumption due to space cooling in buildings, see figure 1 (2).

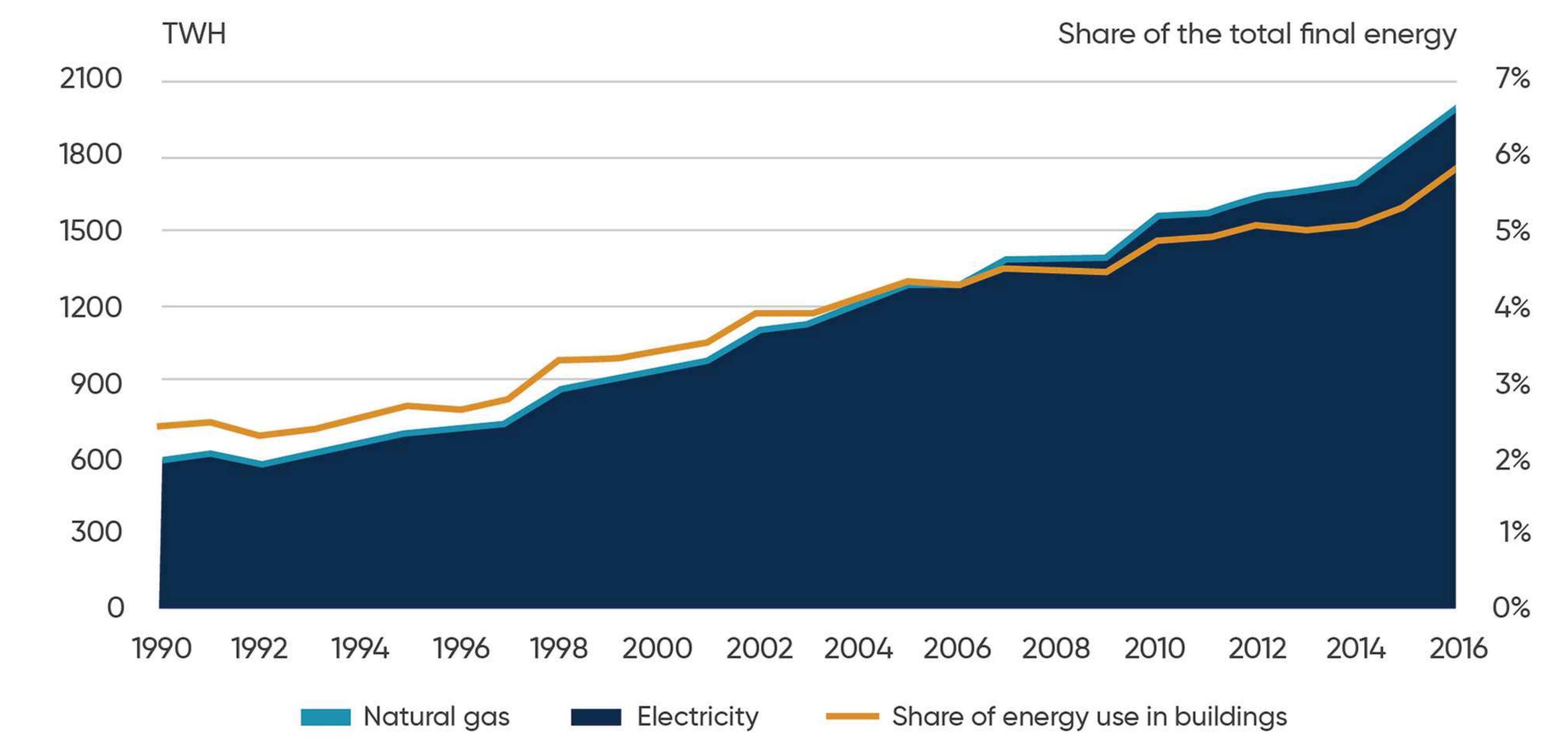

Figure 1: World Energy Consumption for Space Cooling in Buildings

In the MENA region also, cooling is one of the main energy consumers and the demand for cooling is expected to triple by 2050. The increased demand for cooling will come along with increased CO2 emissions but also require increased investment in electricity generation and infrastructure.

When looking at the existing installed cooling systems, there are significant opportunities to reduce electricity consumption and CO2 emissions.

A study (2) done by the Dubai Regulatory and Supervisory Bureau shows that district cooling and central water-cooled plants have the best efficiency in terms of kW/ton, respectively 0.92 and 0.93. The market share for district cooling in Dubai is 18% and for central water-cooled plants 7%, while almost 50% of the cooling market share in Dubai is dominated by Ducted splits/Package units (30%) and Split units/window AC (18%). These units have the worse performance, with respective kW/ton efficiencies of 1.62 and 1.73. The cooling market share in other MENA regions is generally dominated by Ducted splits/package units and split units/window ac. While this study was conducted in Dubai several years ago, and technology has evolved in the meantime resulting in significant improvement in the performance of these units, central water and air-cooled plants still lead in terms of kW/ton efficiency.

The IEA calculated an "efficient cooling scenario" where the astronomical increase in infrastructure investments and emissions due to an increase in cooling demand can be significantly curbed. The IEA estimates that the efficient cooling scenario can reduce energy needs for space cooling by 45% compared to the baseline scenario in 2050 (see Figure 2).

Technological innovations in the cooling industry that enhance cooling equipment performance are considered one of the main drivers to achieve an

05. Energy Effeciency

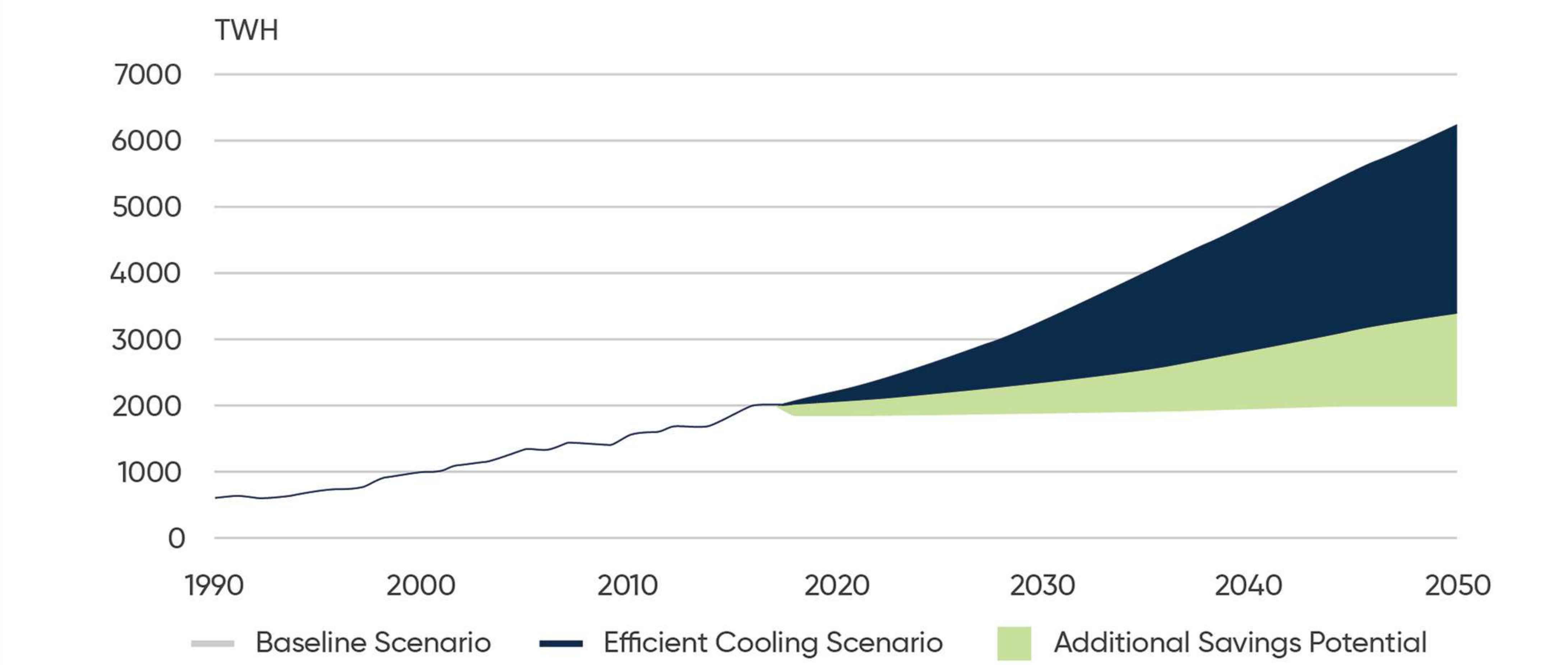

Figure 2: Contribution to World Energy Savings from Energy-Efficient ACs and Additional Potential Energy Demand Reductions Beyond the Efficient Cooling Scenario

efficient cooling scenario; however, innovative business models also play a pivotal role.

Some of the barriers we see in the market to significantly improve the efficiency of cooling equipment are budget and split incentives, where the owner of the building would need to make the investment in energy-efficient equipment while the operator/tenant will benefit from the energy savings since they are paying for the utility costs and not the building owner.

The cooling as a service model can remove the above barriers and many other constraints to boost energy efficient cooling systems in the MENA region. In this model, the CAPEX requirement is converted into an OPEX model, meaning the owner is no longer required to make any upfront investments. The service provider/ESCO will make the necessary investments based on a lifecycle analysis of the cooling system to ensure optimum operating costs, hence highly efficient performance. In addition, the operational risk of the cooling plant is transferred from the owner/tenant to the service provider, who will take full responsibility for the cooling plant operations and meet agreed KPIs such as comfort conditions, kW/ton, and CO2/ton.

Owners associations will also gain significant benefits from the Cooling as a Service (CaaS) model, which will allow them to avoid CAPEX requirements to upgrade old and inefficient cooling systems while enabling charging tenants for cooling consumption rather than based on a $ value per m2 of tenanted space. This will also increase conscientious usage of cooling. Since the service provider/ESCO takes full responsibility for the cooling system operations to meet the agreed KPIs, the project cycle can be shortened because an in-depth technical evaluation by the decision maker will not be as critical a factor; the operational risks are transferred to the service provider/ESCO.

The CaaS model also adds great value for stakeholders in greenfield projects. While the owner/investor focuses on the construction process, the service provider/ESCO takes ownership of the cooling system's design, build, and operations requirement. In the near future, we might very well see extended "as a service" models for greenfield projects where the owner/investor only invests in the structure of a building while ecosystem partners invest and operate the entire building infrastructure (cooling, fire systems and access control) essentially, utilising the most sustainable infrastructure on an "as a service" model.

In 2022 the Basel Agency for Sustainable Energy (BASE), a Swiss not-for-profit foundation, published a fascinating white paper about Cooling as a Service in collaboration with the Clean Cooling Collaborative (3). The white paper contains detailed information about the CaaS model, market barriers, how to get started with CaaS and much more. In keeping with several MENA regional governments' ambitions to achieve net zero emissions by 2050, a game changer model like Cooling as a Service will be an essential contributor to decarbonisation.

References:
1. https://rsbdubai.gov.ae/wp-content/uploads/2020/06/20160210-Webtext-Dubai-Cooling-Study.pdf
2. https://iea.blob.core.windows.net/assets/0bb45525-277f-4c9c-8d0c-9c0cb5e7d525/The_Future_of_Cooling.pdf
3. https://www.caas-initiative.org/wp-content/uploads/2022/05/Cooling-as-a-Service-White-Paper-1.pd

06. Electric Vehicles

EDITORIAL OVERVIEW - ELECTRIC VEHICLES

The transportation sector is one of the egregious emitters of carbon dioxide, amounting to as much as 30% of all carbon dioxide emissions globally. Therefore, adopting lower emission alternatives is vital to reducing our carbon footprint. The MENA region consists of several countries where the per capita carbon emission is one of the highest in the world. The abundance of oil & gas resources has been a contributing factor that has resulted in a transportation sector based predominantly around the internal combustion engine. However, there is early evidence that this is about to change. There are 2 driving forces in the increased adoption of electric vehicles, the first, is the removal of subsidies and the rising costs of fuel, and the second, is electric vehicles becoming viable alternatives. Electric vehicles are now not only more affordable to operate due to their inherent efficiency and the lower cost of electricity but also because electric vehicles are currently comparably priced to the equivalent internal combustion alternative.

Every industry or sector has phases of adoption; while the innovators & early adopters are motivated by their noble principles or their need to be perceived as thought leaders in society. The early majority, the first step in mass adoption, are motivated by pragmatic financial factors. As electric vehicles enter the early majority phase, manufacturers and technology providers see growth and profit opportunities. Thus far, the MENA region has relied on importing electric vehicles from foreign manufacturers, which is expected to continue. However, some businesses and governments sense an opportunity to address a growing market that they can address by domestically manufactured electric vehicles. This is also helped by the fact that all electric vehicle manufacturing worldwide is nascent. New supply chains that break away from traditional automobile manufacturing are being established, and the MENA region is well positioned to capitalise on this opportunity.

Countries with established automotive manufacturing are the first movers in this trend, and naturally, countries such as Morocco[1] and Egypt[2] with existing automotive industries are switching their manufacturing lines to accommodate electric vehicles. Building on their existing human capital and experience in the automotive industry, they are likely to take the lead in growing their market share.

The UAE[3]|[4] and Saudi Arabia[5] are also bringing manufacturing to their shores and investing heavily in developing their manufacturing capabilities. These are still early days, and the lack of a full-fledged automotive ancillary industry will restrict initial production to assembling knocked-down kits before vertical integration. Nevertheless, this is a step in the right direction and portends a vibrant diversification of their economies.

In addition to manufacturing electric vehicles, the realignment of the transportation infrastructure towards electrification is equally essential. There is a need for more charging infrastructure capable of addressing the increased demand. Charging equipment for private and commercial vehicles, along with destination charging stations, will require reconsidering not just the electric transmission and distribution network but also the source of the electricity generation. An increase in distributed solar power plants and utility-scale solutions will ensure that these electric vehicles are supplied with abundant clean energy and have a meaningful impact on reducing carbon emissions. Solar and electric vehicles thus form a symbiotic partnership; interestingly, the adoption of both solar and electric vehicles by households and businesses is a pragmatic and financially prudent investment. Anecdotal evidence suggests an accelerated adoption rate[5] of electric vehicles as more affordable options become available. This adoption rate is bound to continue as consumers realise the benefits of a combined investment in solar and electric vehicles, ensuring that they will no longer be subject to the volatility of petrol or electricity prices.

[1] *Moroccan Renault Subsidiary Begins Production of the First Electric Car in the Country - Teller Report*
[2] *Renault, PSA, Daimler tap N. Africa for Low-Cost Exports - AutoNews*
[3] *KIZAD to Welcome Abu Dhabi's First Electric Vehicles Assembly Facility - Media Office Abu Dhabi*
[4] *M Glory Holding Group Opens New Electric Vehicle Manufacturing Plant in Dubai Industrial City - The National*
[5] *Saudi PIF & Foxconn Launch Ceer - Saudi Arabia's First Electric Vehicle Company - The Electric Cars Report*

06. Electric Vehicles

EV MANUFACTURING IN SAUDI ARABIA

Alex Malouf
Executive Director, Corporate Communications and Public Relations-Ceer

Global electric car sales more than doubled in 2021 when compared to the previous year, to 6.6 million units. This represented close to 9% of the global car market. The International Energy Agency predicts that by 2030, EVs could represent more than 60% of vehicles sold globally.

For all of the growth expected by the EV industry globally, a number of geographies have yet to adapt to this industry development. With the possible exception of the UAE, the Gulf is one region where EVs have yet to go mainstream. A number of reasons have been cited as potential barriers to EV adoption. In research published earlier this year, the University of Nottingham's Saleh Alotaibi, Siddig Omer and Yuehong Su outlined the ten most cited barriers to EV adoption from a sample of 698 Saudi nationals. Of the ten reasons, it could be argued that eight of them are general arguments which could be made in any country globally (the top three reasons were a lack of available charging stations, the duration of charging, and lack of trust in EVs as a new technology). Only two cited barriers could be truly called local, namely that the terrain and weather conditions in Saudi Arabia are not suitable for EVs, and that there is no need to use EVs as Saudi Arabia is one of the biggest petroleum-producing countries.

The experience of the UAE suggests that, if given a chance by manufacturers, EV adoption could be just as fast in the Gulf as in other markets. As of 2021, there were just under 5,000 registered electric vehicles and just over 8,000 hybrid cars in the Emirate of Dubai, based on research from a subsidiary of Dubai Electricity and Water Authority. This was up from approximately 2,300 electric cars and 6,000 hybrid vehicles the year earlier.

In many ways, the UAE's decision to deregulate retail petrol prices by implementing a new flexible pricing policy linked to global prices has accelerated EV adoption. As petrol prices have risen, UAE consumers have increasingly realised that EVs offer better value for the money. As reported by The National newspaper in late 2022, prices for second hand EVs have often exceeded the recommended retail price for new EVs due to excess demand for these vehicles.

The example of the UAE shows that there should be a strong appetite for EVs across the wider Gulf (you can find EVs being driven in every country in the Gulf, despite there being few manufacturers selling EVs into our markets). The introduction of Saudi-based car brands and local manufacturing will only help to accelerate the growth of EVs, the accompanying infrastructure and the wider supply chain.

As of today, the Kingdom has already announced plans for two manufacturing facilities in the Kingdom. At its peak, Lucid, which is part owned by the Public Investment Fund, will assemble up to 150,000 cars at its facility in King Abdullah Economic City (KAEC). Ceer, the first Saudi electric vehicle brand, will both fully design and manufacture approximately 180,000 electric vehicles in the Kingdom at its own plant in KAEC. When combined, the manufacturing capacity of both Lucid and Ceer will help to ignite the creation of a manufacturing hub that is focused on the creation of a regional car industry.

Looking at the bigger picture, the goal isn't just to create jobs and diversify the economy. The vision behind developing a manufacturing cluster is to create a focus on EVs that will both meet the needs of the region's consumers and environment, and prompt other brands to step up their EV aspirations for the Gulf and wider Middle East. Already, we are seeing the establishment of a number of companies that are looking to build EV chargers within Saudi Arabia. The same should be expected for other components, such as solar panels and batteries.

The establishment of a Saudi-based automotive manufacturing industry for the region's consumers is more than just a practical decision; there's a symbolism to the Gulf producing its own EVs. It signals to the wider world that the region both wants to be part of the wider move to sustainable mobility, and also encourages its populations to make the shift as well. The Gulf has long been known for its love of large, gas-guzzling vehicles. With the transformational shift we are seeing today in the EV sector, the Gulf may soon be known for its love of greener, more innovative electric vehicles.

07. Advancements in PV Technologies

PREVAILING TRENDS IN PV CELL TECHNOLOGY AND MODULE EFFICIENCY

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JA SOLAR

The photovoltaic industry is technology and value driven. In 2022, PERC cells reached the peak of cell efficiency in mass manufacturing; TOPCon and HJT cells have now picked up the baton for growth towards higher efficiency. According to the simulation studies of the Institute of Solar Energy Hamelin (ISFH) in Germany, the PERC cell's theoretical upper limit of efficiency is 24.5%. The average cell efficiency achieved during the mass manufacturing of PERC cells is about 23.5%-23.7%. TOPCon cells have now taken the lead in achieving higher cell efficiency in large-scale manufacturing due to the high compatibility between TOPCon cell preparation process and PERC cell manufacturing line, large cell efficiency improvement potential and lower equipment investment cost. The mass manufacturing efficiency at the module level has reached over 22% in 2022.

Efficiency & power capacity, energy generation capacity, and reliability are the three important indicators to evaluate PV module technical features. There are four ways to improve the efficiency & power of modules: cell technology iteration, cell efficiency improvement, optimisation of module encapsulation technology, and increase in wafer or module size. The energy generation capacity of modules mainly requires improvements in power degradation performance, high temperature generation performance, bifacial generation performance and low irradiance generation performance. The reliability of modules is ensured by reliable PV cells, advanced encapsulation technology, superior encapsulation materials, optimised module version design and rigorous reliability test..

To illustrate these objectives with a technical features and customer value analysis using the example of a module that adopts two core technologies: an n-type Bycium+ cell and Gapless flexible interconnection (GFI) technology. Bycium+ cell is a high efficiency n-type passivated contact cell with a Voc that can reach 720mV, which in current mass manufacturing can be produced with a cell efficiency of 25%. The patented high-density GFI module encapsulation technology uses a round ribbon with a special buffer treatment that

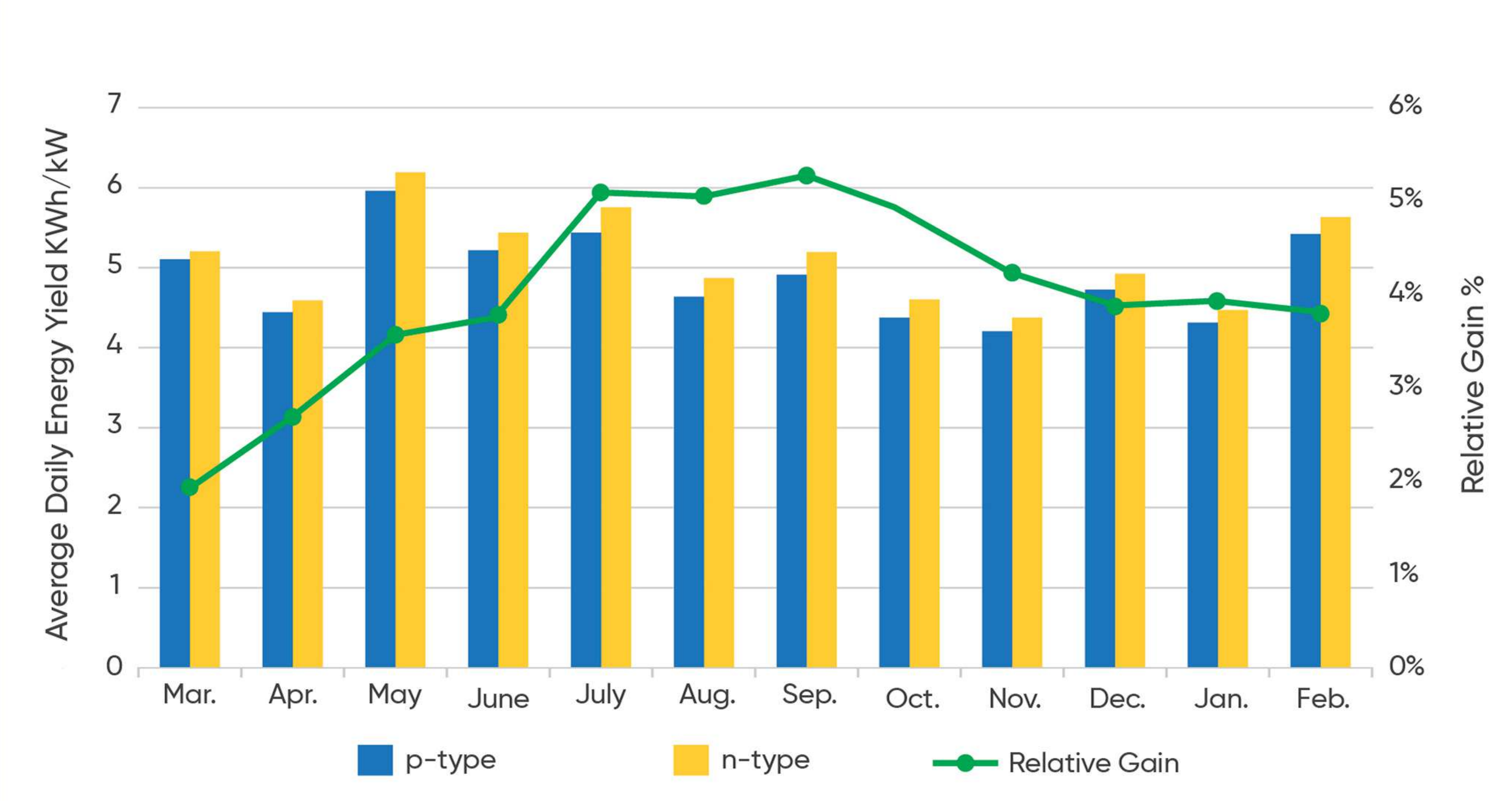


Figure 1: Comparison Data Between n-type Module and p-type PERC Module

07. Advancements in PV Technologies

handles mechanical stress at cell interconnections eliminating the risk of micro-cracks. Meanwhile, the modules' standardised size are maintained to ensure versatility for downstream applications by adjusting the silicon wafers' size. GFI technology is compatible with current mainstream module encapsulation technology. The aim is that the module's efficiency would increase by about 0.4% and module power would increase by about 10W. Based on the high efficiency cell and high efficient module encapsulation, the power of this module (78-cell) can reach 625W, and the efficiency can reach 22.4%.

As the core indicator to measure the power generation of photovoltaic projects, LCOE is closely related to the core value focused on by the end customers. Among the factors directly affecting LCOE, those related to modules mainly include the power, efficiency, energy generation capacity and long-term application reliability of modules. Specifically, high power and high efficiency can effectively reduce the cost of BOS, and energy generation capacity and long-term application reliability are conducive to products' efficient and stable power generation in the full life cycle. In addition, to high efficiency and power, our module also has excellent energy generation performance. Field test at the CPVT National Photovoltaic Experimental Base in Yinchuan, China, showed that the energy yield of the n-type module based on Bycium+ cells is 3.9% higher than that of p-type PERC module (as shown in the figure below). The n-type module's theoretical energy generation is about 4% higher than the p-type PERC module. This number is consistent with field test data and publicly available industry statistics.

Taking a 100MW p-type module project in Dubai as an example and considering the cost of rack, foundation, cable, installation, and land area, these modules can reduce the BOS cost by 2.1% and LCOE by 4.6%. The LCOE can probably be reduced by about 3.5-5% depending on regional differences, climatic conditions, and projects.

In conclusion, efficiency improvement is the core of the development of PV technology. The mass manufacturing of PERC cell will peak at 24% cell efficiency. Still, the PERC cell will likely remain a mainstream solar cell for the next 2-3 years because of its high cost-effectiveness. With further cost reduction and efficiency improvement, the n-type cell technologies (TOPCon, HJT) will gradually take the market. Among them, the TOPCon cell has been put into mass manufacturing, and its capacity can reach more than 60GW by the end of 2022. Through the adoption of SE doping, hydrogen passivation technology, back passivation optimisation, the mass manufacturing of TOPCon cell can reach 26% efficiency. For the module encapsulation technology, GFI technology is a very outstanding solution, both efficiency improvement and quality assurance have been fully verified. Looking forward, in about 5 to 10 years, based on the significant progress of both perovskite and tandem cell, the efficiency of the perovskite & silicon structure tandem cell is expected to reach 30%.

Courtesy: Bubble Luxotel Hotel - Wadi Rum, Jordan - SMA Solar Technology

RISK ANALYSIS OF NEW PV TECHNOLOGIES

George Touloupas
Senior Director, Technology and Quality Clean Energy Associates

Technology Changes

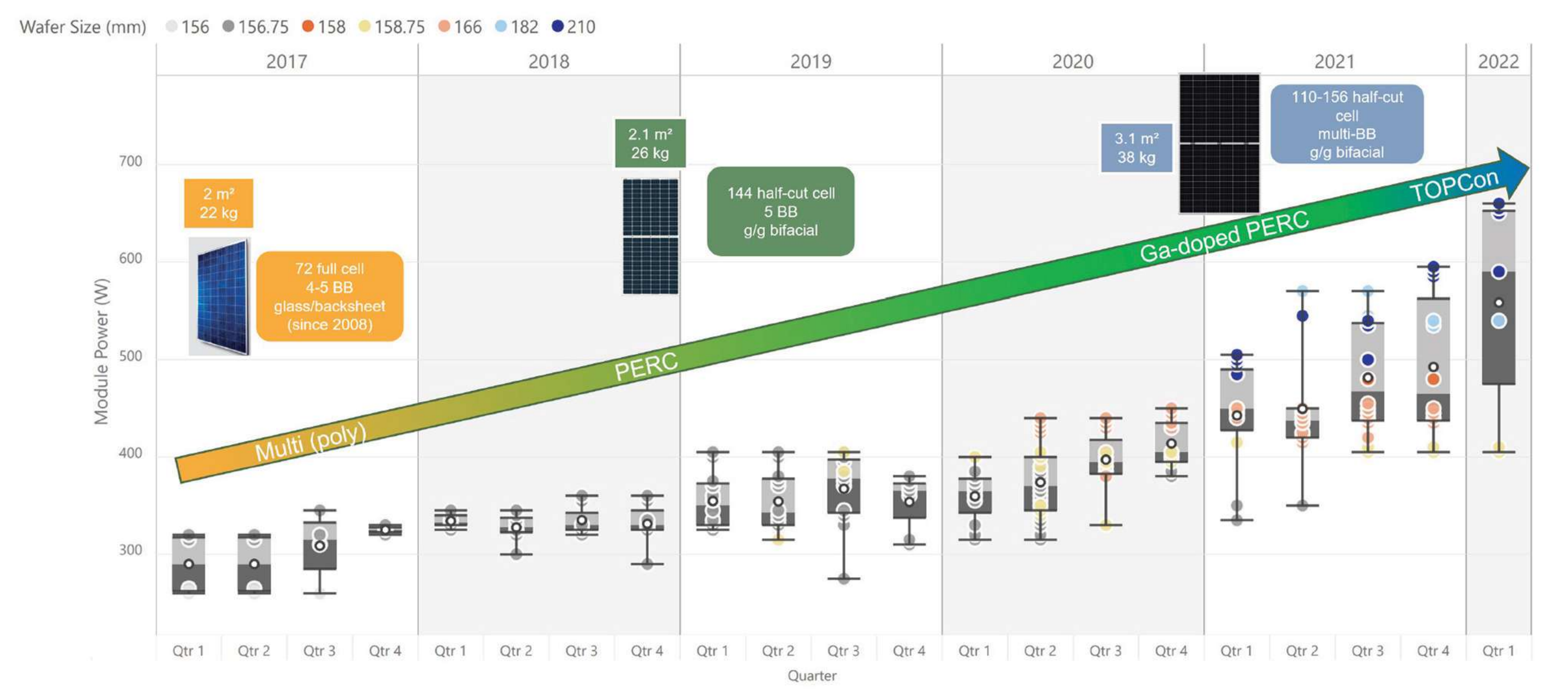
In the past 5 years, PV technology has progressed in multiple components of the PV module, namely, silicon technology, busbars, size and arrangement of cells and backsheets. The objective of all panel manufacturers is to achieve the highest efficiency and the lowest degradation. PV module manufacturers have adopted various permutations and combinations of improvements of these individual components in keeping with their current product and manufacturing capabilities to achieve the aforementioned goals. We shall explore the prevailing progress trends in these specific components of PV modules and how this affects the quality of the manufactured PV module and the LCOE.

The predominant cell technology has evolved from polycrystalline cells to TOPCon cells, with interim technologies such as monoPERC, p-type and n-type cells being the most used technologies. At the same time, cell sizes increased from 156mm to 166mm, 182mm and 210mm.

The size, shape and number of busbars (wires) have also changed, reducing internal resistance. This has also led to an increase in the overall size of the PV modules, and Figure 1 below illustrates this evolution over this period.

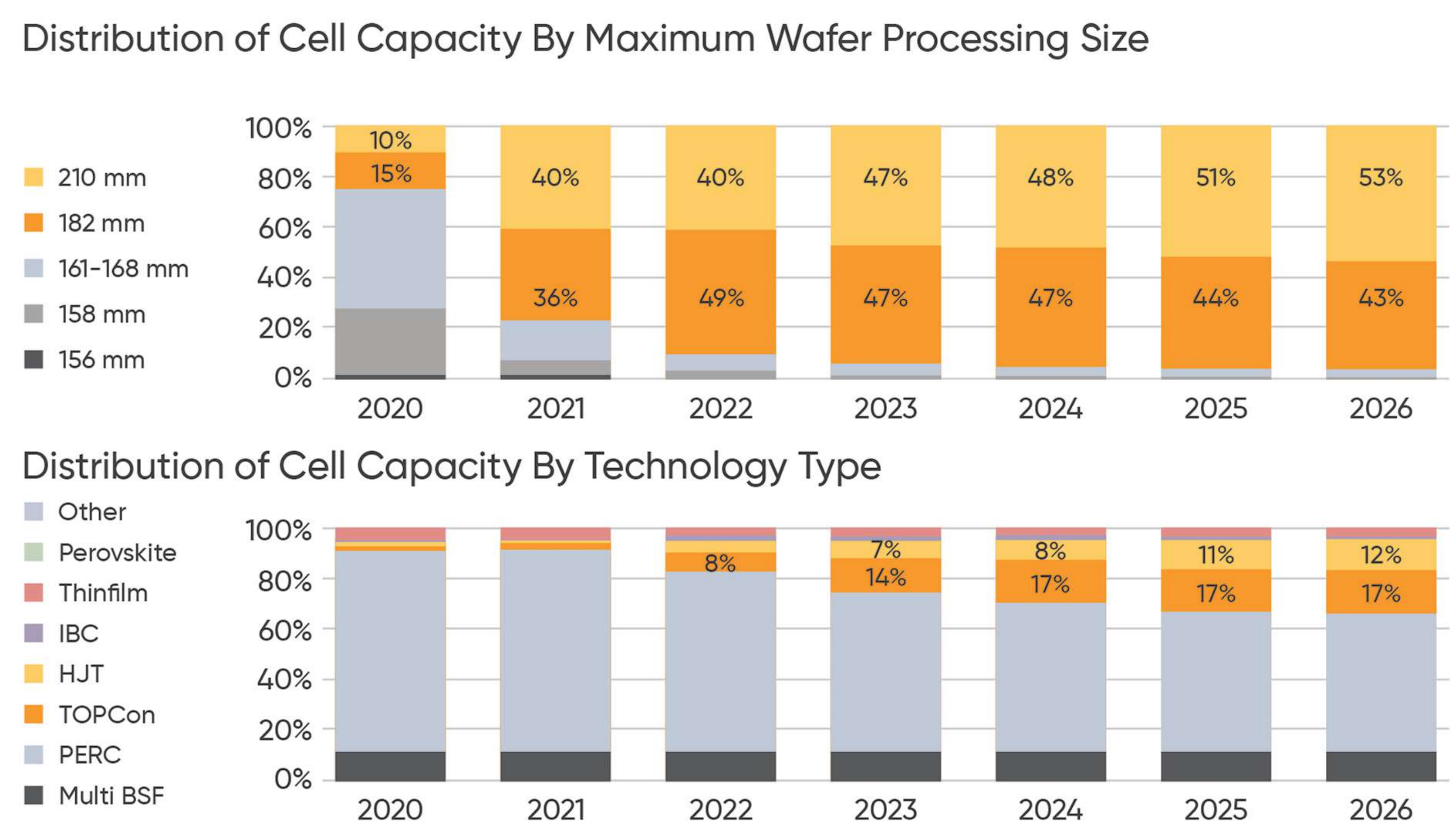
We observe that 210 mm and 182 mm cell sizes have become dominant in the past 2 years, and this trend is likely to continue, as shown in Figure 2. PV module manufacturers use 210 mm manufacturing lines that can also produce 182 mm cells, and most 182 mm manufacturing lines are "future-proofed" to convert to 210 mm if needed quickly. PV cell manufacturers continue to maintain flexibility in manufacturing both 210 mm and 182 mm cell sizes.

Although n-type expansions appear limited, suppliers can accelerate the pace once the technology and cost hurdles are surpassed. At this point, the TOPCon capacity is especially favoured, as most existing PERC manufacturing capacity can be upgraded to TOPCON.



Source: CEA Quality Assurance Project Data Statistics

Figure 1: Module Power and Wafer Size Evolution



Note:- Data aggregated CEA based on company announcements and disclosures. Data does not account for utilization, ramp times, or other potential production delays. Timelines are based on supplier statements or industry best practices if no timeline data was reported.

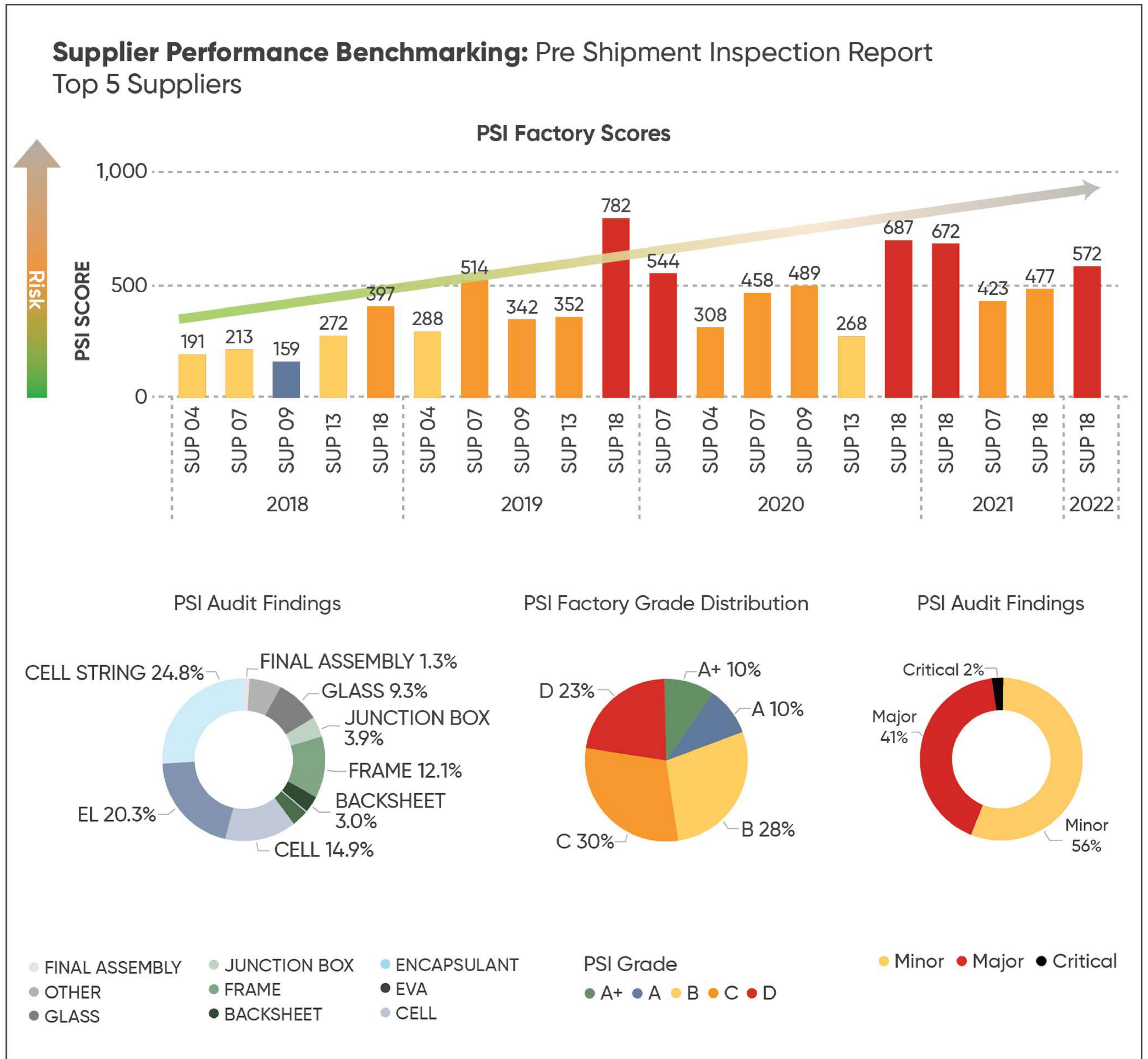
Figure 2: End of year Global Capacity Outlook

Courtesy: Rooftop of COP27 Conference Venue - Egypt - SUNGROW

07. Advancements in PV Technologies

Impact on PV module quality

The rapid and sometimes simultaneous introduction of new technologies increases the overall risk to quality. Hence, quality assurance teams collect multiple data points during factory inspections, including systematically recording defects of various severities and frequencies. Chart 3 - Pre-Shipment Inspection data compares 5 major PV module manufacturers from 2018 to 2022. The data indicates that the complexity of newtechnologies is causing an increased risk to the quality of the manufactured PV module. It is obvious that, although there are ups and downs, the overall quality risk score has gone up. The data shows that cracks, weak soldering, and misalignment are the main factors that cause "spikes" in risk scores for some projects. This will eventually result in an increased number of batch rejections and rework rate. Suppliers have difficulty optimising and troubleshooting their new or upgraded lines and adapting to the latest technologies. Hands-on quality assurance has always been crucial for PV modules, and the need has become more compelling.

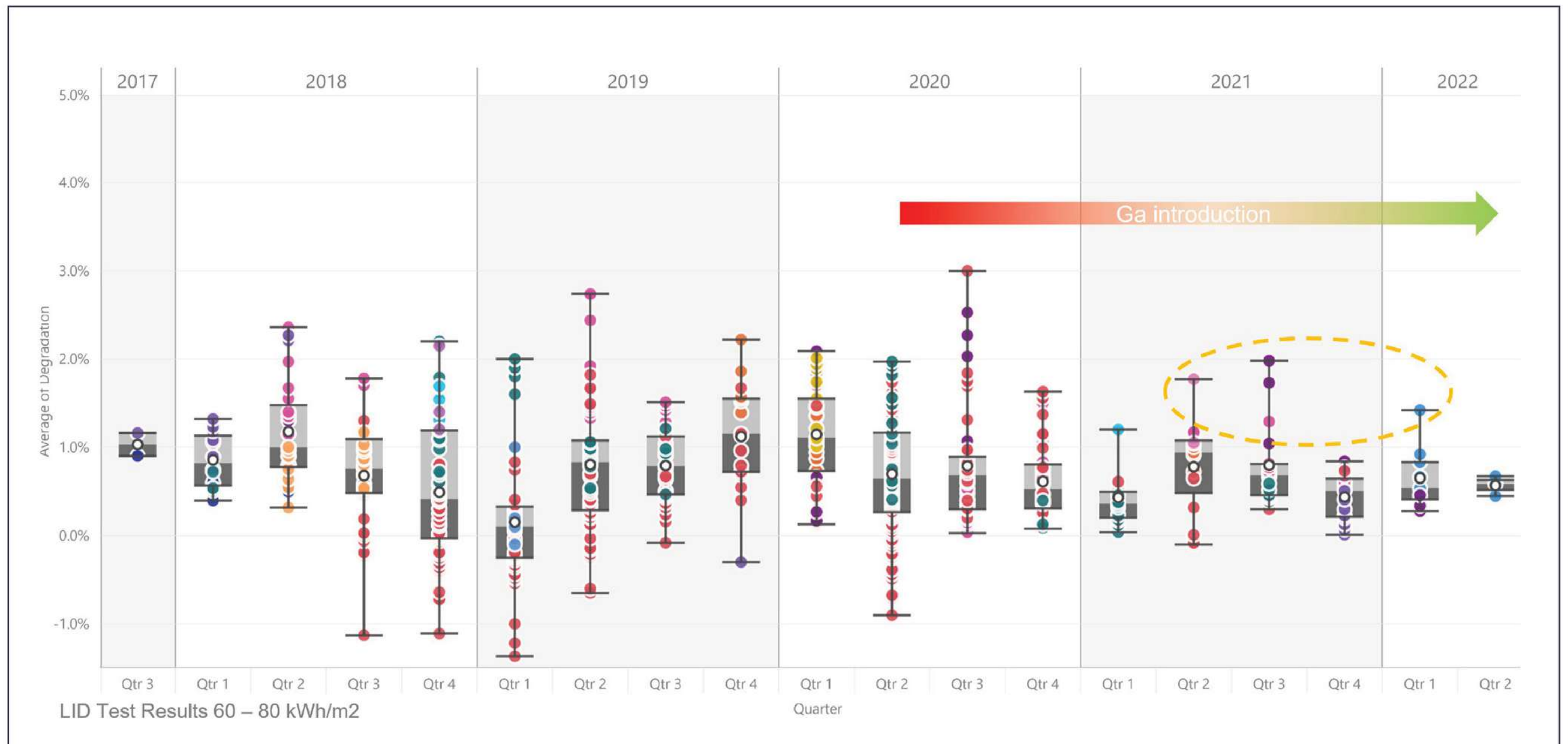


Source: CEA Quality Assurance PSI Risk Score Data

Figure 3: Supplier Performance Benchmarking

07. Advancements in PV Technologies

Chart 4 explores the various project data from the Quality Assurance batch testing program since 2019. Looking at LID performance, the introduction of gallium-doped wafers has improved LID, with the Q1 2022 LID average value being close to 0.40%. However, we can still find outliers, possibly because the industry's transition to gallium from boron has not been uniform. Regarding LeTID, we have seen that LeTID control has improved, but occasionally outliers appear.



Source: CEA Batch Testing Data, Multiple Labs

Figure 4: Various Project Data from the Quality Assurance Batch Testing Program 2017-2022

Courtesy: H4 Robotic Cleaning Solution - Ecoppia

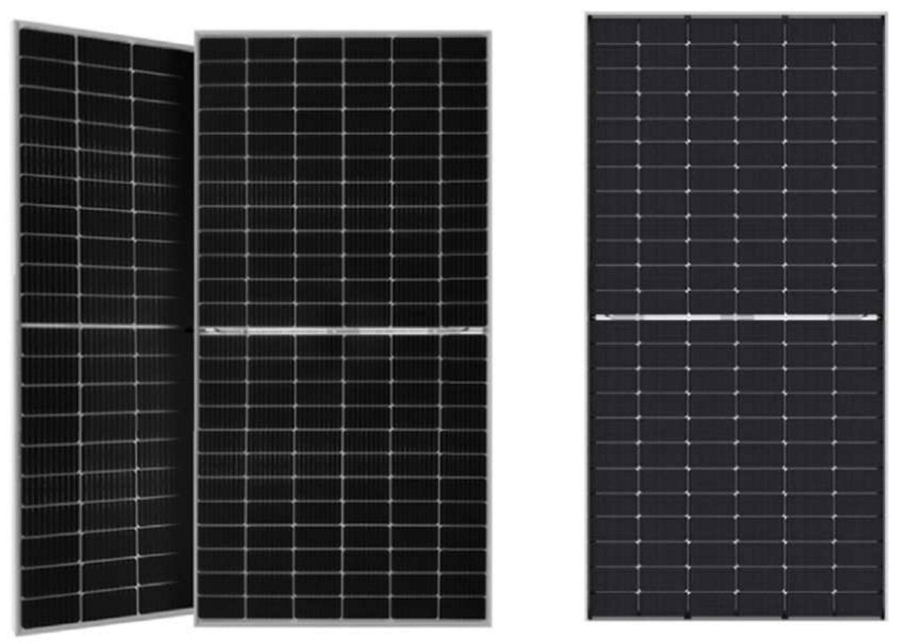
07. Advancements in PV Technologies

LCOE and Price Premium

LCOE is another important factor in selecting the components and design parameters. Bifacial TOPCon modules, although currently more expensive than PERC, have the potential to achieve lower LCOE than PERC modules because of reduced BOS cost. This reduction in LCOE is achieved because of higher efficiency, higher energy yield, lower temperature losses and lower 1st year degradation.

To understand the impact of higher efficiency and advanced technology modules on LCOE, we studied a 100 MWp PV system located in Spain using single-axis horizontal trackers. For this comparison, we selected 2 PV module products with the same construction, 78 cells, half-cut, bifacial modules, one with PERC cells and the other with TOPCon cells. See chart 5. Several assumptions for BOS components cost for the baseline PERC system were informed from Fraunhofer ISE and supplier data. The module cost and price data points were taken from CEA's PV Price Forecasting Tool and price tracking. The most popular, bankable energy yield simulation software PV Syst was used to derive the respective energy yields.

Modules	Pmax (W) 2022	Pmax (W) 2025	Width (m)	Length (m)	Module efficiency 2022	Module efficiency 2025	Bifaciality Ratio	Pmax Temperature Coefficient (%/°C)
Jinko TOPCon 72 cell bifi	560	590	1.134	2.278	21.68%	22.84%	80%	-0.30
Jinko mono PERC 72 cell bifi	540	560	1.134	2.278	20.90%	21.68%	70%	-0.35



Jinko Pro series, 72 cells, half-cut, bifacial PERC module

Jinko Neo series, 72 cells, half-cut, bifacial N-type TOPCon module

Figure 5: LCOE Advantage Sensitivity

To perform our analysis, we defined a useful new metric, the "maximum price premium", which is the price premium of a high-efficiency PV module, TOPCon in this case, that could be commanded over a PERC PV module baseline price, if the goal is to achieve the same LCOE.

In our analysis, we equalised the LCOE for PERC and TOPCon systems by deriving the TOPCon module price by adding the maximum price premium to the PERC module baseline price.

07. Advancements in PV Technologies

In Chart 6, we calculated a maximum price premium of TOPCon is $0.0319/W in 2022 and forecasted it to be even higher, at $0.0327/W in 2025, due to the expected increased efficiency advantage of TOPCon to PERC.

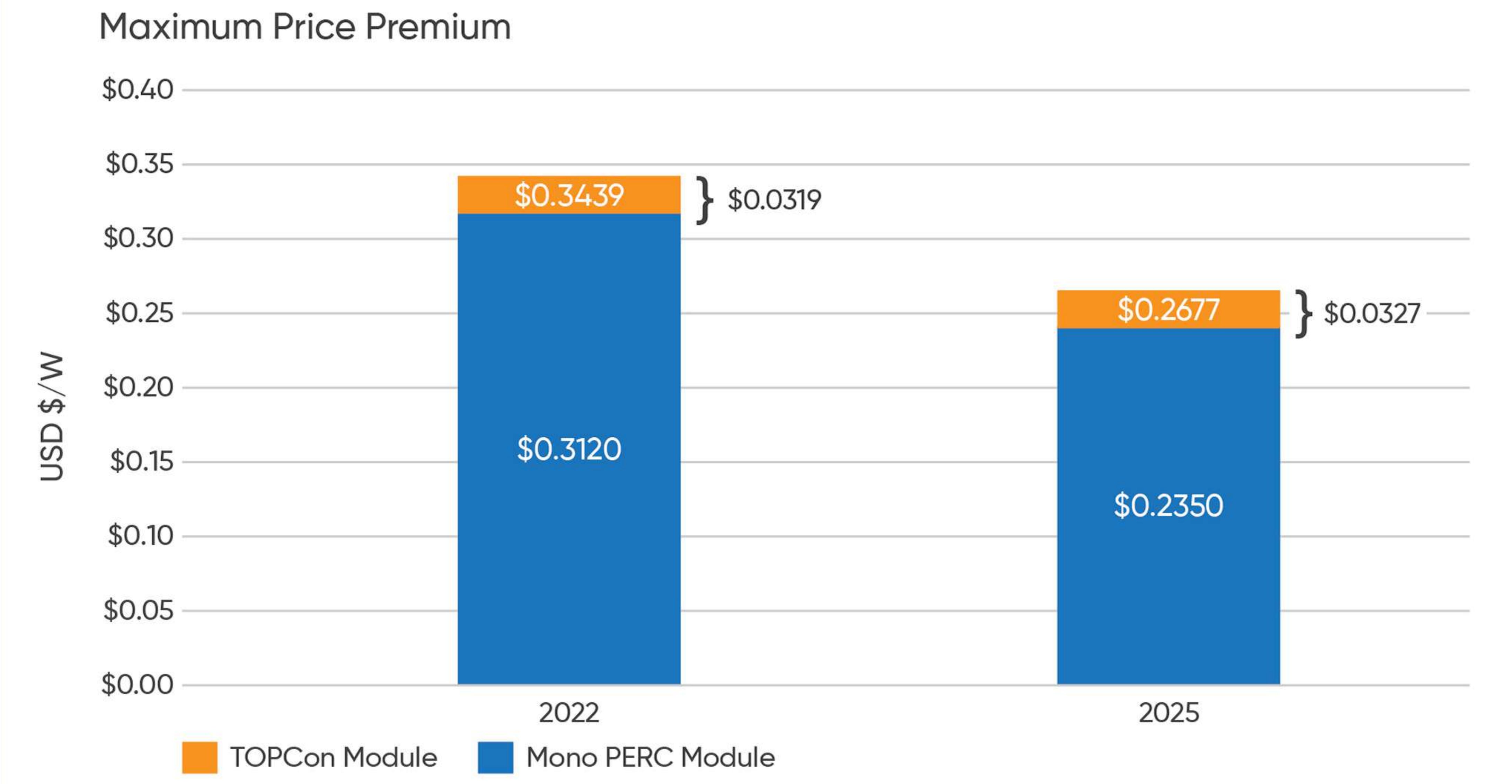


Figure 6: Compared PV Module Products with the Same Construction

It certainly doesn't make sense for a buyer to pay the maximum price premium and gain a 0% LCOE advantage. However, it does make sense to pay a fraction of the maximum price premium to reduce the LCOE. Chart 7 shows the sensitivity of the LCOE advantage to the price premium, with price premiums ranging below 50% of the maximum price premium resulting in LCOE advantages of 2.5% or higher.

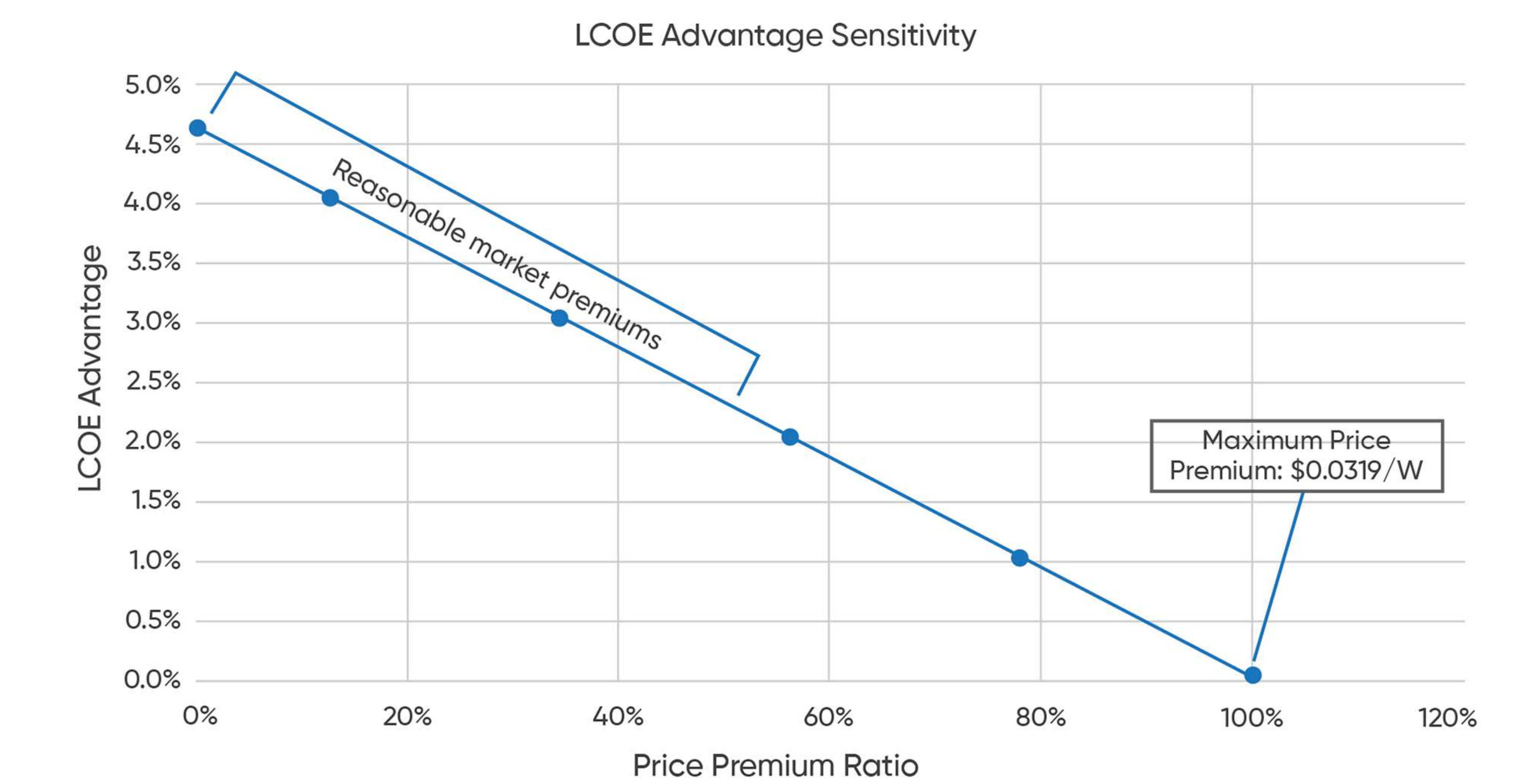


Figure 7: Maximum Price Premium for TOPCon Module and Mono PERC Module

07. Advancements in PV Technologies

The Maximum Price Premium Is Sensitive to 3 Main Factors:

1. Efficiency advantage, which affects the BOS CAPEX.
2. Specific energy yield advantage, that in turn depends mainly on bifaciality, power temperature coefficient and affects the cash flow.
3. First and subsequent year degradation in the module warranty, which affects the cash flow.

By Varying These Parameters Individually with Respect to the Base Case, We Estimated Their Effect on Price Premium, with Some Interesting Results:

1. Increasing the relative efficiency advantage of the TOPCon module with respect to the PERC module from 3.7% (base case) to 8%, increases the price premium by 28%.
2. Even if the specific energy yield advantage is reduced to 0%, the maximum price premium is still 60% of the base case, because of the BOS CAPEX savings.
3. Increasing the 1st year degradation from 1% to 2% results in a price premium reduction of 23% and increasing the annual degradation from 0.40% to 0.45% results to a reduction of 11%.

For clarity, the base case refers to the TOPCon module with the specifications in the table above and the energy yield advantage as calculated using the original PV Syst assumptions.

Conclusion

PV modules will continue to improve in the quest for higher efficiency and higher energy yield, leading to lower LCOE. However, technology forecasts remain risky, considering the timelines and moving beyond specific tipping points will accelerate change. Introducing new technologies and production methods at new facilities perennially ramping up could create unknown risks that will probably need to be continuously investigated and assessed. Sustainability is another important future key performance indicator, but LCOE is currently the most significant driver in technology selection. The new technologies invariably offer efficiency, energy yield and degradation and durability advantages, all leading to lower LCOE. However, due to the complex interaction of multiple parameters affecting the LCOE, suppliers' claims for higher performance and lower LCOE must be carefully assessed and verified. Thus, these developments make technology assessment, and manufacturing quality audits a valuable service for PV asset stakeholders.

Courtesy: T4 Robotic Cleaning Solution - Ecoppia

08. Floating Solar

FLOATING SOLAR: AN UNREALISED POTENTIAL

Karel De Winter
Director - Floating PV
Phelan Energy Group

Floating solar systems are a solution to 2 requirements that are particular to the MENA region, the need to grow renewable energy sources and the conservation of natural resources, land and water. Therefore, floating solar systems will be an answer that warrants a closer look by the authorities and developers in the MENA region.

A large part of the Middle Eastern and North African climate is classified as hot and dry. Deserts dominate the landscape, and water resources are scarce; this drives the need to conserve existing water resources and develop additional methods to meet the population's water needs. The economic growth of the GCC has been predominantly because of the use of abundant oil and natural gas for energy and desalination needs. However, in the coming years, with the region's governments focused on reducing carbon emissions and increasing renewable energy electricity generation sources, alternatives such as Floating Solar will be an essential piece of this puzzle.

Floating Solar system is often dubbed the "Third Pillar of the PV industry" next to ground mount and rooftop. Deploying Floating Solar systems on water bodies contributes to our insatiable energy demand from renewable sources while reducing the evaporation of our water resources by covering them from direct sunlight. Floating Solar pilots at island settings and some large projects near-shore have already been deployed and look promising; for example, the 181 MWp plant in Changhua, Taiwan, floated in a sheltered dock at a port. This solution offers enormous benefits as an ideal alternative for island nations desalinating water using imported fossil fuels.

08. Floating Solar

The innovative utility company, the Dubai Electricity and Water Authority (DEWA), launched an initiative as early as 2019. The initiative was further revamped in February of 2021 but has yet to be fully realised. Another regional solar leader, Morocco, has also made advances in developing Floating Solar and has a project planned for a 360kWp system. However, most of the growth in Floating Solar has mainly been in other regions, especially South-East Asia, where 70% of the world's Floating Solar capacity, approximately 5GWp, has been built. Although, in South East Asia, the primary motive was high land prices and not for water conservation purposes. Nevertheless, the successful development of floating solar in the South East Asian region has validated the technology's importance in overall solar growth.

Now that MENA has gone through the first wave of solar growth with solid growth in utility-scale projects and the tangible successes of rooftop solar, where payback periods of 3.5 years have been achieved. We, as a society, have fully understood the enormous benefits solar energy can bring, giving us the confidence to expand further and embrace more innovative applications. In the words of renowned French poet Victor Hugo, "Nothing is More Powerful than an Idea Whose Time has Come", and the time has come for Floating Solar in the MENA region.

Advantages of Floating Solar

In addition to the apparent advantage of using otherwise underutilised water surfaces for electricity generation, a floating solar installation has an increased energy yield, an additional 10%, due to the cooling effect of the water on the photovoltaic modules. That in itself is a significant argument in favour of Floating Solar. Phelan's technology allows the photovoltaic modules to be encapsulated in floating structures that position the panels very close to the surface to benefit from the natural cooling offered by the water surface.

Dust and soiling, another major hindrance to higher energy yield, is also avoided as less dust particles land on floating solar panels. In addition, proprietary automated cleaning technology developed in tandem with the FloatSun structures further reduces the effects of soiling and reduces the need for any labour intensive cleaning requirements.

Furthermore, in regions with high solar irradiance, floating solar systems cover a water body's surface and reduce evaporation by 80%. A high-level study conducted by us on 5 of Saudi Arabia's largest dams showed a potential saving of 28.4 billion litres of water every year while generating 1.5 TWh of electricity in the process. A similar study in Iraq showed that the potential saving would be 78.3 billion litres of water while generating 3.6 TWh of electricity annually.

Globally, the potential for Floating Solar PV plants is estimated by the World Bank[1] to be 400 GWp if only 1% of manmade reservoirs are covered. India's TERI institute[2] mapped the Indian potential at 260GW. Research by the National Energy Renewable Laboratory[3] in the USA projected the potential of Solar + Hydro hybrid plants at 7.5 TWp globally at 20% reservoir coverage. And a European[4] focused study in 2020 pointed out that a 14% coverage of European hydro-reservoirs could theoretically bring 729GW of new solar capacity to the continent. Closer to home, Morocco has over 17 dams, and Egypt loses 20-30% of its Nile water allocation due to evaporation at lake Nasser[5]. Applying Floating Solar on the Great Renaissance dam, for example, could mitigate water allocation & water shortages downstream.

Floating Solar & Pumped Hydro

Deploying floating solar not only improves the utilisation of the water surface of hydro-dams but can also be effectively used in tandem with the hydropower plant acting as storage. In practical terms, even when applied to low-head dams with built-in pumped storage, a floating solar power plant can store the surplus electricity generated during the daytime in the dam, which can then be used during peak demand. Co-locating a ground-mounted solar plant next to a hydropower plant is often difficult; using a floating solar solution is an obvious solution. Furthermore, when compared to solar PV with battery storage solutions, the levelised cost of electricity (LCOE) will be much lower for such a solution; even if one does not factor in the limited life cycle, energy density, power density and depth of discharge factors that limit the capabilities of battery storage.

Conclusion

The cost to build Floating PV is currently expected to be, on average, 10% higher than ground-mount PV solutions, but this is easily offset by the additional yield and, therefore, earlier payback of invested capital. Furthermore, the time needed to build floating systems is much shorter than ground-mounted PV solutions; thus, it is a quicker option for authorities mandated with

1 - WorldbankGroup, ESMAP, SERIS (2018)
2 - Teri (2019)
3 - Lee et al. (2019)
4 - Lee et al. (2020)
5 - Elshafei et al. (2021)

08. Floating Solar

aggressive renewable growth timelines. The challenge and the inherent advantage of floating solar lies below the surface. Anchoring and mooring of floating solar structures in off-shore or near-shore developments is a critical factor; however, the know-how and skill sets required are available thanks to ample technicians in offshore Oil & Gas and Marine services in the region. We see the most common applications and low-hanging fruit on lakes, dams, reservoirs, and ponds for irrigation, sewage treatment and flood control. In conclusion, floating solar solutions have clear benefits and are well suited for the MENA region, and thus, we hope to have triggered your curiosity to explore this third pillar of the PV industry further as we move our society forward on the path of sustainability.

MATURING TECHNOLOGY AND STANDARDS OF FLOATING SOLAR

Eckhart K. Gouras
Managing Director - PV magazine group GmbH & Co. KG

Floating PV (FPV) has become a very exciting niche market in recent years with 3.4 GW of FPV projects having been installed by the end of 2021. The annual global market size of this segment is expected to exceed 1 GW/year in 2022 according to the IHS Markit FPV Report 2022. In fact, IHS Markit forecasts 1.6 GW of FPV installations in 2022, so a big jump from the previous year. In the next four years, by 2026, the global FPV market growth rate is expected to triple to top 3 GW annually.

The Asia Pacific region is leading the way with large projects in India, Indonesia, Thailand and Vietnam. The largest project in the region is being built by Sunseap Group and involves 2.2 GW of FPV capacity on top of Duriangkang Reservoir in Batam. The planned completion is in 2024.

Closely related to FPV is marine PV, which does not involve inland bodies of water, but rather near- and offshore floating solar installations. As Thomas Reindl, Deputy CEO of the Solar Energy Research Institute of Singapore (SERIS), pointed out at the recent 8th World Conference on Photovoltaic Energy Conversion in Milan, Italy, marine PV can easily cover all of Indonesia's energy demand in the decades to come. By 2050 this demand would require about 6.7 TWp of solar PV, equivalent to an area of about 35,000 km2. Looking at the country's vast near- and offshore area and excluding areas with a maximum wave height of over two meters and winds in excess of 15 m/s, the remaining areas would be sufficient to power the entire country. It should be noted that waves of less than 2 m and wind speeds of less than 15 m/s provide for very calm environments, ideal conditions for marine PV installations.

In his remarks at this conference Reindl pointed to the flexibility provided by the near- and offshore marine environment. According to Reindl "if we go into marine spaces you have many more degrees of freedom compared to a reservoir, which has many other purposes, be it hydropower, irrigation or potable water supply." He envisions marine PV being integrated with fish farming or crop growing to not only provide clean energy, but also contribute to the food supply. Other applications can include PV + desalination to provide fresh water or PV + green hydrogen to provide both clean electrons and clean molecules.

Turning back to the classic FPV paradigm of floating solar on reservoirs, lakes and other inland bodies of water, SERIS estimates that FPV could produce about one quarter of the world's energy needs by 2050 – in a 100% renewable energy scenario – if only ten percent of existing reservoirs around the world were covered with PV. This would amount to 23 TW of installed FPV capacity, equivalent to 25 TWh of energy per year, the current electricity demand of the entire world. With about 5 GW FPV installed so far worldwide, there remains massive potential to go from just 5 GW to 23,000 GW in the coming decades.

But there are significant challenges in rolling out FPV and marine PV globally. For one mixing electricity and water is a fundamental challenge. All components in an FPV system need to handle the various challenges of a marine environment, from waves and winds, as already mentioned, to marine life, high humidity and the corrosive effect of saltwater (if the system is in a salty environment). But FPV engineering and technology have improved to the point where the long-term durability of FPV systems is within reach, if not proven already. Major certification and testing labs like TÜV Rheinland have scrutinised FPV systems and the components involved, and in last year's MESIA Solar Outlook Report 2022, the section on FPV contained an update on emerging standards and recommended best practices by TÜV Rheinland. For example, TÜV Rheinland recommends the use of PV cables that adhere to the new 2PfG 2750/09.20 standard.

08. Floating Solar

There are additional upsides to putting PV modules on bodies of water. For one, water provides a cooling effect, which mitigates the detrimental impact rising temperatures have on PV plant performance. In regions such as the Middle East, this provides a strong driver for FPV adoption. Also, marine PV systems can be placed close to major urban demand centres, such as the pioneering 80 kW Nurai Island FPV installation developed by Enerwhere on an island close to Abu Dhabi.

Other advantages include the fact that sunlight reflecting from the water surface can boost PV system performance. And when it comes to installations on reservoirs, FPV systems can reduce evaporation, an important benefit in a hot and water-scarce region like the Middle East and North Africa.

As FPV standards and best practices emerge in various corners of the globe, we can expect a booming market not only in Asia, which so far has attracted the major share of global FPV investment. It might not take long for marine PV to take off as well, making offshore PV as commonplace as offshore wind.

This 5 year forecast shows strong FPV growth rising to almost 3.5 GW of annual global FPV installations. The Asia Pacific region is expected to continue its dominant position in this market.

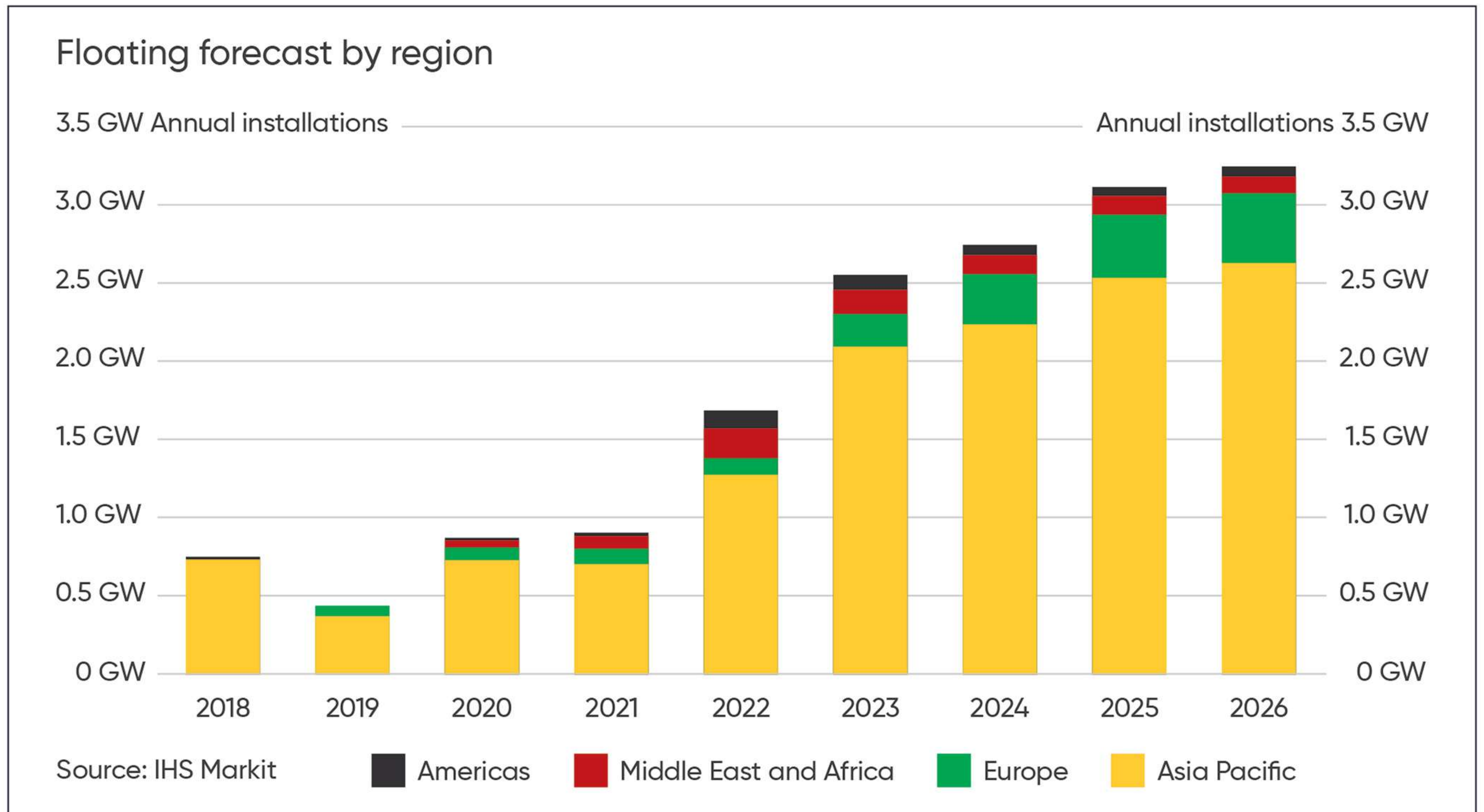


Figure 1: IHS Markit Floating PV Forecast 2022-2026

Photo 1: 80 kW Nurai Island marine PV installation off Abu Dhabi, UAE

Courtesy: Enerwhere

The gentle waves off this resort island near Abu Dhabi provide ideal conditions for this pioneering marine PV installation by the Dubai-based solar developer Enerwhere.

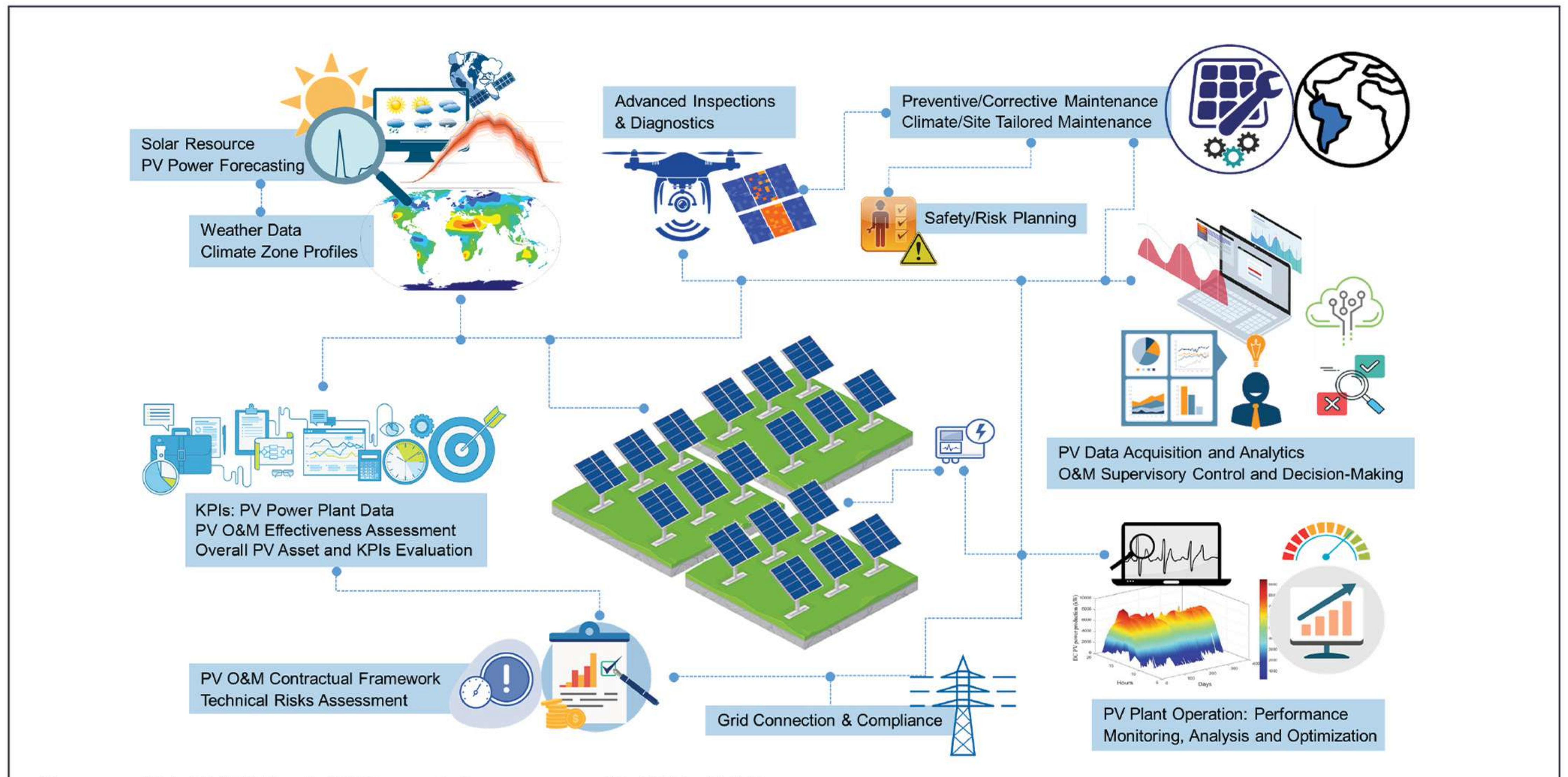
09. O&M Digitalization

O&M GUIDELINES FOR PV POWER PLANTS IN DESERT COUNTRIES

Kevin Punzalan
Head of Business Development

Ulrike Jahn
Manager - IEA PVPS Task 13

In October of this year, the International Energy Agency Photovoltaic Power System Programme (IEA-PVPS) Task 13 (1) expert group published new guidelines for climate-specific operations & maintenance (O&M) programmes. These recommendations are intended to address the lack of a standardised regime for climate-specific O&M while also addressing topics such as O&M performance indicators, preventive maintenance, and fault diagnosis (Figure 1).



Source: IEA PVPS Task 13 Report. Image credit: CEA-INES

Figure 1: Overview of O&M Aspects and Services for PV Power Systems

These guidelines are meant to help PV asset owners and investors with operation and maintenance for utility-scale PV plants in four climate zones – moderate, hot and dry, hot and humid, and deserts at high elevation areas. PV power plants in desert areas offer unique conditions for high production of solar PV energy, but at the same time, there are significant challenges to guaranteeing the reliability and durability of PV systems. Thus in this article, we focus on recommended O&M practices for the hot and dry climate zone that applies to the majority of the Middle East and North African (MENA) region and explore the challenges that arise from these conditions by providing 5 key learnings gleaned from the published report. (2)

First, owners and operators of PV plants are advised to select the technology for installation carefully (for example, modules, cables, mounting structures, and power conditioners). Because the current international standards for accelerated ageing applied to the PV industry have largely underestimated the irradiation and temperature conditions in desert regions like MENA. For example, current technologies for implementing photovoltaic power plants are sensitive to extremely high irradiation levels and specific solar spectrum (in the UV-B range). Furthermore, some deserts have:

1. Corrosive environments due to the presence of salts and water condensation during night hours.

References:

(1) - https://iea-pvps.org/research-tasks/performance-operation-and-reliability-of-photovoltaic-systems/

(2) - Full technical report from the IEA-PVPS: Guidelines for Operation and Maintenance of Photovoltaic Power Plants in Different Climates - IEA-PVPS. https://iea-pvps.org/key-topics/guidelines-for-operation-and-maintenance-of-photovoltaic-power-plants-in-different-climates/

09. O&M Digitalization

2. Fine powder or dust that adheres to the components of the power plant and causes operational problems.

Therefore, the performance and life span of the plant may be severely affected by desert conditions. Temperature extremes and salt exposure also increase material degradation in modules, frames, junction boxes and transmission cables.

Second, the typically remote nature of PV sites in hot and dry climates entails significant travel and preparation requirements due to logistical risks in supplying these facilities and access to emergency medical care. Appropriate planning for visits to typically remote sites should include consideration of hydration requirements, suitable personal protection equipment (PPE) and anti-venom procedures considering wildlife risks. Wildlife risks include poisonous animals and insects that can harm humans directly and nesting insects and animals that can cause short circuits or arc flashes.

Third, since the intensity of UV radiation and temperature oscillations are uncontrollable factors, it is recommended to perform periodic visual inspections of PV modules to detect if there is any degradation or failure phenomena. These inspections should include thermographic analyses and measurements of the quality of the modules' isolation to check for the formation of hotspots and the probability of the electrical isolation becoming compromised. To determine when complementary analyses must be conducted, it is suggested to compare the plant's energy production with the results of the visual inspections.

Fourth, suppose a continuous decrease in energy production is recorded. In that case, even after the plant has been cleaned, the maintenance plan must be executed to reduce energy losses and avoid possible permanent damage to the facilities. It is important that any change in the colour of the cells must be reported since this indicates that something is happening with the encapsulant and the cells themselves. These changes must be carefully observed, and the identification of where these changes are taking place within the plant's zones should be recorded. This way, it is possible to focus maintenance efforts on the zones most affected by problems in the modules, reducing the time taken to evaluate the plant, determine the failures, and isolate the failed zones.

Similar to the recommendation for modules; for cables, cable ties and junction boxes, the main recommendation to prevent failures due to degradation is to perform periodical visual inspections to assess the operating conditions. All these inspections can be done simultaneously, guided by a checklist that allows the operators to determine whether the equipment is operating in adequate conditions. Furthermore, systematising these checklists might help determine which of the plant's zones have more degradation issues (for example, junction box failures).

Fifth, due to the potential risk associated with the loss of mechanical properties of the mounting structures, their "degree of health" must be constantly evaluated. The degree of health is assessed in synchronicity with the evolution of the corrosion process starting from the day it is first detected. This should assess the corrosion process of the structure being evaluated and if the process is impacting other nearby structures or elements (for example, cap screws and module frames). A visual evaluation of the structure's mechanical properties should be the first step for determining if abnormal buckling is taking place. If this takes place, it indicates that a structure is becoming warped.

The Middle East and Gulf Region also have market and industry conditions that bring other management recommendations into focus. For instance, many of these countries' power generation sectors remain state-owned. Therefore, O&M service providers should consider national or local legislation concerning the availability of staff on-site and guaranteeing plant and worker safety by ensuring that staff are trained and qualified in safety procedures, equipped with PPE, and the relevant tools and consumables. They must also anticipate site-specific risks arising from heights or extreme weather conditions.

Asset owners should also carefully describe the scope and responsibilities of operators to prevent any ambiguities concerning their responsibilities and define these using quantifiable Key Performance Indicators (KPIs). Acceptable metrics include Guaranteed Performance Ratio, Guaranteed Plant Availability, and Response Time. Adequate compensation in the event of failure to discharge these responsibilities should be defined in advance if possible.

Taking these 5 recommendations into account in operating a PV power plant in hot and dry (desert) conditions will help proactive asset owners and O&M providers identify problems before they become serious and help prevent losses from avoidable circumstances.

09. O&M Digitalization

PV OPERATIONS & MAINTENANCE DIGITALIZATION

Moneef Barakat
CEO
سولارابيك SOLARABIC

PV Assets can use digitalisation to optimise the Operations and Maintenance "O&M" of PV assets, leading to increased efficiency, cost savings, and improved reliability.

Digitalisation can be applied to renewable energy assets and PV plants using digital monitoring and control systems. These systems allow operators to remotely monitor and control the operation of renewable energy assets, such as solar panels or wind turbines. This can be as simple as an app on your cellphone provided by your residential 3kW inverter manufacturer or expand to include sophisticated SCADA systems, data loggers, and commercial monitoring systems that monitor GW-level plants.

Another aspect of O&M digitalisation is the use of Computerised Maintenance Management Systems "CMMS" with corrective, preventative, and predictive maintenance techniques. The latest uses data analytics and machine learning algorithms to predict when maintenance is required, allowing operators to proactively address potential issues before they become serious problems. This can significantly reduce downtime and improve the performance of renewable energy systems. CMMS systems are also useful for managing inventories, optimising procurement decisions, and avoiding scenarios of multiple site visits to perform the same task due to unclear inventory status.

It is well known that digitalisation combined with robotics can be a game changer in PV plants. Three major applications are being implemented in many plants around the world, and these are:

Drones have been widely used in most large-scale PV plants from the construction phase throughout the lifetime of the plant. Drones combined with AI technology have proven to be effective in inspecting PV plants for defects, particularly successful in detecting hotspots with thermal imaging. This combination demonstrated high efficiency to achieve such results with minimal human interaction at both the imaging and analysis phases leading to major cost reductions and valuable data feed to preventative maintenance plans. Such efficiency depends on the level of autonomy of the drone flight paths and the deep learning advancement from the software side.

Image Credit: Solarabic

Robotic PV module cleaning has been of notable success in the MENA region due to the unique combination of desert sand that leads to high soiling rates and high humidity in many countries in the region. The region has been home to almost every type of robotics, from semi-manual machines to highly autonomous robotic solutions with AI solutions that learn and adapt from the daily gathered data on-site. These AI-Powered systems have been used in large-scale PV plants and have proven to be crucial to control soiling levels and reducing labour costs.

Image Credit: NOMADD Desert Solar Solutions

Robotic lawnmowers have been less common in the MENA region but are becoming very popular in Europe and the USA. These robotic solutions have reached a high level of autonomy and overcame many initial slope-management issues they faced in the early days. The autonomous lawn mowers can be equipped with GPS data, mowing pre-programmed paths to allow a little army of mowers to be managed by a single operator, and mowing multi-MWs of PV plants per day. Such solutions reduce the carbon footprint of big mowing machines and increase efficiency.

Image Credit: Solarabic

Digitalization can also help to reduce costs. By automating certain tasks and processes, operators can reduce the need for manual labour and group multiple activities in one site visit, significantly reducing maintenance costs, especially for unmanned PV plants.

By optimising the O&M of renewable energy systems through digital technologies, operators can significantly improve the performance of these assets and increase their life while also reducing costs and increasing process efficiency.

PV O&M Digitalization Challenges

There are several challenges associated with the digitalisation of O&M processes:

1. **Cost:** One of the main challenges of O&M digitalisation is the cost of implementing and maintaining digital systems. This includes the cost of purchasing hardware and software, as well as the cost of training employees to use these systems.

2. **Integration with legacy systems and processes:** Another challenge is integrating digital systems with existing processes and systems. This can be a complex and time-consuming process, requiring the integration of multiple systems and data sources.

3. **Integration with other digitalisation initiatives:** Most of the commercial digitalisation solutions don't natively integrate with each other. For example, if you use an advanced CMMS system, it is very unlikely that this could be integrated with the cloud-based platform access you receive from your drone thermal imaging supplier. Such incompatibility would lead to having multiple issue lists with duplicate records across the platforms. PV plant monitoring systems are also a major generator of alarms and maintenance requests, but they don't integrate with popular CMMS systems. Such providers started to provide their own integrated ticketing systems and brand them as full-fledged CMMS systems, but they have not proven to be reliable yet.

4. **Data security:** Digitalization of O&M processes involves collecting and storing large amounts of data, which can be vulnerable to cyber-attacks and data breaches. Ensuring the security and integrity of this data is a major challenge. Concurrently, we have witnessed national cyber security initiatives in the GCC countries with special requirements that are not typically considered in global digital solutions for PV assets.

5. **Employee resistance:** Some employees may resist the adoption of digital systems, particularly if they are used to traditional methods of O&M. This can be a challenge to overcome and may require training and support to help employees adapt to the new systems.

6. **Technical issues:** Digital systems can be prone to technical problems and may require ongoing maintenance and support. This can be a challenge for companies that do not have the necessary technical expertise or resources.

7. **Data accuracy:** Ensuring the accuracy of the data collected by digital O&M systems can be challenging, as it is crucial for decision-making and problem-solving. This requires robust quality control processes and ongoing maintenance of the systems. Central databases for weather data, for example, have been a popular option to fill data gaps and provide a baseline for on-site sensor measurements.

DATA, DIGITAL TWINS & THE DIGITALIZATION OF SOLAR

Kitty Chachra
Cofounder, Chief Revenue Officer
Quadrical Inc

Solar is currently in the middle of exponential global growth, especially in the Middle East. The MENA region, already home to the world's largest single-site PV plant, the 1.17GW Sweihan independent power project (IPP) in Abu Dhabi, is on an ambitious and rapid growth trajectory. Storage and Green Hydrogen are also expected to grow concurrently. This unprecedented growth will drive grids to evolve and adapt to a more decentralised, interconnected network of power generation and consumption.

Digital Twin, AI, Data and Digitalization will be required to manage these ever more complex systems for production, transportation and installation. Building Digital Twins at the installation stage and ensuring data is not siloed will allow for effective tracking of performance and degradation from Day 1 and continue to the Operations and Management (O&M) phase, so that power is produced smoothly for the entire life span, as the plant matures.

Traditionally, the solar industry has used "looking for the average" models using physics & math rules. These are static – and by its nature, a static model does not adapt and ignores actual operating conditions. Solar IPPs generally use SCADA data collection, spreadsheets and personnel to look at alerts and faults after they happen and perform analytics to compare with generation forecasts based on these models. Maintenance is generally based on fixed schedules, and issues are dealt with after they happen.

Digital Twin based models add inputs based on more substantial amounts of data and inputs from sensors.

09. O&M Digitalization

Using a model structure designed by Machine Learning (ML) experts leads to performance being improved by training with ever larger amounts of data arriving from an ever larger number of solar power plants. This process of Machine Learning is done over an extended time with careful selection of model structure and configuration parameters (hyperparameters) and thus immeasurably improves on the static models.

Digital Twins crucially improve solar assets for their owners and managers because Monitoring through Digital Twins also improves the asset quality of plants, as models are tuned to local environmental conditions and can optimise accordingly. Advantages of Digital Twins include;

Adaptability: Models can adapt to component tolerances, transportation and installation damage, local environmental concerns, geographic conditions, and changes in the nature of recurring faults.

Continuous Learning: Learn performance patterns driven by principles which are unknown to (or maybe even dismissed by) the model designer.

Degradation: Degradation is accounted for using hypothetical time travel; models can change their nature as the physical system ages or changes in environmental conditions.

With Digital Twins and AI, plants are now monitored predictively as opposed to reactively. Instead of simply monitoring for when a fault occurs and visualising the alert when it does, we move from preventative maintenance to proactive maintenance. The AI renders human error detection unnecessary for managing these larger portfolios. The AI, based on the Digital Twins, tracks signs & signals of impending issues in components. It then compares the impact of issues with revenue to issue work orders prioritised by revenue impact, ensuring that talented human capital spends less time on rectification and more on complex long term decisions. This automation and digitalisation of systems reduce the number of issues that occur over time as they are often solved before they happen, having a compounding effect on more careful inventory management for the whole portfolio. Lastly, the AI gets smarter and more accurate over time while running on the plant, reducing issues in the longer term.

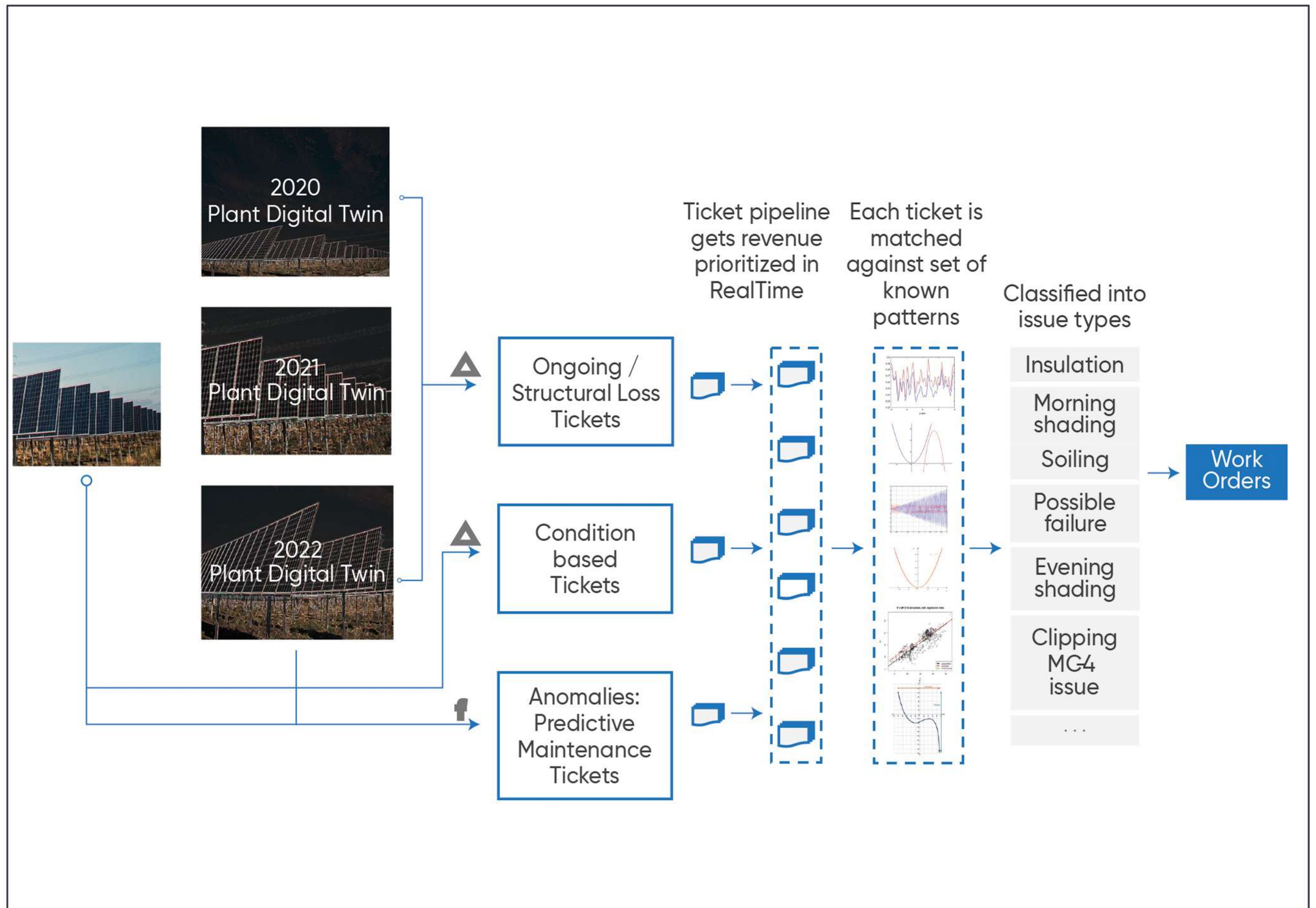


Figure 1: Condition Based Maintenance Via Revenue Prioritised Ticket

09. O&M Digitalization

Larger plants like those planned and built in the MENA region will require more focused technology resource planning for limited human resources handling ever larger portfolios. Here system-specific models will be more applicable than single, simple, idealised plant models rendering human error detection unnecessary for the asset management task. Specific characteristics of PV Plants already show that degradation leads to changes in their operational requirements and energy yield. This means adaptive models are needed for long term planning. With AI technology providing better tools, work teams are freed up to focus on minimising degradation over the lifetime of the plant. After all, these solar power plants are expected to remain operational & generate electricity for the next 30-40 years. Asset Owners and Independent Power Producers will also apply the qualitative learnings accrued by these adaptive Data based Digital Twins to the design phase of new projects, thereby creating a virtuous cycle of improvement.

These continuous learning and design guidelines utilising Digital Twins have been applied first to solar projects. The future development of Battery Storage and Green Hydrogen will require the same Digital Twins & Data solutions. We are already seeing Digital Twins maximising battery capacity, improving charge and discharge characteristics, improving availability during peak demand, and streamlining OEM claims. As more Green Hydrogen goes into production, we will see Digital Twins look at historical data and the interconnected relationships for rectifiers, electrolysis buffers, compressors and storage tanks. Technology vendors who can improve asset performance and apply lessons from Digital Twins to Battery Storage & Green Hydrogen will be ahead in MENA's ever more competitive energy marketplace. Digital Twins & AI applied correctly reduces the concern of gird operators and consumers pertaining to the intermittent nature of solar power and maximises the capacity utilisation of these installations, making this collection of technologies an invaluable addition to the solar industry.

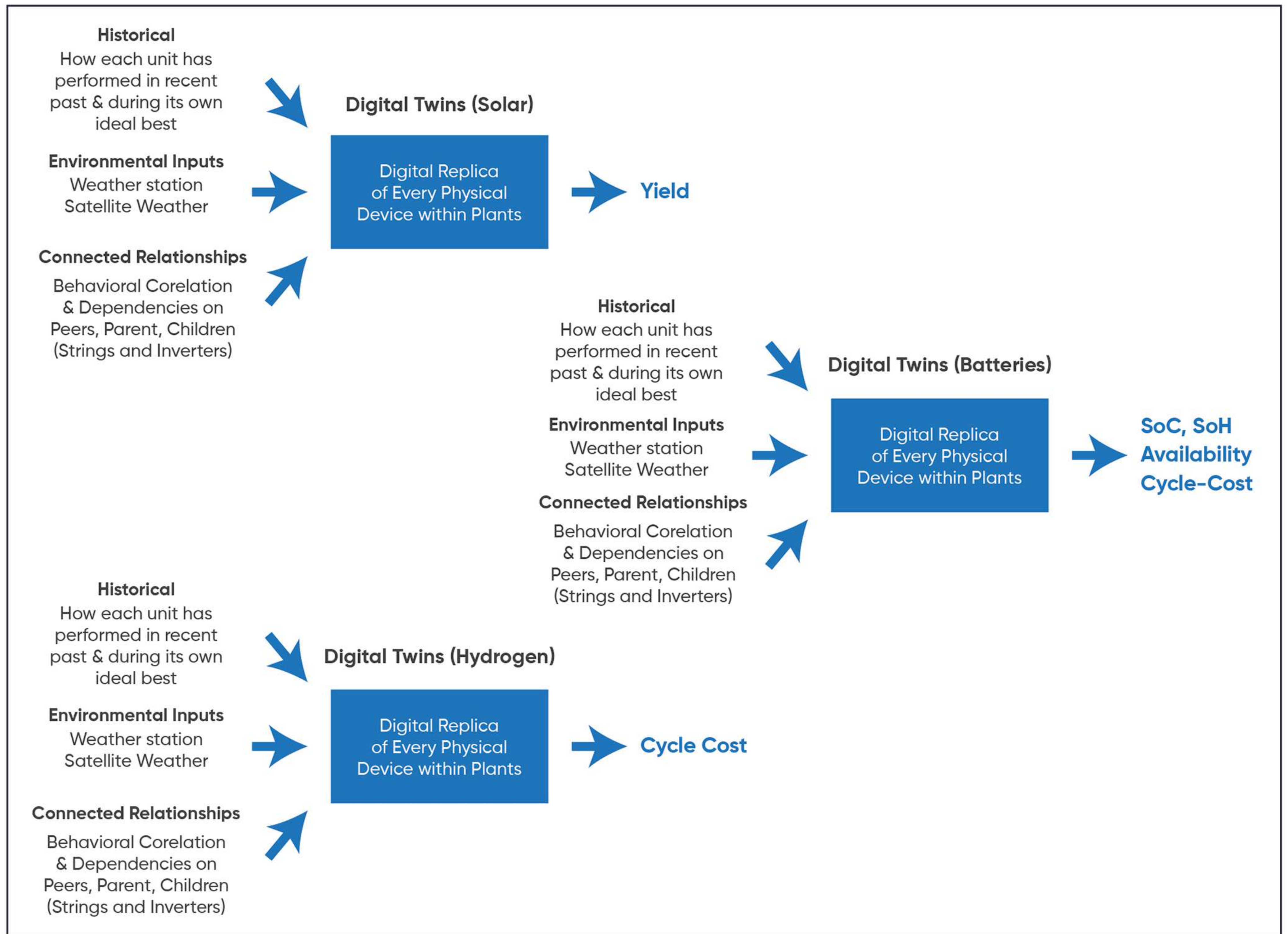


Figure 2: Transferable Base Digital Twins. Model, Predict & Simulate.

10. Robot Cleaning

CREATING STANDARDS FOR PV MODULE CLEANING

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Program Lead
PV Performance and Reliability
هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

ncreasingly, PV systems are installed in desert environments due to higher irradiation levels and more available space. Desert winds often carry sand and dust that is deposited on the PV modules, thereby significantly reducing energy yield. The soiling effect is greater at the lower tilt angle of the installed PV modules. Therefore, various waterless cleaning methods in desert regions are often used to avoid performance degradation. DEWA is installing a large PV test field to systematically assess the effectiveness and impacts of different automated cleaning systems in realistic and controlled conditions. This article introduces the system capabilities and objectives in the context of the challenges of cleaning modules in the desert.

At the end of 2022, the new DEWA test field for automated PV module cleaning systems was inaugurated at the DEWA Research and Development Center in the MBR Solar Park in Dubai. After the installation of 384 modules on fixed and single-axis tracking mounting structures, the installation of various cleaning systems will begin. In the first year of operation, continuous daily cleaning of PV modules is planned for all systems to validate the assessment methodology. In the second year, the scope will be expanded to include more specific testing in collaboration with manufacturers who can demonstrate their capabilities with standardised test sequences. The results will apply to the entire MENA region, especially to hot desert regions with quartz-containing dust.

Advantages of Floating Solar

Dry cleaning methods, preferred due to water scarcity in desert environments, use friction to dislodge dried dust layers, which is less effective than removing dust and salt with water. Also, dry cleaning can damage PV modules due to the friction required to overcome the adhesion of particles to the glass surface. Even if the brush materials are soft, the dust particles themselves can scratch the surface, causing permanent abrasion on the PV module surface. In addition, if the dust sticks on the glass surfaces and the cleaning frequency is not high enough, harder brushes may be needed to remove the stuck particles. The harder brush, in particular, requires testing and evaluation due to its anticipated increased abrasive effects on PV modules. Overall, the effectiveness and frequency of cleaning are inversely correlated, and an optimum frequency would be between one to eight days.

Most PV module manufacturers use PV module glass with an anti-reflective coating (ARC) to reduce reflection losses at the glass surface. ARC is more sensitive to abrasion than glass and may be removed or scratched by repeated cleaning. Such damage is not visible to the naked eye but may result in yield losses from abrasion that reduce the anti-reflective properties of the ARC.

When it comes to robotic cleaning devices, most use the module frame and glass surface as a rail and mechanical support for the cleaning system. In these cases, the ability of the PV modules to withstand the additional load without damage needs to be verified. The cleaning load or pressure applied directly to the front of the modules should not exceed the mechanical load capacity of the modules. Additionally, heavy or uneven loading in modules with crystalline silicon cells could cause microcracks in the cells, resulting in hot spots and power loss. Semi-automated systems pose a particular risk in this regard, as they must be manually placed on each table of PV modules. The weight of these systems ranges from 35 to 65 kg and could have a material impact if mishandled.

Finally, cleaning during the day must be avoided, as there is a risk of damaging the PV modules by forming hot spots because of partial shading. The reason is that the hot spot effect occurs when individual solar cells within the series connection in the PV module are covered and shaded. The hot spot effect can also be caused by uneven cleaning, especially at the bottom edge of modules where brush coverage may be limited, or tougher soiling may be prevalent.

PV Module Cleaning Test Field in Dubai

In order to optimise PV system operations, the long-term performance of PV modules and cleaning robots needs a detailed study. A standardised evaluation system is required to consider the harsh climatic conditions of deserts (sand and dust storms, high temperatures, UV light and often condensation during the night). The study will create criteria and metrics that evaluate the effectiveness and reliability of existing and new cleaning systems and anti-soiling coatings. As a result, the evaluation will provide important insights into the relative performance of different options and identify further improvement opportunities.

The Cleaning Test Field (CTF) has been established at the DEWA Research and Development Centre near the MBR solar park. The CTF provides an opportunity to test different robotic cleaning systems on various modules that have been or may be installed in the different phases of the MBR solar park. The CTF will allow researchers and customers to test different cleaning equipment, PV modules with different coatings, and different test procedures with different parameters (cleaning time, brush rotation speed, and module tilt angle). The primary cleaning method is dry cleaning, but wet cleaning could also be evaluated.

The CTF is a grid-connected PV system with 384 modules. It consists of eight 16-module strings with fixed mounting at a 25° tilt angle, eight 16-module strings on one-panel single-axis trackers and eight 16-module strings on two-panel single-axis trackers (see Fig. 1). The CTF is used to test the performance (cleaning efficiency, power dissipation) and reliability of different types of cleaning systems under various conditions on 24 module strings using IV data from the inverter. The evaluation process consists of two aspects: operations and assessment. Through this process, different cleaning systems such as robotic cleaning, semi-automatic brush cleaning methods and others are selected and integrated to investigate their performance and reliability compared to no cleaning and manual cleaning. In addition to string evaluation, electronic loads and microinverters with data acquisition systems will be available to measure individual modules at the end of the strings or to measure additional modules from other manufacturers.

After a prescribed period, potential damage to the glass surface and ARC will be investigated with various methods, including spectral reflectance measurement, evaluation of abrasion using optical microscopy, roughness measurement, and electroluminescence. These methods are used to study potential invisible damage caused by the mechanical stress of the cleaning process. Each PV module installed has been individually tested in the laboratory before installation and will be assessed monthly in situ and again in the laboratory after one year.

In conclusion, further tests are planned to; measure cleaning efficiency after artificial soiling with a sand blower, test the climbing ability of robots using flexible bridges and study the effect of mechanical loading of robots on modules due to different attachment points and purlins. The results and learning experience from these tests will be used to develop a standardised testing method and standards for cleaning equipment. This addresses an unfulfilled need to adopt test specifications in the assessment of cleaning equipment by PV module manufacturers, PV module plant operators and cleaning companies.

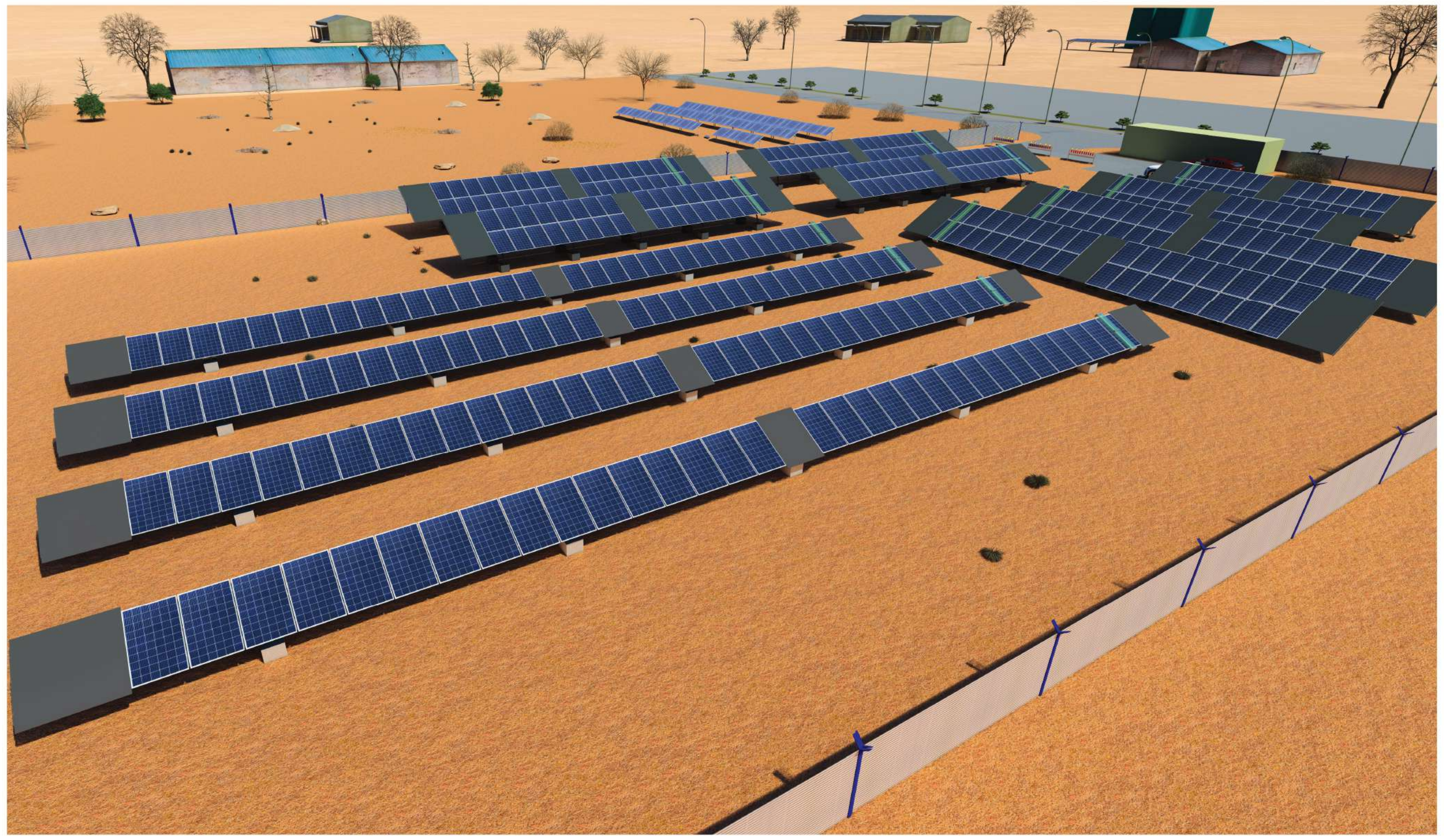


Figure 1: Sketch of the cleaning test field in the DEWA R&D centre with four fixed tables facing south and eight single-axis movable tables. Each table has four strings with 16 modules. Docking stations for the cleaning systems and the space between two strings are coloured grey.

10. Robot Cleaning

10. Robot Cleaning

MINIMISING SOILING LOSS WITH ROBOT CLEANING

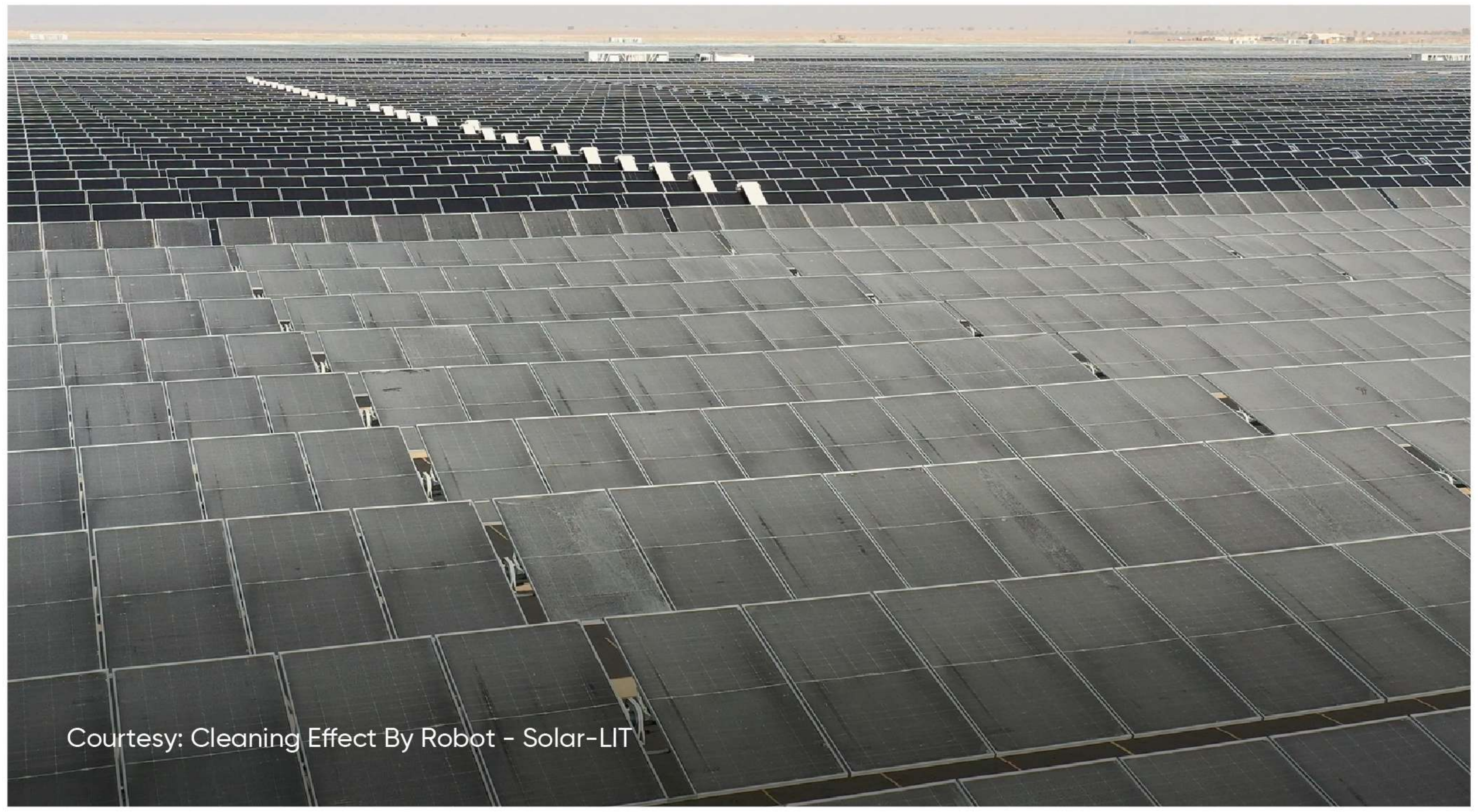
Product Department
Solar-LIT

Solar PV has achieved recognition as the lowest levelised cost of electricity (LCOE) when compared to all other electricity generation technologies. The question remains, however, how to maximise capacity utilisation of PV plants and maximising the energy yield during the operational life has become an essential concern for asset managers. Solar energy generation is affected by many factors, but in this article, we shall focus on soiling. Soiling has many forms, including dust, sand (especially in desert areas where sandstorms are very common), and organic deposition from insects, birds and small animals. Accumulative soiling on the PV modules can form a layer that significantly reduces the amount of sunlight penetrating through to the cells; consequently, the energy yield will be negatively impacted. To make matters worse, the partial soiling in specific areas often causes hot spots on the PV Modules, which in some cases permanently affect their power capacity. Therefore, the modus operandi for cleaning PV modules becomes essential for the financial viability, operational safety and long-term durability of the assets under management.

Traditionally, cleaning primarily involves using water and a large workforce. This method is clearly costly and inefficient. In water-scarce desert areas in the MENA region, potable water is not only expensive but also primarily produced by desalination. Furthermore, frequent desert sandstorms require more frequent cleaning, making it necessary for utility-scale solar plants to be cleaned weekly or even daily, which is challenging to accomplish manually. What's more, fine dust sticks to the wet panel moments after cleaning with water on windy days, requiring another cleaning cycle. For efficient economic cleaning in arid areas, non-water and manpower-free cleaning have become an ideal solution for asset managers. The ultimate objective is the improvement of ROI during the operational life of the PV plant. Considering these points, dry robotic cleaning is the optimum solution.

In mid-2021, the Solar-LIT automatic robotic cleaning system was successfully deployed at DEWA V, a utility-scale solar power plant with a total capacity of 900 MW, where the benefits of regular dry robotic cleaning were recorded. Naturally, soiling loss varies in different locations and depends on the dust accumulation rate, which in turn dictates the O&M team's approach to the cleaning method and frequency. Asset management requires a consistent OPEX estimate and constant control to balance workforce and loss in energy yield. However, our experience has been that, with a cleaning robot, the energy yield could be enhanced by as much as 35% immediately after a sandstorm, easily achieved by an approximately 3-hour cleaning cycle for the entire solar plant. The analysis of our operations in Dubai shows that the average soiling loss can be controlled to less than 0.35% after adopting robotic dry cleaning. With the efficient integration of the robotic cleaning system, an improvement in energy yield from the PV modules can be realised. The increased energy generation shortens the payback period. Return on investment in the cleaning robots is recognised immediately, possibly within one year, particularly in high irradiance but high soiling loss regions. Cleaning robots are a tiny percentage of CAPEX compared to components such as modules, trackers and inverters. Although now it plays a critically important value addition to efficient plant operation.

Undoubtedly, high cleaning efficiency and reliability support solar plants' long-term sustainable energy yield. To reach these targets, the regular maintenance and inspection of cleaning robots must also be factored into the cost of the operations. When selecting the cleaning robot, the service package, warranties, and the operational longevity of individual components must be fully considered. Several factors must be considered to have an economical cleaning solution, from design, detailed engineering, and project management to support service. The economics of the cleaning solution must aim to reduce CAPEX and OPEX costs in either greenfield or brownfield projects. Owners and developers have begun considering cleaning robots as a standard component in their long-term plant operation strategies. This is evidenced by several projects in the pipeline in which cleaning robots are included in the tender requirements. After the successful design and detailed engineering, our robotic cleaning systems will soon be put into operation in 900 MW & 450 MW projects in Sudair and a 300 MW project in Jeddah, both in Saudi Arabia, amongst other utility and distribution solar projects.



Courtesy: Cleaning Effect By Robot - Solar-LIT

10. Robot Cleaning

DUAL USE OF ROBOTS FOR CLEANING AND PERFORMANCE OPTIMISATION

Irene Kalesi
Research Writer

Countries like Saudi Arabia, UAE, Egypt, Jordan and Morocco have undergone a significant energy transition in the last couple of years and have become regional leaders in the solar revolution[1]. Solar installations have been growing significantly in the MENA region. Many more are underway, such as the 2060 MW PV plant in Al Shuaibah at Makkah province in Saudi Arabia, set to be operational by 2025[2]. Therefore, preventative maintenance in the form of a multifaceted robotic PV maintenance and cleaning system should already be at the top of the priorities when developing a new solar plant.

In this article, we answer the pertinent questions. What could an end-to-end robotic cleaning and maintenance solution offer to a utility-scale solar plant that occupies thousands of acres? And how does it contribute to the operations and maintenance processes?

The ways vary and are all essential to the solar plant's longevity and the facilitation of everyday processes. Automation and uninterrupted operation are two features that make solar professionals turn to robotic cleaners. In this time and age, choosing robotics is thelogical and most viable choice since mobilising hundreds of people to clean or deploy a sizeable number of modules is neither efficient nor financially viable.

In order to add PV maintenance to the scope, an end-to-end PV cleaning solution should comprise the actual cleaning robots equipped with robust computing systems consisting of integrated software and hardware tools that enable more functionalities than just PV cleaning. These robotics units and their integrated system will collect and analyse valuable data in real-time. Therefore, the software will be able to notify the plant's central system about microcracks, hotspots, or failures in the structural integrity of the modules. Each robot will be equipped with cameras that monitor the module's performance. Then, by employing deep learning algorithms, the robot will adjust the cleaning frequency or mode (from soft to intense), taking into consideration the real-time estimation of the soiling rate. Lastly, the system will provide information on the microclimate conditions of the solar plant in real-time, driving a virtuous cycle which will bring down OPEX costs and close the gap from theoretical maximum yield.

Robotics solutions like Solbotix implement such an ecosystem of tools and technologies that will systematically lead to data-driven decisions and prompt PV repairs that safeguard solar modules from technical shortcomings. Since no two solar plants are the same, this MRO (Maintenance, Repair, Operations)

References:
(1) - https://www.thenationalnews.com/weekend/2022/09/16/solar-power-in-the-middle-east-how-some-countries-are-racing-to-go-green/
(2) - https://ieefa.org/articles/saudi-companies-teaming-build-2060-megawatt-solar-farm

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set of services is adjusted to the respective solar plant to offer a holistic preventative approach to any upcoming problem.

Which solar business models should developers opt for when it comes to waterless robotic PV cleaning and maintenance?

In a world where technology progresses quickly, following the CAPEX over the OPEX model reduces the chances of a solar plant adopting future solar innovations that will come up along the way in the 25 years of its existence. The decision should be based on three significant notions, cost-effectiveness, high quality of services and peace of mind. By choosing to lease a robot cleaning service for a solar plant instead of buying a robotic PV maintenance fleet, the initial investment required is eliminated. At the same time, avoiding a capital investment means that the leasing company is responsible for servicing the cleaning robots, maintaining their hardware/software, and bearing the performance risk. This way, the concerns of handling O&M costs, finding the technical expertise needed to handle such matters and receiving continuous technical support no longer occupy the minds of the decision-makers. Making the strategic choice to follow this model will also offer solar professionals daily updates on the performance of the modules and an extra sense of security in a world where energy costs keep rising.

Can a solid robotics O&M decision make a PV difference?

In reality, there are more crucial factors in making a profitable decision to solidify the future of a solar plant than the cost. Partnering with a reliable robotics company is the key to that future. A reliable robotic cleaning company will fully understand the solar project's needs, and their technologies can streamline O&M procedures. Moreover, they will be the ones to guarantee their products' consistency and the quality of their services by protecting the modules' coatings and offering valuable input towards improving a solar plant's functioning. Lastly, a robotics PV cleaning and maintenance solution is not a secondary investment but an O&M asset that can extend a solar plant's life, increase revenue and maximise solar energy yield.

11. AI - VR Monitoring

EFFECTIVENESS OF AI & AR ON SOLAR ASSETS

Faisal Kittana
Project Development
EDF & Emerge

Artificial Intelligence can be a virtue to the Solar industry if used to its potential, starting from using it in manufacturing solar modules up to using AI-equipped drones in Operation & Maintenance (O&M). Humans have seen AI during the 20th century. In Terminator, Wizard of Oz, and Star Wars. Alan Turning investigated AI mathematically in the 1950s. Dartmouth Summer Research Project on Artificial Intelligence began in 1956. (DSRPAI). McCarthy and Minsky hosted in 1956. Across 2022, AI is being developed in all markets. Stephen Hawking observed, "AI may be the best or worst thing to happen to humanity." MESIA is excited about the future of AI in the solar industry, so we want to emphasize the term "best" and show how AI can be a virtue. In this essay, we'll discuss four ways AI or AI & AR might be employed in our industry.

This article will focus on the four different applications related to: decision-making, O&M, utility-scale, and AI and AR. The Solar Industry has been studying AI in many sectors of its business, such as automated decision-making in O&M or preventative maintenance, which involves feeding a computer a database of issues and causes. The computer can foresee a fault through I-V curve tracing or automatic lowers. Artificial intelligence and its applications in Solar is highly dependent on machine learning. Machine learning is the ability of a machine to mimic intelligent human behavior. Artificial intelligence systems are employed to carry out complex jobs like humans tackle difficulties. Also, similar to humans, machine learning will depend on the quality of the data put into the system, which takes us to the most critical job in AI or machine learning: gathering data from plants worldwide. Imagine if unified monitoring platforms bring all PV plant data together. This would assist O&M to gather information and benefit plants worldwide. This presents challenges: different PV Systems, locations, ages, and granular monitoring. If done well, it can be a breakthrough for the PV Industry by optimizing O&M through automated-decision making, which can assist O&M operators in being more effective and efficient.

The second case can also utilize O&M, whether using thermal imaging drones for inspections proves to be highly successful in identifying potential defects in the system. This comes with many challenges. Obtaining permits becomes exceptionally challenging if the site is located near a sensitive area such as a military base or international airport. Addressing the big elephant in the room is again the availability of the data. AI-powered inspection drones need to be fed with a large set of images of defects and their thermal vision for the Machine-Learning Algorithm to work; we again need a large data set.

The third case that represents the usage of AI is in Utility-Scale PV, which can help manage the supply and flow of power in our systems; this is extremely useful in off-grid applications and can significantly improve the energy mix of our system. It is mainly due to forecasting the future loads and linking them to the power supply using PV generation. AI in utility-scale can continuously improve throughout the years of operation as the site data will continue to be fed to the algorithm developed. This can help grid operators optimize the system's dispatch using irradiance forecasts for short-term outputs from our PV systems in minutes rather than days. In off-grid applications, this can save millions of dollars as the more accurate our forecasting is, the more we can lower the reserves of the system, which can cause a significant impact on the sizing of the system. Another important virtue is grid stability and improving plant availability. This follows the concept of creating a digital twin of your plant that can mimic the plant's operations and is continuously enhanced by data collection.

The fourth case represents a mix-use case of AI and AR. We have been experimenting in our projects, from the early stages of project development to the commissioning of Plants. An example of where we used this type of technology was during site surveys, where we used a 360-degree camera that also holds the GPS tracking of the location. This can then be viewed as raw footage, which can view a 360 video of the site. The innovation comes with the process afterward by inputting this data into Digital Twin software that can hold the drawings of the plant and be utilized to record construction progress and changes in different design aspects. The user can view authentic 360 images and videos of specific points of the site within the AutoCAD drawing itself and can view the progress of the site from anywhere in the world. This, of course, minimizes the risk of reporting errors and miscommunication. The reader might ask how AI can be integrated into these AR applications; well, many of the tasks necessary to create immersive AR experiences have been made relatively

11. AI - VR Monitoring

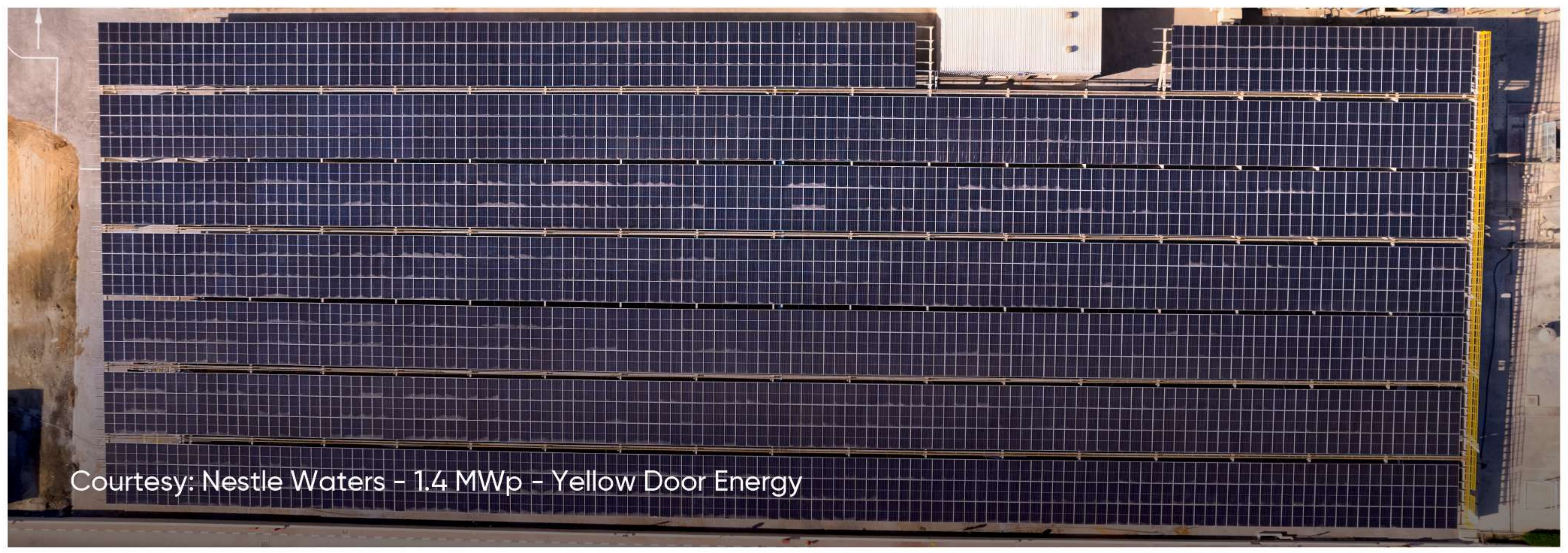
easy for AI models to handle. Deep neural networks are capable of inferring 3D positions of objects in real-time, estimating depth, segmenting images for realistic occlusion, and even detecting vertical and horizontal planes. Due to these capabilities, several of the more established computer vision techniques that support AR experiences are being replaced by AI models. A great example of this type of application has been used by Electricite De France (EDF). They have been utilizing this type of technology in their Nuclear Fleets based on high-resolution 360 photos and scans. They can use this in different stages, including the process, building, system, and even individual components. We don't see any restrictions in which this technology cannot be used in Solar Plants, whether Utility-Scale, Commercial and Industrial sectors.

Furthermore, in the MENA region, one of the highest losses of PV systems consists mainly of thermal losses and soiling. This can be significantly decreased through robotic cleaning; with the help of Artificial Intelligence, cleaning robots can detect soiling levels and efficiently optimize the cleaning pattern. Numerous studies are undergoing in the academic region to help aid the development of such solutions. Five students from Abu Dhabi University have developed a solar-powered robot that uses Artificial Intelligence (AI) to clean the sea from plastic and other floating and mineral wastes to protect the marine environment. It uses its algorithm to study the possible paths and decides based on the most energy-efficient path. The robot, powered entirely by solar energy, can navigate autonomously in a marine environment by studying multiple paths and deciding on the most energy-efficient path based on the amount of waste and detected obstacles. Can provide a detrimental positive impact on the Operation & Maintenance of PV Plants.

On the other hand, government bodies are also investing in the development of Artificial Intelligence. One of them is Digital DEWA, which was founded to advance solar power technologies, deploy a renewable energy grid with cutting-edge energy storage technologies, expand and integrate AI solutions, and make Dubai the first city to deliver electricity and water services using AI technologies and digital services. They have been exploring possible Asset Performance Management Using AI in their Power Stations that are also used to integrate the different energy sources currently part of Dubai's Electricity Mix. Overall, 2022 has been a slow but steady advancement in Artificial Intelligence in the MENA region. With the support of the Academic Sector, the MENA region can contribute significantly to the global movement of AI, which can be used in our Solar Industry, as iterated in this article.

To conclude, with the substantial advancement the world is going through in terms of different aspects of technology, we can use it to our advantage where other parts of technology will fit differently in our use cases. The COVID-19 pandemic highlighted the importance of using technology to our advantage. We envisage a future in which engineers can perform site visits from the comfort of their homes using their 5G network to connect to a site with minimum connection delays that can help our global target of building a sustainable future for the generations to come. The cases presented in this article are plausible. They can be implemented and used to complement Stephen's vision of AI, making it the "best" thing that happens to humanity.

References:
https://www.khaleejtimes.com/environment/uae-female-students-develop-solar-powered-ai-robot-to-clean-ocean?_refresh=true
http://wam.ae/en/details/1395303072197


Courtesy: Nestle Waters - 1.4 MWp - Yellow Door Energy

12. Drones for PV Inspection

DRONES BOOST THE SOLAR INDUSTRY

DEWA R&D

The solar power industry has advanced at an exponential rate during the last two decades covering thousands of square kilometres on the earth's surface and maintains a strong growth momentum with a massive need for further expansion. Considering the large surfaces inherently involved in solar power generation installations at urban and industrial levels, the facilitating role of drones that offer a bird's eye view becomes evident. Drones are Unmanned Aerial Vehicles (UAVs) with a wide variety of applications and classification types, depending on their wing type, automation capabilities, endurance, flying range and height, weight, special features, etc. Drones are already transforming selected activities in the solar industry, like topography studies, construction development and final commissioning surveying, as well as periodical inspections during operation. As a result, dozens of start-up companies work in this field, while all large and medium scale solar plant operators are looking to improve asset performance management (APM) in terms of efficiency, reliability, and preventive maintenance using drones. This article focuses on the intersection between drones and the solar power industry by providing a review of applications, benefits, technology drivers and the outlook for this domain.

Drones supported by the appropriate payloads and artificial intelligence (AI) can fly over solar PV panels and capture thermal and visual images for automated anomaly detection and performance monitoring. This application has evolved over the last decade to a competitive level of maturity by detecting cell hotspots, diode issues, bypassed substrings, module failures, cracks, soiling, potential induced degradation and electrical connection problems. Thermographic inspections are typically required on an annual basis, while combined thermal and visual inspections can be insightful on a quarterly and even monthly basis, depending on operating conditions and the level of automation in APM functionalities. Similar services have also been launched recently for concentrated solar power (CSP) plants, especially those using parabolic trough type collectors. An aerial inspection that combines state-of-the-art UAV technology with electro-luminescence (EL) image capture is an emerging technology to support quality control, predictive maintenance and performance evaluation of PV plants. Beyond inspection, drone solutions are currently being developed for PV module cleaning, mainly for remote or hard to access areas.

We highlight the potential benefits of these applications. At first, drones reduce PV plant maintenance costs and operation times. They can provide PV health assessments through thermal inspections at a speed of 10 minutes per MW, while a manual method like the standard I-V curve tracing would need 2-5 hours per MW, which is more than 10 times faster. Similarly, ground inspection technologies are an order of magnitude slower than airborne ones for solar generation plants. Drones achieve high professional standards in image acquisition that enable smooth post-processing and accurate analysis to conclude inspections by means of image processing and customised algorithms. The inspection reports can be automated, and the results can be sent to the technical crew for targeted and effective action using smart dispatching. Furthermore, rapid, comprehensive and automated historical archiving can be implemented by means of drone systems with elaborate sensors, Internet of Things (IoT) technology, complemented with AI and data transfer & storage functionalities. Thus, solar power producers and maintenance service providers can derive baselines of data for future inspections and performance comparisons. Similarly, automated inspections can effectively support contractual and warranty claims to reflect the appropriate standards, such as IEC TS 62446-3 for thermography. Improved accessibility is another great advantage of drone technology for the solar industry. Indeed, solar PV plants are often installed in remote locations, whereas rooftop and floating installations can be particularly challenging in terms of accessibility without a drone.

The technology drivers of drone applications to solar energy systems are summarised in Figure 1. The core driver is the field of drone technology, which has been evolving rapidly in the last two decades. We expect rapid advances in flying range, smooth and highly autonomous flight capabilities, and lift capacity. As shown by Ernst 1997, patent data can offer valuable insights into technological forecasting and thus, Figure 2 (a) depicts the patent count associated with drones by year over the last 10 years. Comparing the shape of this trend with the shape of a likely industrial field lifecycle, the current market status is observed to have surpassed the emerging phase and heading towards full commercialisation.

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The evolution of drone payloads, another important drone technology driver, is constantly adapting to the prevalent drone types and includes sensors (like infrared and visual cameras), actuators (like valves, spraying systems, and robotic arm manipulators) and IoT devices for communications and positioning functionalities.

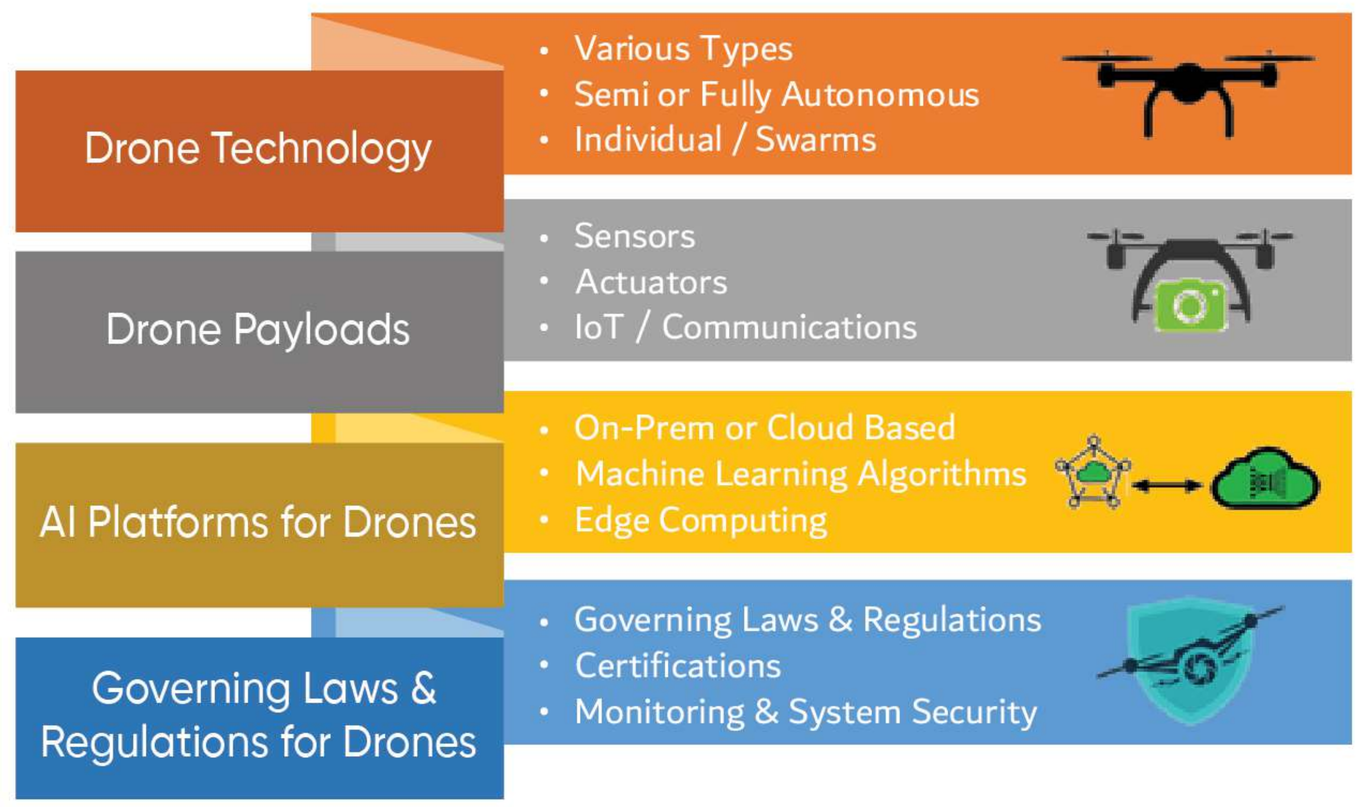
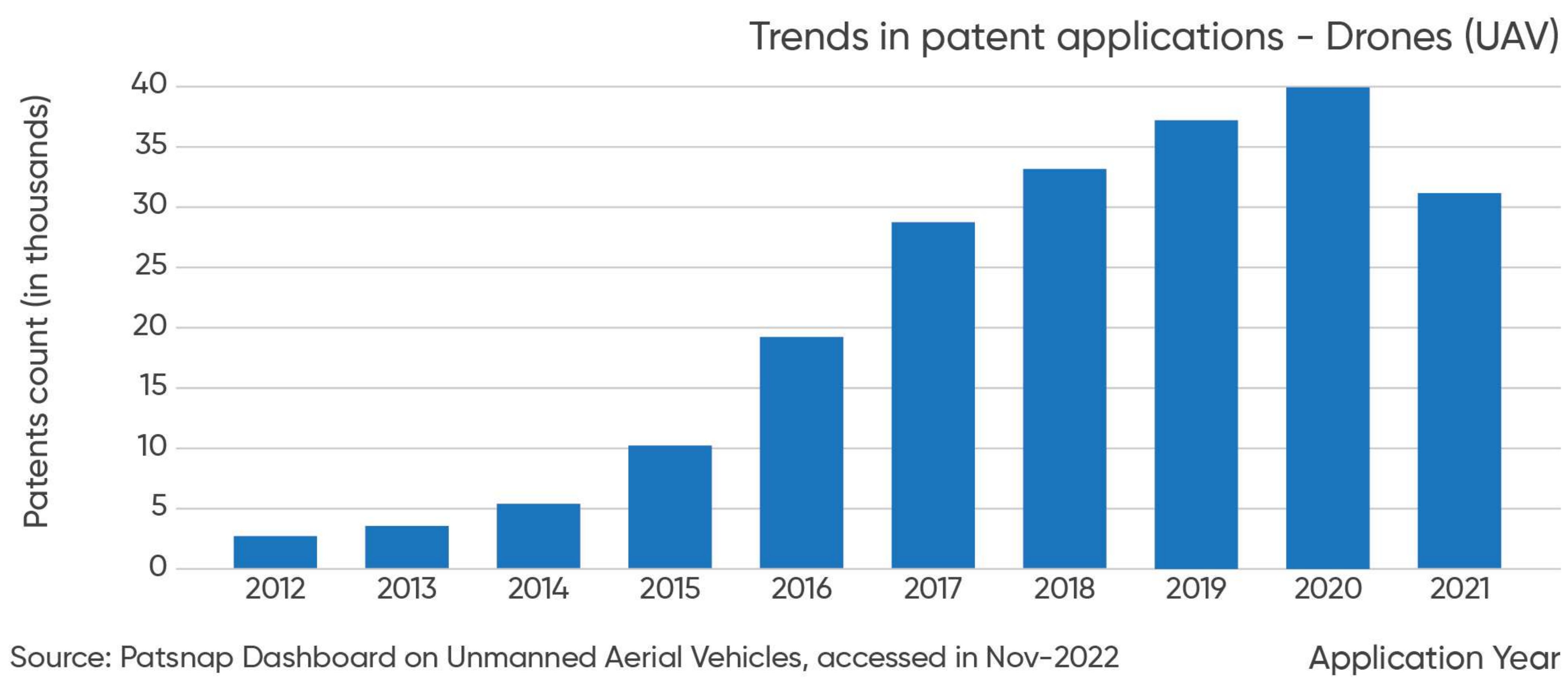


Figure 1. Technology Drivers Behind the Solar Industry Applications of Drones

The third in this stack of technology drivers corresponds to AI and IoT platforms for drones. This architectural solution is instrumental for efficiently managing drone operations and promoting scalability. Such platforms provide control, navigation, storage and extra computational power for drone operations in a user-friendly compact matter. Given the advancement in data transfer technology and the introduction of 5G, real time control is now more reliable, which gives room for most computationally extensive tasks to be transferred to an online server, reducing the computational load undertaken by drone payloads. By shifting computationally intensive tasks to the cloud, like computer vision for navigation, a drone's flight time can be effectively increased.

The last driver for drones refers to governing laws & regulations for drones and directly affects market challenges and opportunities. This entails the development of systems that ensure security in controlling drone flights, risk mitigation, reliable certification processes and the elimination of uncertified activities. Currently, the MENA region features a variety of regulatory frameworks for organisations flying drones that mostly involve strict registration and security clearance requirements.

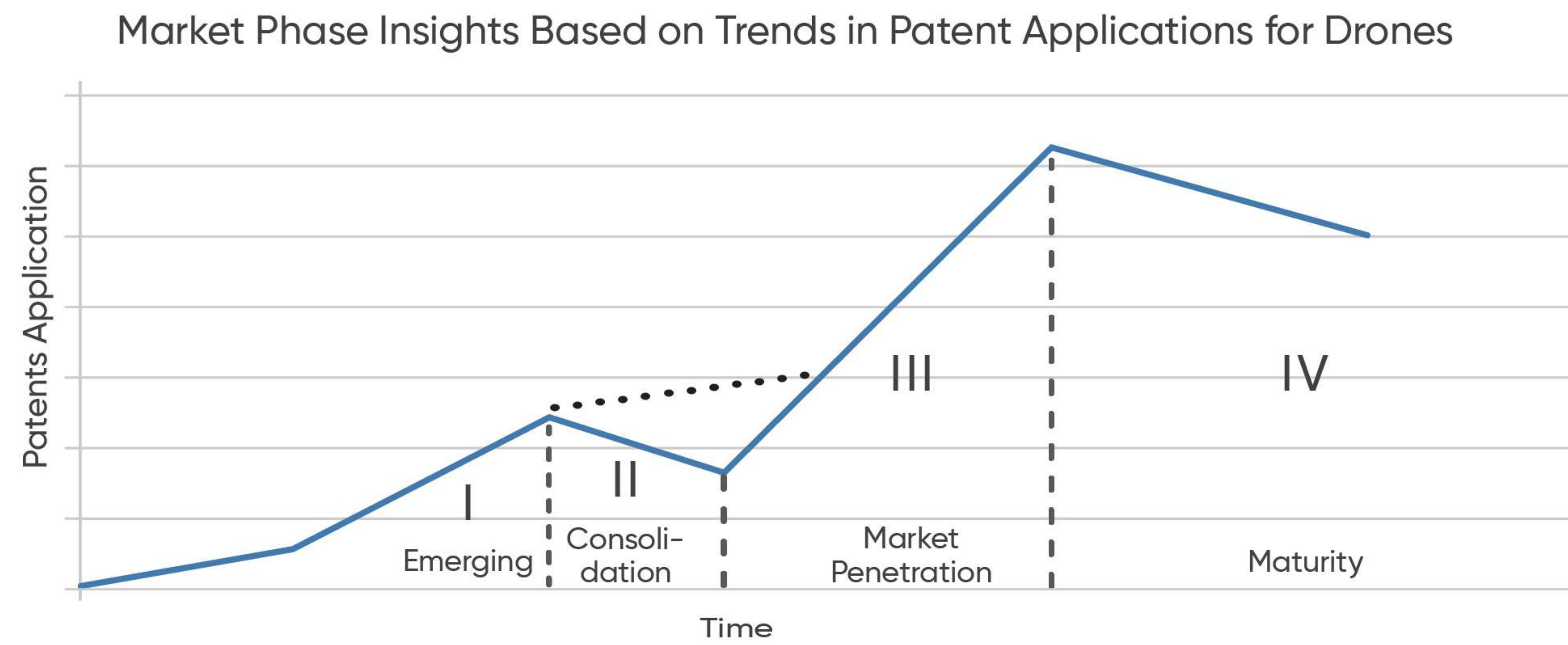


Source: Patsnap Dashboard on Unmanned Aerial Vehicles, accessed in Nov-2022

Figure 2 (a): Market Phase Insights for Drones

12. Drones for PV Inspection

DEWA R&D Centre, strategically located at the Mohammed bin Rashid (MBR) Al Maktoum Solar Park with an expected solar capacity of 5GW by 2030, is testing DRONIMOUS (Figure 3). This fully in-house developed drone-based solution uses thermal and visual images captured by drones with Real-Time Kinetic positioning systems and processed by deep learning to detect soiling, hotspots and other anomalies. Drone-based solar inspection service providers who are keeping abreast of the regulatory landscape and technology advancements have a great outlook, especially if they target economies of scale. Such economies of scale can be amplified either by combining services and clients in areas with a high density of solar generation capacity or by adding similar asset monitoring services like electrical distribution and transmission, agriculture, and more.



Source: Ernst H., "The use of patent data for technological forecasting: the diffusion of CNC-technology in the machine tool industry.", Small Bus. Econ. 1997

Figure 2 (b): Market Phase Insights for Drones

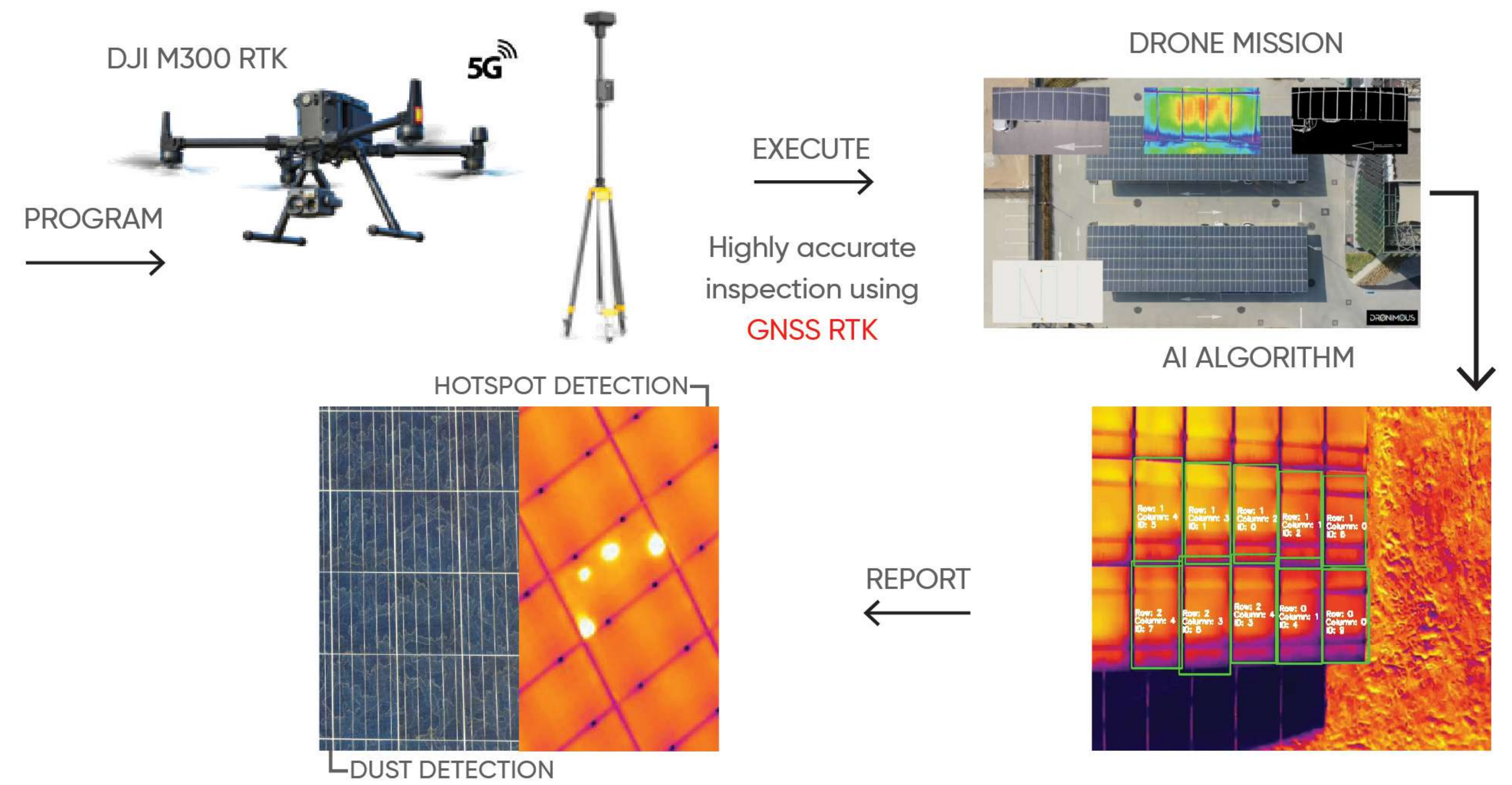


Figure 3. DEWA R&D DRONIMOUS System Overview

12. Drones for PV Inspection

IMPROVING ASSETS PERFORMANCE WITH DRONES MONITORING

Viola Hoffmann
Global Marketing Manager
Above Surveying Ltd

Michael Michalowski
Managing Director
Fly-By Guys

Solar plants are getting bigger, companies are more international, component technology is constantly changing, and all whilst the availability of qualified people decreases. These trends increase the risk to the build quality and modelled yields, but also increase the complexity of construction projects exposing them to inefficiencies and increased cost. In this article, we explore how drone-surveyed data paired with digital models and automatic data analysis tools already offset these risks and increase returns.

The current solar growth trajectories of the MENA region predict solar capacity will double over the coming five years from 15 GW to over 32 GW, according to the International Energy Agency, posing specific challenges to the development of solar farms.[1] For one, the sheer size of solar farms is, on average bigger than in other regions, illustrated by the 800 MW Al Kharsaah project. Often for solar assets of these sizes, a traditional, manual approach to construction supervision is inefficient because it is too time-consuming and human resource intensive, which in itself is a serious threat to construction quality.

Additionally, despite the extreme weather conditions, the region is favourable for new module technologies with higher efficiency, such as bifacial modules. However, Dr. Ben Figgis from the Qatar Environment and Energy Research Institute (QEERI) highlights the effect of these extreme weather conditions by stating that "in Qatar, they see a reduction in generation of around half a percent a day due to soiling. Therefore without cleaning, power generation can fall by roughly 15% over a month, depending on the time of year.".[2] Since the effects of extreme weather, especially for new module component technology, are insufficiently tested; it could give way to unexpected early degradation of solar sites.

To counter these and other challenges, more and more solar companies have adopted modern technologies such as drone-based data collection and digital software solutions. The aim is to increase quality, improve labour efficiency and, most importantly, reduce risk to solar assets posed by lack of adequate construction oversight and module degradation. We are one of the companies tackling these challenges, Above is a U.K. aerial inspection and data analytics specialist.

The first step to ensure high-quality built assets is to perform aerial topographic mapping, a combined aerial and ground-based data collection approach. The level of detail and quality of the data collected with this approach is the baseline for a high-quality PV layout design. Often developers make the mistake of basing their solar plant's design on traditional ground surveying methodology with lower granularity or, even worse, on satellite data. With this approach, they sacrifice better yield estimations and make the project vulnerable to unforeseen challenges during construction.

The next step after aerial topographic mapping is to employ drone and software-based construction management to diligently monitor construction progress. Drone-based data collection is very efficient, covering 100+ hectares daily, which is valuable for large projects. For instance, the previously mentioned 800 megawatt-peak (MWp) solar plant built in Al Kharsaah, equipped with 2 million bifacial solar modules with trackers, has been built on over 1000 hectares of land.[3] The construction progress data provides a detailed overview of the site that, otherwise, cannot be achieved from the ground. Automatic image recognition makes it possible to quantify the progress down to the number of modules placed. Any deviations from the construction CAD during the build are quickly identified, reducing quality risks.

Together with our MENA-based drone partner, Flyby Guys, we conduct detailed drone scans throughout the project, frequently aligning the drone scans with critical milestones. The drones are equipped with sensors and high-definition cameras to capture a highly accurate and detailed image of the solar plant construction site. Our in-house software is used to digitally place the images over the solar plant construction drawings, showing how the construction progress compares to the construction plan. Users can assess the progress, track it against milestones, record design deviations, and share project information with stakeholders. Each time new data is collected and processed into an orthomosaic, it appears as a new layer within the platform.

[1] https://iea.blob.core.windows.net/assets/5ae32253-7409-4f9a-a91d-1493ffb9777a/Renewables2021-Analysisandforecastto2026.pdf
[2] https://www.pv-tech.org/what-does-it-take-to-build-and-maintain-solar-in-menas-harsher-climes/

12. Drones for PV Inspection

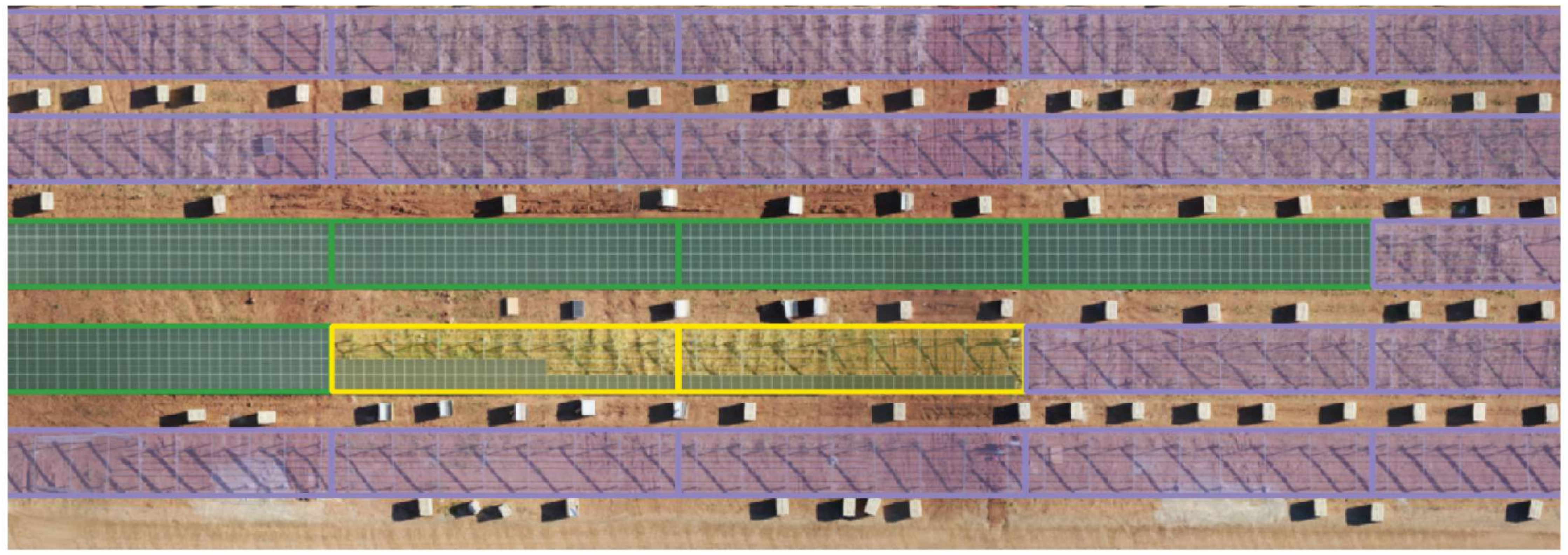


Figure 1: Orthomosaic of construction progress overlayed with construction CAD, wide view.

Having successfully monitored the project's complete construction, commissioning is the final step before the solar asset switches into operational life. At this stage, there are several other opportunities to employ drone and software-based data collection and analytics. This approach gives a quick and complete understanding of the asset's health from the moment of its birth. Furthermore, the ability to collect location-specific serial numbers makes it possible to connect aerial thermographic data with, for instance, factory flash test information, EL tests or IV curve measurements.

With this approach of drone data and analytics software, once a solar plant project reaches the commissioning stage, the plant design has already been digitised, making it possible to oversee component degradation.

Experience in other regions, mainly early European markets, has shown that solar assets are not maintenance-free after being commissioned. The amount of revamping and repowering projects already happening gives an idea of the magnitude of issues created by low-quality build projects. It is yet to be seen if solar projects in the MENA region will change owners as quickly as many of the projects in Europe or the US. Indeed, a transparent approach, as outlined above, increases the value of projects during asset transfer. Even more important, though, applying a high-quality approach to solar projects will ensure that solar assets can live up to the expectations of a 30-to-40-year life span.

Figure 2: Orthomosaic of construction progress overlayed with construction CAD, close view.

[3] https://totalenergies.com/media/news/press-releases/total-develop-qatars-first-large-scale-800-mwp-solar-plant
https://solarquarter.com/2022/10/20/his-highness-the-amir-inaugurates-al-kharsaah-solar-pv-power-plant-in-qatar/

13. Agrivoltaics

EDITORIAL OVERVIEW: SOLAR FOR FARMING, FOOD PROCESSING AND AGRIVOLTIACS

Agriculture in desert regions is an energy intensive proposition. Primarily because of the scarcity of water. Water needs to be pumped from deep wells or great distances, and where no other potable water sources exist, it must be desalinated. If the farm is remotely located, which is very often the case, electricity generation and pumping are provided by diesel engines. Thus, the early pilot projects in the MENA[1 2] region provided solar PV solutions for water pumping and irrigation requirements.

In modern farming and food processing industries, energy is the key to several requirements in addition to water needs. Food processing industries, for example, require cooling and heat. Food processing industries with large roof spaces have adopted solar PV for their electricity needs for cooling equipment, thereby partially offsetting some of their needs. For processes such as sterilisation and pasteurisation, hot water and steam are required, which has the potential to be addressed with solar thermal solutions.

Agrivoltaics are specific solar applications that benefit from the dual use of land for agriculture and solar power. In such applications, the solar installation is not designed for the consumption of electricity by the agricultural activity alone but to generate surplus electricity. The solar panels act as shields while simultaneously generating electricity which can be sold to the electricity grid for additional revenue. With early piloting success stories in Europe and the US, it is now being applied to MENA regions where growing vegetables or plants shielded from the intense sun is a common practice.

With the advent of vertical and containerised farming, which uses water conserving technologies such as hydroponics, a lot of the energy demand is because of the LED lighting used in addition to the water circulation and supporting equipment that needs to be powered. The lack of stable low electricity prices and insufficient demand for the particular produce that can be grown in vertical farms makes vertical farming financially untenable[3] in other parts of the world. So, several vertical farm companies are considering opening or shifting their operations to the GCC region because of the growing demand and stable electricity prices. The needs of vertical and containerised farming differ from traditional agriculture and are more easily addressed by solar solutions. While containerised farms are not particularly defined as agrivoltaics, there is increasing potential for utilising the abundant surface area to install solar panels that generate sufficient electricity for self consumption and supply surplus to the electricity grid.

There is a mandate for food security in the MENA region, and recent disruptions in food supply chains and inflation have brought this to a sharper focus. Governments have therefore launched well-funded initiatives to encourage adopting new technologies that improve food production. Vertical farming and agrivoltaics are essential components of these new technologies and the future of food security for the region. Solar technology has excellent synergy with the requirements of farming and food production. One hopes that the forward momentum of this synergy will be the positive influence and a necessary impetus to propel solar for farming, food processing and agrivoltaics forward.

AGRIVOLTAICS IN MENA, THE LESSONS FROM SAUDI ARABIA

Ahmed Ashraf
Technical Sales Engineer
HAALA Energy

Agrivoltaics is the simultaneous use of land for different agricultural purposes and the installation of solar photovoltaic systems. In the past decade, the world has shifted to sustainable farming, and the coexistence of solar modules with crops or livestock has become a growing trend in the solar industry. The term "agrivoltaic" may have been used for the first time in a 2011 publication, but the concept was introduced in 1981 by Adolf Goetzberger and Armin Zastrow. In 2019, more authors started broadly using the term "agrivoltaics", including all sorts of agricultural activity among existing conventional solar systems. These activities included grazing sheep, installing beehives and powering nearby barns and sheds. A common misconception is that solar panels and crops compete for light, with the addition of solar at the detriment of the crops. The fact is, in some cases, crop yield increases due to the shade of the solar panels mitigating some of the stress on plants caused by high temperatures and UV damage.

In Boulder, Colorado, a family-owned farm that originally started as a simple local producer of hay and wheat has helped slowly transform the way the world looks at Agrivoltaics by integrating solar energy and agriculture under the name of Jack's Solar Garden. The Jack family saw an opportunity in 2019 and, through several partnerships with reputable institutions like the National Renewable Energy Laboratory (NREL) and multiple universities, has become a leader in the booming agrivoltaics industry. The farm is not only training locals and young farmers on agrivoltaic techniques and providing consulting services to anyone who wants to explore the benefits of agrivoltaics, but they have also conducted research studies with NREL that highlight the win-win situation of combining solar and agriculture in Arizona, and generally arid climates that are similar to conditions in much of the middle eastern region and Saudi Arabia.

Industry experts highlight the scenario where farmers and energy developers collaborate to preserve the agricultural character of their lands and make the most of agrivoltaics. In remote areas, it offers access to clean and reliable energy, lowers carbon emissions and could be used for cooling purposes and pumping water during the day. Integrating solar energy with an existing power system offers a sense of security against grid blackouts or any shortage in diesel supply. The resilience of agrivoltaics and its aesthetically pleasing features are great perks to farm owners looking for a sustainable approach to power their farms and a marketing opportunity to a sustainability-minded audience.

Saudi Arabia understands the pressing need to fight against climate change, so the Saudi government has made multiple commitments to achieving a green future in line with their Saudi vision 2030 and the Saudi Green initiative. Some of the main goals of this initiative are to restore natural greenery, plant billions of trees across the kingdom, rehabilitate 40 million hectares of land and reduce overall emissions. The kingdom is also hosting multiple non-profit research centres working on securing sustainable agricultural products for the people of Saudi Arabia. The concept of agrivoltaics goes hand in hand with these targets and is a low-cost, renewable, and resilient source of power, especially in remote areas.

In 2022, Saudi Arabia launched a food security action plan with an initial funding of $10 billion to tackle the global food supply crisis, and on the domestic side, the kingdom's agricultural sector grew by 7.8 percent compared to the previous year. Our team at HAALA Energy believes that integrating solar energy will further boost these numbers.

We are constantly trying to do our part in the food and agriculture sectors by installing off-grid solar systems to power remote chicken farms and greenhouses, but perhaps our biggest contribution to the agrivoltaics sector is our collaboration with the local Saudi startup, Mirai Solar. The King Abdullah University of Science and Technology (KAUST) spinoff developed a futuristic, foldable, flexible, and modular solar panel to cover greenhouses. These panels are referred to as PV shade screens, specifically designed for locations with high solar radiation levels and installed in greenhouses that require a controlled environment. We have installed these foldable panels at multiple sites across Saudi Arabia, integrating their technology with world-class monitoring systems that include a host of sensor technologies and, in the process, helped greenhouse owners generate electricity in a sustainable manner.

Hydroponic farming is also a growing trend in agriculture and could be easily paired with solar energy. Hydroponics is the science of growing plants without soil, with limited amounts of water and LED lighting that is tailored specifically to the energy needs of the plants. Saudi Arabia, which covers most of The Arabian Peninsula, has limited clean water resources and severe climatic conditions. Saudi's Ministry of Environment, Water and Agriculture is exploring the option of localised vertical-farming technologies and has allocated $27 million to develop them as part of its food security action plan. Our frequent collaborators at RedSea are setting a strong example of deploying solar energy systems to run Variable Frequency Drives (VFDs) for cooling fans and water pumps for a sustainable saltwater-based agriculture system. Their technology enables farmers to grow food and cool greenhouses using saltwater in larger quantities and better quality levels than traditional farming systems and our solar systems allows them to do this with clean and renewable energy.

References:

1 - First Solar, Al Watania Agricultural Co. Pilot Solar-Powered Irrigation Project - Zawya

2 - Abu Dhabi-based International Holding Company harnesses solar energy to power Egypt's agri production - Gulf Today

3 - Vertical Farming Has Found Its Fatal Flaw - WIRED

13. Agrivoltaics

14. Cryptomining by Solar Power

CRYPTO MINING THROUGH SOLAR POWER

Sana Ibrahim
Accounts team lead
سولارابيك SOLARABIC

Recently, There has been such a growing interest in cryptocurrency and you've probably heard about Bitcoin, Dash, Ethereum, and other types of cryptocurrencies.

The future is promising for crypto miners and enthusiasts. However, the topic of cryptocurrency mining and Energy consumption often comes up. This may leave you wondering, "what is crypto mining?", "is it really energy intensive ?" and "could cryptocurrency by Solar Energy solve this problem?"

What is Cryptocurrency?

Cryptocurrency is a digital currency that's bought and sold online. With no bills or coins, and it doesn't go through traditional financial institutions. Instead, they are operated in a completely decentralised system that uses blockchain technology.
In a more technical sense, cryptocurrency mining is a transactional process that involves cryptographic processes to solve equations through the use of computers and record data to a public record (ledger) known as a blockchain. There are entire networks of devices that are involved in crypto mining and that keep shared records via those blockchains.

Why Cryptocurrency Mining?

Cryptocurrencies are a growing area of interest for many technophiles and investors. Some, they're looking for another source of income. For others, it's about gaining greater financial freedom without governments or banks butting in.
Cryptocurrencies operate in a decentralised system with a blockchain, so there's no central authority, nor is there a centralised ledger. Unlike the traditional banking system, anybody can participate in the cryptocurrency system. You can send and receive payments without going through a central bank.

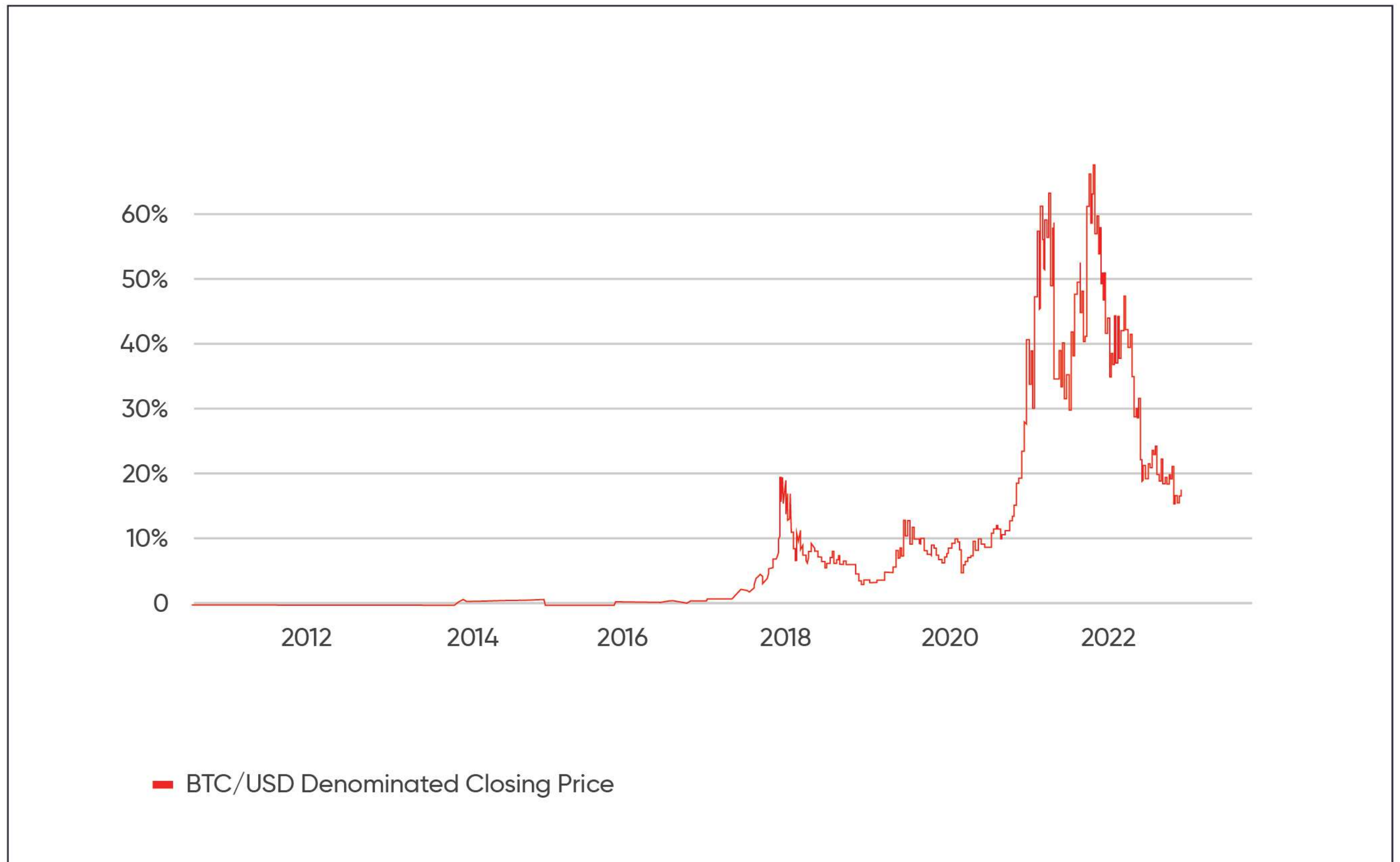


Figure 1: Denominated Closing Price in USD

14. Cryptomining by Solar Power

Leaders of the Mining Market

In January 2022, Kazakhstan ranked third (13%) in terms of the share of the hash rate of the largest cryptocurrency by capitalization Bitcoin after the USA and China. The transparency of financial payments is expected to contribute to the growth of the cryptocurrency market in the next few years. The growth of the market is also caused by the entry into the cryptocurrency industry of large companies. Asia-Pacific was the largest region in the cryptocurrency market in 2020. Analysts at ResearchAndMarkets.com expect the market to reach $2.73 billion by 2025 at a CAGR of 13.8% For example, the total earnings of bitcoin miners in 2021 reached $15 billion, an increase of 206% compared to 2020. At the end of December 2021 analysts of The Block Research reported about it.

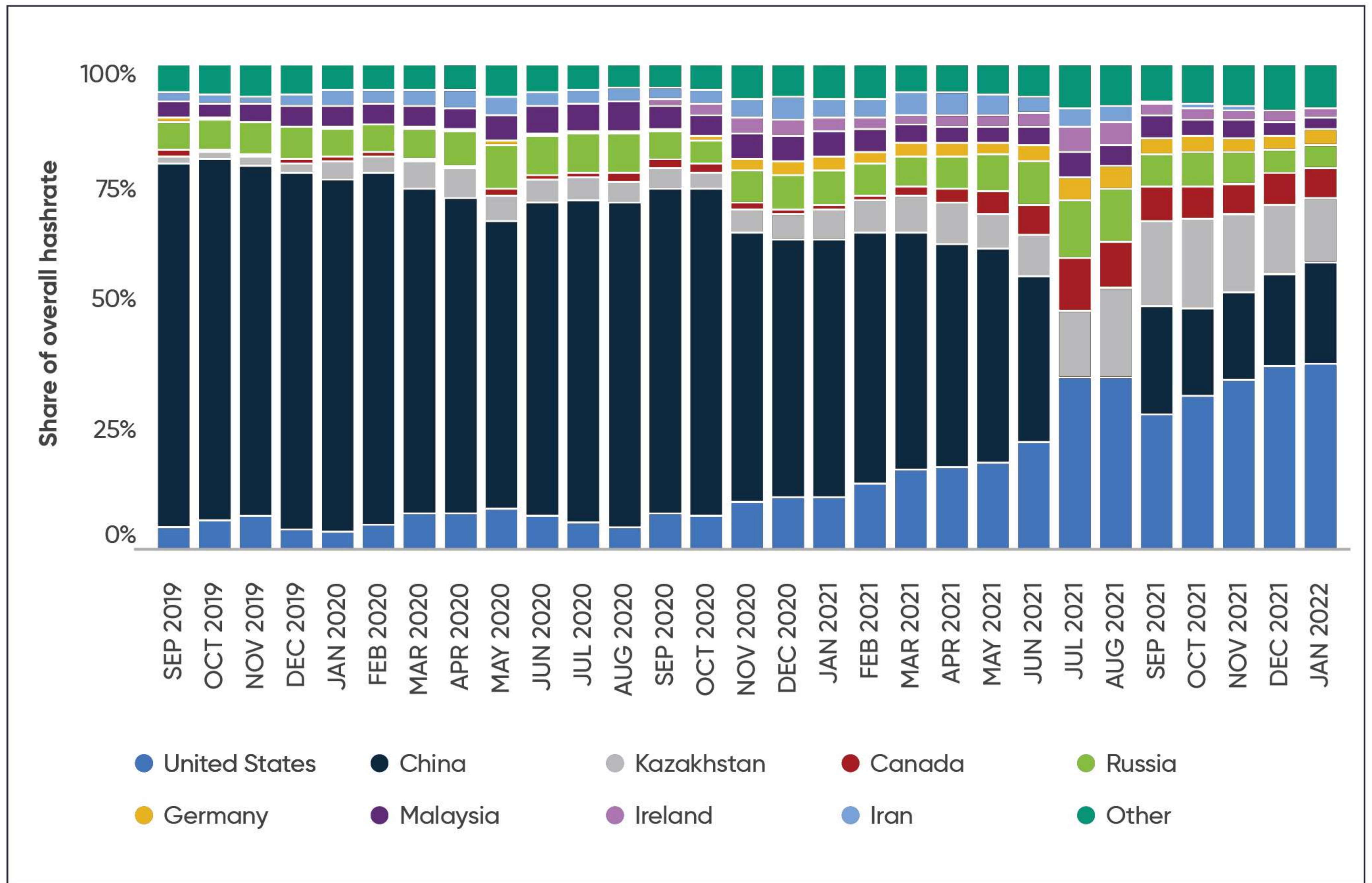


Figure 3: Shares of Overall Hash Rates by Country from September 2019 Until January 2022

Cryptocurrency Energy Consumption

The process of mining cryptocurrencies is associated with a huge number of monetary operations. And in addition to a one-time purchase, you have to regularly pay tidy sums for electricity. Crypto mining requires more and more energy due to the increasing difficulty of solving each operation and transaction made: In the process of verifying the transaction, the participating node solves complex mathematical problems and in return receives fixed rewards. These transaction fees and newly minted coins are the results of efforts that validators put to carry on the transaction.
Today, mining with just one device is almost impossible. Crypto enthusiasts use miners - special heavy-duty equipment. Suppose you will use AntMiner, which will work all year round 24/7, and will mine 1 BTC. This will require about 20,000 kWh of electricity. If you translate this into money, then one Bitcoin mined will cost you from 800 to 2200 dollars, depending on the potential energy costs.

Researchers claim that cryptocurrency mining is a serious enemy of energy saving and an additional competitor of many countries in the gas and coal market. The volume of energy consumption is enormous.

Researchers claim that cryptocurrency mining is a serious enemy of energy saving and an additional competitor of many countries in the gas and coal market. The volume of energy consumption is enormous.

14. Cryptomining by Solar Power

Some believe that cryptocurrency mining is a new boom industry, especially in places where real mining once dominated. But crypto mining is not physical mining, the hard work is done by computer processors, not people.

Bitcoin mining is also a very new and very unpredictable industry that, to put it mildly, has a rather unreliable track record in terms of enriching the communities around it.

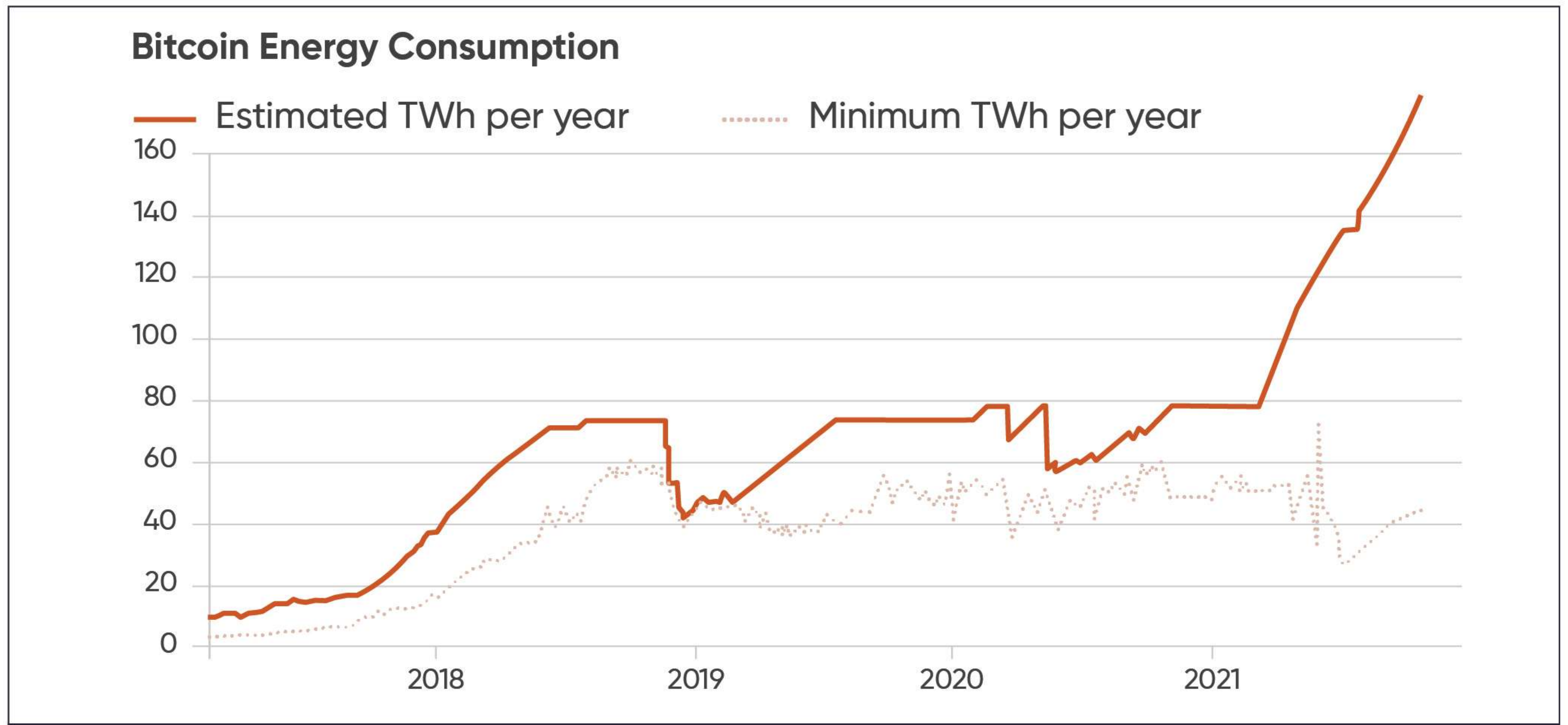


Figure 4: Bitcoin Energy Consumption from 2017 Until the End of 2021.

According to JPMorgan Chase & Co, the cost of Bitcoin mining has decreased from about $24,000 in early June to about $13,000 in mid-July 2022, which can be seen as a negative factor for pricing. On the other hand, the unpredictability of the crypto market and the price of electricity have significantly reduced the profitability of cryptocurrency mining. As a result, miners large and small are forced to turn to renewable energy sources such as solar panels to keep costs down.

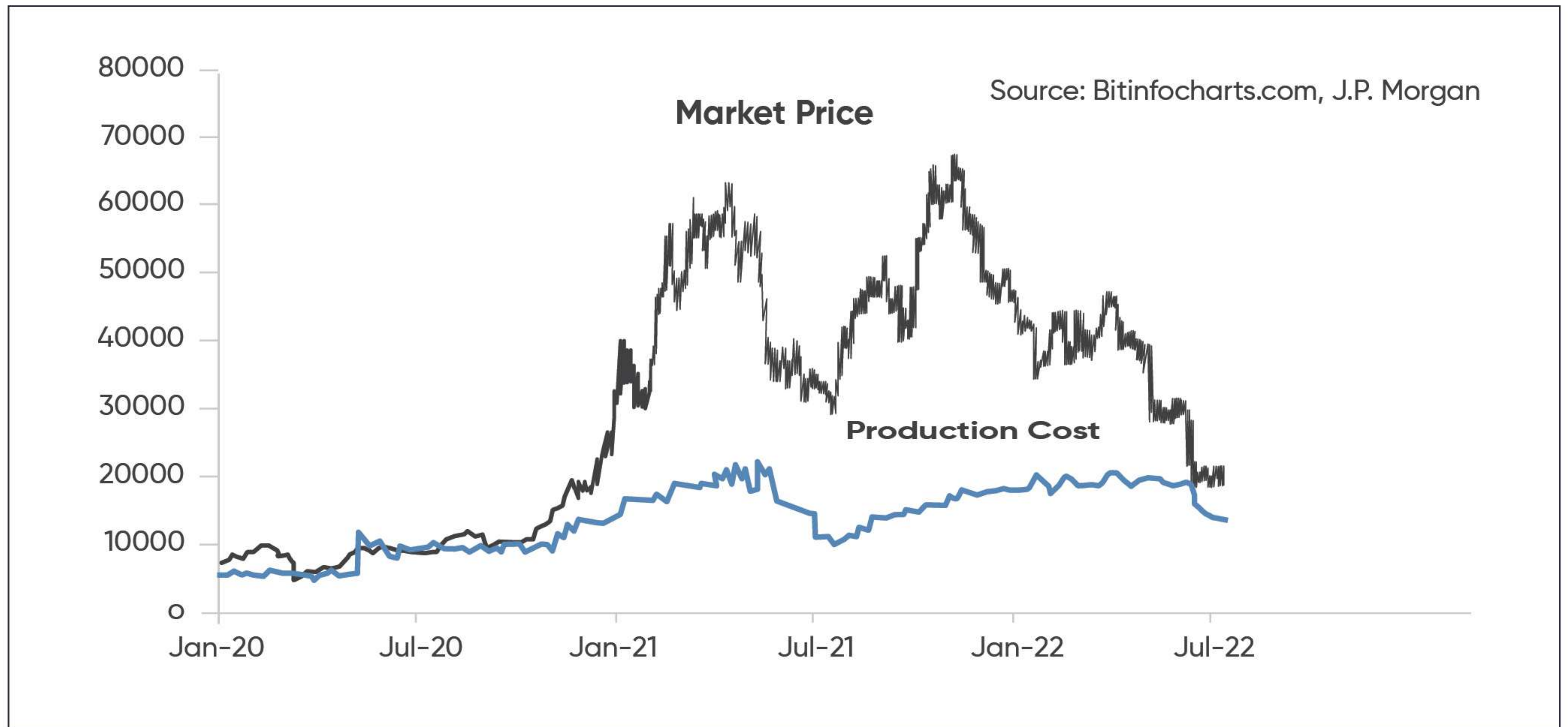


Figure 5: Bitcoin Market Price and Average of Cost of Production From January 2020 Until July 2022.

14. Cryptomining by Solar Power

Energy Consumption of Mining Cryptocurrencies

According to the University of Cambridge, the total annual energy consumption of Bitcoin mining is 175 TWh, which is about 0.32% of the total global energy consumption. Over the past five years, the energy cost of Bitcoin mining has increased from 11.8 to 120.5 TWh per year. This number will continue to grow – many experts predict that by 2027, electricity consumption for Bitcoin mining could rise to 706 TWh. Here's another startling statistic: Bitcoin consumes more electricity every year than Argentina. This raises many questions among environmentalists. In addition, the difficulty of mining is constantly growing, and miners are constantly forced to look for ways to make cryptocurrency mining more efficient.

Crypto Mining Affects the Climate

Crypto mining affects the climate as much as raising cattle or burning gasoline, scientists calculated in September 2022. For every $1 worth of bitcoin mined, the planet is damaged by an average of 35 cents. By comparison, burning $1 gasoline costs 41 cents and beef production costs 33 cents. Although bitcoin is referred to as "digital gold", in terms of climate damage, it is more like "digital oil", because. the climate damage from bitcoin mining is almost 9 times greater than from gold mining, the researchers conclude.

According to the Cambridge Center for Alternative Finance (CCAF), by January 2022, fossil fuels such as coal and natural gas accounted for almost two-thirds of all electricity consumed in bitcoin mining - over 62%. At the same time, clean energy sources accounted for 38% of BTC's energy balance.

According to the study, coal alone accounts for about 37% of total Bitcoin mining electricity consumption as of early 2022, making it the largest energy source for BTC mining. Among the renewable energy sources, hydropower has become the largest, with a share of about 15%.

For example, in mid-September 2021, economists from the central bank of the Netherlands, in collaboration with specialists from the Massachusetts Institute of Technology, found out that one bitcoin transaction leads to the formation of the same amount of electronic waste as recycling two iPhones. Although the carbon footprint of bitcoin has been well studied, less attention has been paid to the circulation of the computer equipment used in the operation of cryptocurrency. From year to year, the complexity of computing in the bitcoin network is growing; for cryptocurrency mining, it is necessary to use special ASIC devices that are produced only for these tasks. Since mining efficiency is achieved due to the technical characteristics of new chips, miners need to regularly update the equipment they use, utilising obsolete ones to install more productive solutions.

In addition to threats from malware, large-scale crypto mining poses an environmental risk. As the demands on hardware and computing power increase, so does the power consumption by farm-style mining processes. According to the same study, mining in China alone is expected to consume 297 terawatt-hours of electricity by 2024 and account for 130.5 million tons of CO2 emissions.

Green Mining

Cryptocurrency mining requires huge amounts of electricity and is becoming less profitable due to the downturn in the cryptocurrency market. To avoid the mining ban and continue to earn, miners are switching to "green" mining to get the cheapest energy possible.

Cryptocurrency miners have been trying to cut costs, especially since the advent of Bitcoin (BTC). Some use solar energy to run farms since the use of solar panels is becoming more and more economical compared to standard electricity.

That's why the trend toward green mining is becoming more and more distinct. Farms are using renewable energy sources. Many market players are engaged in industry research and are increasingly interested in using solar energy for mining. Some companies are driven not so much by financial interest as by the desire to raise awareness in society and show how cryptocurrency mining can catalyse the adoption of clean energy.

The Future of Crypto Mining and Solar Energy

A 24/7 computer consumes electricity, so almost half of the profit goes to paying bills. Thus, mining is energy-intensive and risky, but at the same time, it pays off quickly as an investment method.

Crypto miners claim that cryptocurrency mining presents an opportunity to accelerate the global energy transition to renewables by serving as a complementary technology for clean energy production and storage. More and more solutions appear for miners. Today, cryptocurrency farms are powered by renewable energy sources, produced by their photovoltaic plants.

By deploying more solar, crypto miners affirm that these generation technologies will likely fall even further down their respective cost curves, bringing them closer to zero

14. Cryptomining by Solar Power

marginal cost energy production. Especially since the majority of bitcoin mining takes place in large regions containing affordable renewable energy sources.

Developing renewable energy for an industry that only benefits a few is not an automatic task. This becomes even more difficult when you consider how difficult it is to sell large clean energy projects across one country at a time when we need to ramp them up to decarbonize entire industries that millions rely on.

The Use of Solar Energy

First, you need to calculate the power consumed by Asics and other mining equipment. Then find out what area of solar panels is suitable. It is also good to know the level of insolation in the region since on cloudy days the power of solar panels drops by 15-20 times. Secondly, you need auxiliary equipment - batteries, converters (inverters), controllers, and so on. All this will require initial investments, the payback of which in the conditions of the current market will be not two or three years.

Miners can enter into agreements with local power grids whereby, in exchange for electricity discounts, they agree to turn off mining farms during peak power consumption. At the same time, they can consume excess electricity generated by hydroelectric power plants, solar power plants, and wind turbines. Such an agreement helps to balance the industry.

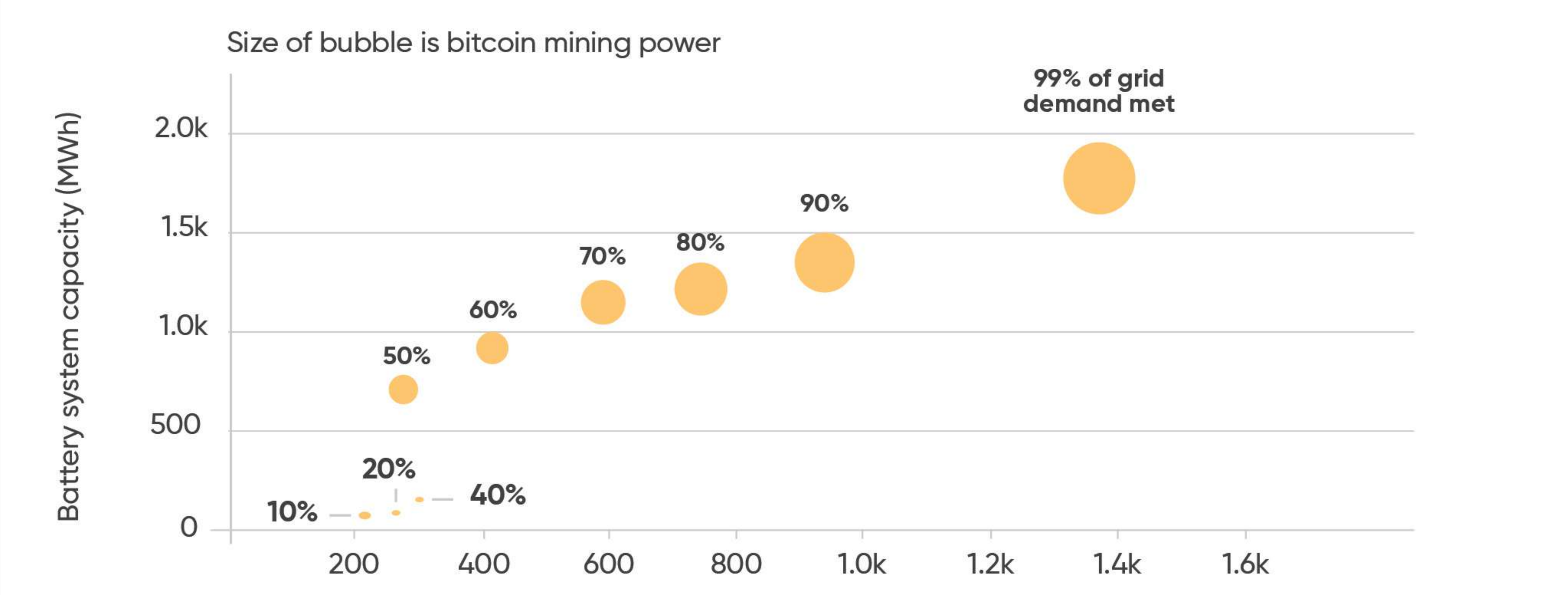


Figure 6: Size of Bubble in Bitcoin Mining Power

Example: the Profitability of Bitcoin Mining

In April, Square and ARK Invest released a white paper explaining how bitcoin mining can monetize excess solar energy during peak hours of sunshine. The paper focuses on the intermittent nature of renewable energy sources. The sun only shines for part of the day. The amount of light also varies depending on the season. This reduces the efficiency of solar panels. The researchers also point out that batteries are still extremely expensive and not efficient enough to store and transport excess energy. Because of this, a significant part of the energy generated by solar panels is lost.

To maximise income, miners must work 24/7. They lengthen the payback period of investments in green mining and negatively affect their profitability. The paper from Square and ARK Invest refers to an open-source model designed to serve as a proof of concept for integrating solar systems into bitcoin mining.

Today, a significant portion of the energy that crypto mining uses comes from renewable sources (57%). This includes hydroelectric power plants, wind and solar energy, nuclear and geothermal energy, and other forms of energy produced in an environmentally friendly way. With miners looking to minimise energy costs, green energy is currently the cheapest source of electricity in many countries, according to the World Economic Forum. Therefore, we expect that the share of "green" mining will also grow, which will bring important benefits to miners.

Conclusion

Green energy is the cheapest energy available today. In the context of a severe crisis and a drawdown in the cryptocurrency market, it is very important to reduce the cost of electricity for miners. Also, the mining difficulty changes every two weeks, potentially making the process more and more expensive for miners. The use of green electricity will significantly reduce costs.

15. Highlights In MENA's Leading Solar PV Markets

A. ALGERIA

Sofiane Bouaichaoui - Research Associate - CDER - Energy Consultant - ESOLARTEK

RE Target by 2035	RE Target by 2035	RE capacity 2021
15,000 MW	**35%**	**438,2 MW**

Source: IRENA & CEREFE

I. CURRENT SITUATION:

Algeria is moving steadily towards achieving its goal to increase the renewable energy share of the total energy mix to 35%, (around 15,000 MW) by 2035, from photovoltaic energy, solar thermal energy, and wind energy, in addition to cogeneration, biomass, and geothermal energy.

The country seeks to generate about 1,000 MW of solar energy annually, with the country having natural capabilities that qualify it to play a prominent role in the international renewable energy production market, in parallel with its essential role in the gas trade.

In 2021, The total capacity of renewable energy connected to the grid - without counting hydroelectric sources - was about 438.2 MW, which included 12 MW of new solar photovoltaic energy, in 2022, the government worked on adding about 59 MW of solar photovoltaic power plants. While the capacity of off-grid renewable energy reached 39 MW in 2022.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Financing and Developing Renewable Energy Projects Through the National Fund for Energy Control

The Ministry of Finance and The Ministry of Energy Transition and Renewable Energies issued a joint decision to support the development of renewable energies through the "National Fund for Energy Control and Renewable and Shared Energies.".

Develop and Accelerate the Digital Transformation in the Energy Sector in Algeria

Algeria Venture signed a partnership agreement with Schlumberger to develop and accelerate digital transformation in the energy sector in Algeria, In the presence of the Algerian Minister Delegate to the Prime Minister in charge of the knowledge economy and emerging institutions, Yassine El Mahdi Walid, the President of the Algerian-American Chamber of Commerce, Karim Ahmed, and a number of representatives of the US Embassy in Algeria.

III. PROJECTS:

Solar 1000 (1000 MW)

The Ministry of Energy Transition and Renewable Energies in Algeria opened the door for implementing the Solar1000 tender, which aims to build 1000 MW solar stations distributed throughout Algeria.

About Solar 1000 MW

The Solar 1000 project consists of several solar stations with capacities ranging from 50 to 300 MW, with a combined capacity of 1000 MW. The land area allocated to this big project reached 3000 hectares, and the Solar stations will be built in 10 locations. Five of them have been announced:

- Bechar
- Touggourt
- Ouargla
- El Oued
- Laghouat

Inauguration of a New PV Modules Factory in Algeria (180 mw)

Algerian holding Zergoun Green Energy has inaugurated a new photovoltaic modules factory in Ouargla in southern Algeria, with an annual production capacity of 200 MW. The factory will manufacture P-type solar module PERC M3 technology, with output power between 405 and 415 W. These products will be

15. Highlights In MENA's Leading Solar PV Markets

available in glass-backsheet or glass-glass versions as well as bifacial or monofacial panels.

At the beginning of 2023, it's expected to adopt the line production of solar cells to M10 and M12 sizes. The plant is already compatible with the TOPCon cell technology and is planned to succeed in the mono PERC tech within the next few years.

BRN2 10 MW

Sonatrach lays the foundation for the new photovoltaic station BRN2 10 MW, in the Bir Shamal area in the Berkine basin. It will be connected with BRN1 station, which was inaugurated in 2018, and will contribute to supplying the facilities of the North Well Field by generating an additional 10 MW.

Solar Lab

The Solar Lab aims to study various types of photovoltaic panels in an environment characterised by very high levels of solar radiation. It will also collect and study data in order to reach more efficient technologies in this field. In addition, the Solar Lab will be available for scientific research purposes in cooperation with public institutions and universities. It will contribute to the promotion and development of renewable energies in Algeria.

IV. CHALLENGES AND OUTLOOK

The availability of fossil fuels at reasonable prices is considered one of the major obstacles to the development of renewable energy in Algeria, especially due to the low LCOE of fossil fuels compared to renewable energy.

According to the announced energy transition roadmap, Algeria planned to increase the share of renewable energy in the total generation to 35% by 2035. Yet, due to the increase in energy demand, with the national energy supply growing from 7% to 10% annually, and the need to reduce carbon emissions, there is an urgent need for an alternative plan with a greater emphasis on renewables energies, especially CST Technology. However, the challenges discussed must be addressed and resolved in order to speed up the process and meet the targets set.

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN ALGERIA

Sofiane Bouaichaoui
Research Associate - CDER
Energy Consultant - ESOLARTEK

"Algeria's energy transition roadmap, previously outlined to reach 30% renewable energy (RE) installed capacity by 2035, is more important than ever in light of the high demand for natural gas and electricity worldwide. In addition, the country's financial situation and policymakers' intentions make it necessary to accelerate the energy transition process for both beneficial and technological reasons. The annual national energy supply is growing at a rate of 7-10%, and the needs of our neighbours and EU countries require the development of an alternative plan that focuses more on renewable energy sources like PV, wind, CST, and hydrogen technology.

As a result, the Algerian energy sector will see significant growth in human resources, R&D and infrastructure requirements for facilitating the growth in wind farms and solar power plants and even cleaner fossil fuels like natural gas. Don't miss out on the opportunity to participate in this exciting and necessary development!"

15. Highlights In MENA's Leading Solar PV Markets

B. BAHRAIN

Ebrahim Ahmed Radhi - Co-Founder & Board Member - Green Innova

Total Power Capacity (2020)	RE target by 2025	RE target by 2035	RE installed capacity (2020)
8,781 MW	250 MW	710 MW	10 MW

Source: IRENA

I. CURRENT SITUATION:

Bahrain started working early on developing the renewable energy sector, as it commissioned its first project in the country ten years ago, the pioneering 5MW Project by Bahrain Petroleum Company (Bapco). Bahrain initially set a goal to increase the renewable energy share of the total energy mix to 5%, (around 250 MW) by 2025, and to 10% by (around 710 MW) by 2035. In addition, during COP 26, Bahrain pledged to double its targets to reach 10% by 2025, and 20% by 2035.

Bahrain's proposed renewable energy pipeline consists of solar energy, wind energy, and waste-to-energy technologies, and it is expected that solar energy will constitute the largest part of this percentage due to the geographical location and the climatic conditions of Bahrain. The year 2023 shall reveal projects in shopping malls, hospitals, universities, factories, and others. This progress is attributed to the establishment of required legislation, and the local presence of regional developers, qualified local EPCs, and world-class manufacturers of solar system components.

Bahrain is working diligently to ensure sustainability conditions in all infrastructure updates and new buildings. Green buildings codes, waste management, conversion into energy, waste recycling, and the use of clean energy are being widely implemented especially in the commercial and industrial sectors.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Bahrain has had renewable energy legislation since 2017, under the National Renewable Energy Action Plan, outlining many initiatives to accelerate the deployment of renewable energies across many sectors. The legislation had three main policies for Net Metering (started), Feed-in Tariffs, and Renewable Energy Mandate for New Buildings (Yet to be implemented).

Platform for Hydrogen Studies

Bahrain Petroleum Company (Bapco) and Aluminum Bahrain (Alba), the world's largest Aluminum smelter outside of China, signed a Memorandum of Understanding to share knowledge and collaborate on implementing Environment, Social and Governance ESG initiatives of common interest. The MoU will set the platform for conducting a feasibility study on utilizing current and any future developments on surplus hydrogen to be made available from Bapco to Alba.

III. PROJECTS:

100 MW Tender

Bahrain's Electricity and Water Authority (EWA) launched its tendering process to appoint a qualified contractor to remediate a two square kilometre landfill site to prepare for the development and implementation of a solar project with a minimum capacity of 100 MW. The landfill site is located at Askar, in the Southern Governorate of Bahrain.

72 MW Tender

Bahrain's Ministry of Electricity and Water Affairs launched a 72 MW rooftop and ground-mount PV project tender in the Sakhir region. The tender is open to both local and international bidders.

15. Highlights In MENA's Leading Solar PV Markets

1 MW Power Purchase Agreement

Solartecc Green Energy Factory and Green Innova as EPC implemented a 1 MW project for American Mission Hospital (AMH) in its two locations in Saar and Al Ali, making it one of the leading hospitals to adopt sustainability and renewable energy.

2.3 MW Power Purchase Agreement

Yellow Door Energy signed a Power Purchase Agreement with the Mondelez Bahrain Biscuits to install a photovoltaic station on the roofs of the factory with a capacity of 2.3 MW.

IV. CHALLENGES AND OUTLOOK

Bahrain has set the goal of net zero carbon emissions by 2060. To achieve this target, massive deployment of solar systems in the governmental premises is needed including ministries and governmental companies, which started with the 72MW tender.

Adapting renewable energy in the residential sector requires further focus. This sector is subsidised by the government, and the tariffs are low; thus, the incentive for the end user to switch to renewable energy is insufficient. Innovative subsidisation is needed to unlock the potential for the broader deployment of solar energy in the residential sector.

For the industrial sector, which relies heavily on natural gas in electrical generation, the way forward for decarbonising needs cutting-edge technologies along with solar energy, which includes the implementation of Energy Efficiency initiatives, development of green hydrogen, and deployment of carbon capture technologies.

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN BAHRAIN

Ebrahim Ahmed Radhi
Co-Founder & Board Member
Green Innova

"Bahrain has recently launched a 72 MW solar tender as part of its efforts to increase the use of renewable energy in the country. Originally, Bahrain's target was to have 5% of its energy mix be renewable by 2025, but this goal was doubled to 10% at COP 26. The government is also working towards achieving net zero carbon emissions by 2060, which includes the construction of five new cities with a focus on sustainability, including solar energy.

The Ministry of Electricity and Water Authority has implemented innovative policies, such as an open-cap net metering policy, to support the deployment of solar energy in Bahrain. The country has seen a significant increase in solar PV capacity over the past 8 years, and to continue this progress, there needs to be a shift in mindset from consumers to prosumers. This can be achieved through the development of green skills, as well as the expediting of laws such as feed-in tariffs and mandatory energy mix targets for establishments."

Courtesy: Hassan Allam - Egypt - SUNGROW

15. Highlights In MENA's Leading Solar PV Markets

C. EGYPT

Abdelhamid Sallam - Energy Expert - Infinity Solar

RE capacity by 2022	RE share in electricity generation by 2022	RE target by 2035
8,778 MW	**14.4%**	**50%**

Source: IRENA & ITA (US)

I. CURRENT SITUATION:

At the beginning of 2022, Egypt announced plans to add about 10,000 MW to the national electricity mix by the end of 2023. This comes within the framework of Egypt's plans to increase the share of renewable energy in the electric energy mix to 50% by 2035.

The share of renewables in electricity generation in Egypt increased from 8.7 GWh in 2019-2020 to 10.2 GWh during 2020-2021, an increase of 17.2%. By 2022, the share of renewables in electricity generation, which includes solar energy, wind energy, and hydro-power, reached 20% of the total energy mix, distributed as follows (See Figure C):

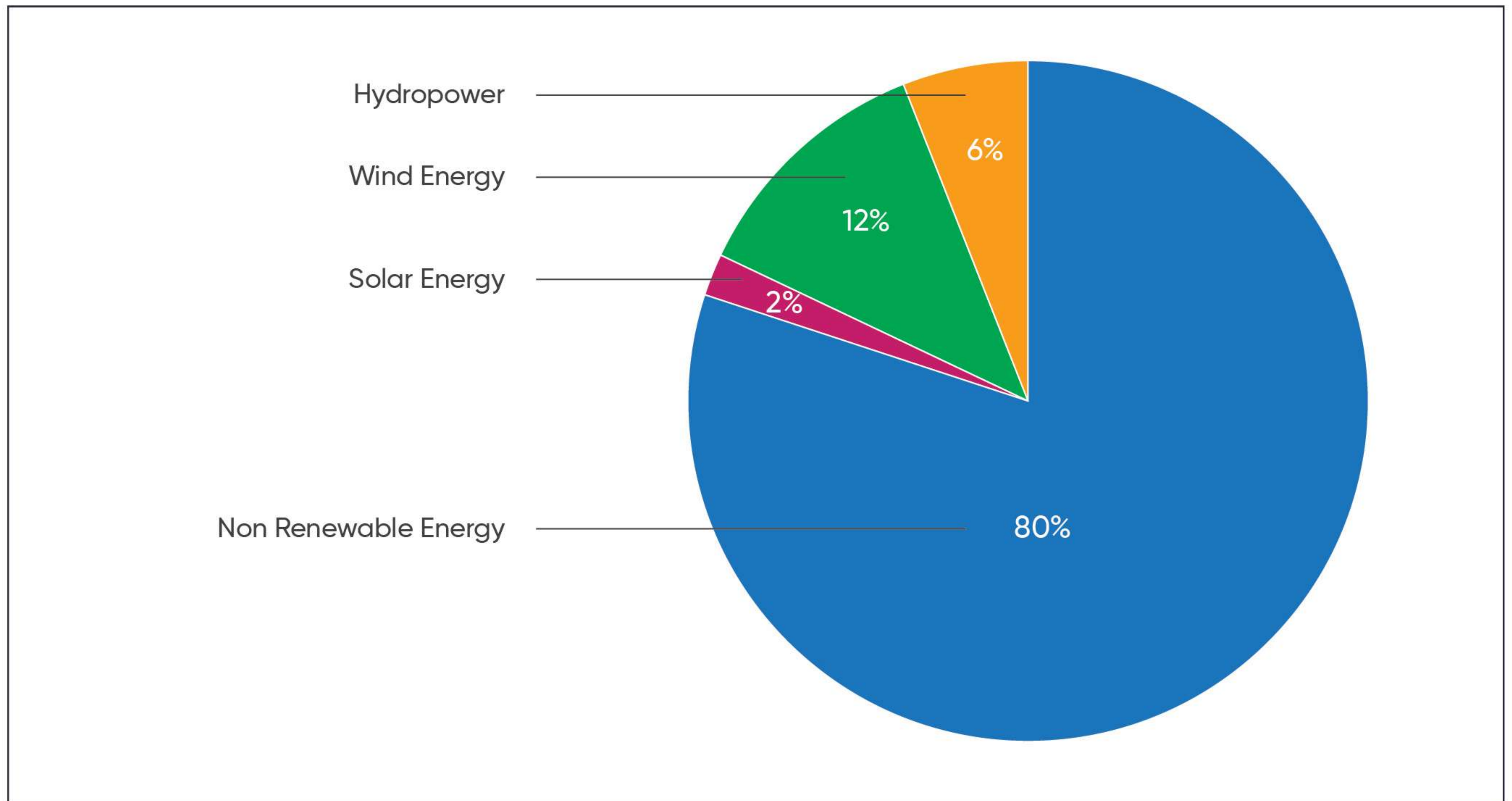


Figure C: The Share of RE in Electricity Generation by 2023

The majority of this renewable energy growth is expected to come through independent power producer (IPP) contracts. The net-metering scheme is also expected to support the expansion of distributed PV, particularly large utility-scale projects for onsite consumption in the agriculture, cement, and commercial sectors. (*)

*IEA

15. Highlights In MENA's Leading Solar PV Markets

II. UPDATES ON REGULATIONS AND FRAMEWORKS

On the occasion of Egypt's hosting of the Climate Conference in Sharm El-Sheikh and within the framework of the implementation of the Arab Republic of Egypt and its aim to transform the city of Sharm El-Sheikh into a green city, it was decided to amend the periodic book of the Electricity Utility Authority for the following items:

1 - Raising the limit of capacities allowed for contracting, from 300 MW to 1000 MW inside the Arab Republic of Egypt.

2 -Projects contracted under the net metering system, with a capacity of 1000 kW are exempt from the integration fee, an increase from 500 kW, as per the previous version of the periodic book. This exemption applies to self-sufficiency projects.

Fees for Connecting Photovoltaic Systems to the Electrical Grid

In February 2022, The Electricity Utility and Consumer Protection Regulatory Agency set an integration fee for connecting photovoltaic systems to the electrical grid.

III. PROJECTS:

1. "Masdar", "Infinity Power" and "Hassan Allam Utilities" signed a cooperation agreement to establish a 10 GW wind energy project in Egypt.
2. ACWA Power signed a memorandum of understanding with the Egyptian New & Renewable Energy Authority "NREA" and the Egyptian Electricity Transmission Company to implement a 10 GW wind energy project in Egypt.
3. Karm Solar obtains EGP 47m bank financing for the first storage PPA project in Egypt.
4. The EBRD is increasing its equity stake in Infinity, Egypt's leading renewable energy developer, through an additional US$ 41.5 million commitment. The EBRD is a current shareholder in the company, having invested US$ 60 million in 2020.
5. The New & Renewable Energy Authority (NREA) issued A tender for the establishment of a solar power plant with a capacity of 20 MW and a 30 MWh storage system that will be conducted according to the applicable Guidelines for JICA.
6. Commissioning a solar power plant on the roof of the Jushi factory, with a production capacity of 10 GWh annually.
7. The Saudi company Triple M seeks to participate in renewable energy projects in Egypt with a capacity of 1,500 MW.
8. Agreement between ACWA Power and Hassan Allam Holding Company to develop and build a wind power project with a total of 1.1 GW at the cost of US$1.5 billion
9. The European Bank for Reconstruction and Development EBRD announced it would invest US$100 million in green bonds issued by Scatec to refinance six of its solar plants.
10. Hassan Allam Utilities Company develops a 5MW solar plant in Sharm El Sheikh.
11. Gila-AlTawakol Electric & GTCI Company develops a 5MW solar plant in Sharm El Sheikh.
12. Infinity power Company develops a 6MW solar plant in Sharm El Sheikh.
13. TAQA Arabia launches 20 MW solar plant in Sharm El Sheikh.
14. Electrolux and SolarizEgypt join forces to build solar power plants.
15. Infinity Power has partnered with Saint-Gobain Glass Egypt to power their float glass line in Ain Sokhna with Infinity Power's sustainable energy solutions, producing up to 9,875 MWh of electricity per year and reducing up to 5,324 tons of carbon emissions each year.
16. Juhayna Food Industries Company signed a contract with KarmSolar Solar Energy Company to establish a hybrid central plant to generate and sell energy using solar panels, diesel generators, and industrial batteries at the Enmaa farm in the Abu Minqar area in the New Valley, with a production capacity of 8.3 MW for solar energy, 10.8 MW for diesel, and 27.5 MWh battery storage system.
17. Signing a contract for the construction of the largest integrated industrial complex for the production of methanol and ammonia in the industrial zone of Ain Sukhna in Suez, at a value of US$ 2.6 billion.
18. LONGi Solar signed a distribution agreement with Maryzad, one of the leading players in the Egyptian distribution market. The signing ceremony was held at Cairo's Marriott hotel with the attendance of more than 70 guests.

15. Highlights In MENA's Leading Solar PV Markets

D. IRAN

Mohammad Parhamfar - Consultant in Power and Renewable Energy
Behrouz Adelshahian - Commercial Manager - Rahsun

RE installed capacity by 2022	RE share in electricity generation by 2022	RE target by 2026
1,000 MW	**1.1%**	**2.5 GW by 2026**

Source: Iranian Ministry of Energy

I. CURRENT SITUATION:

By the end of 2022, the total renewable capacity installed in Iran will reach approximately 1 GW. However, the share of renewables in electricity generation is only 1.1%. In its 7th national development plan, Iran's thirteenth government aims to increase the renewable capacity to 10 GW or which 4 MW will come from solar power plants.

Currently, 974.1 MW of renewable energy is installed, and 519.12 MW of it is supplied by solar energy plants.

Qazvin, Fars, and Kerman are leading provinces in terms of renewable energy plants, with respective capacities of 169.6, 92.5, and 89.5 MW.

Electricity produced from renewable energy sources	8,887 Million KWH
Saving fossil fuel consumption	2,506 equivalent to million cubic meters of natural gas
Saving Water	1,955 Million Litter
Preventing greenhouse gas emissions (CO_2)	5,787 thousand tons

Table 1: Renewable energy Market until 21 October 2022

In 2022, a total of 95,969 rooftop solar projects were installed in offices, commercial and residential complexes, with a total capacity of 8.291 MW.

However, only 0.6% of the newly added electrical generation stations were from renewable energy.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Utility-Scale Solar Energy Project Tenders

Initially, the government had permitted private companies to independently develop utility-scale solar projects by facilitating a suitable power purchase rate for electricity supply to the national electricity grid. Therefore, many companies signed PPA and installed solar plants. But recently, the government introduced new regulations stating that the installation of utility-scale solar plants should be done only through tenders organised by the government.

Feed-in-Tariff

The primary mechanism to promote renewables in Iran for all types of renewable power plants was Feed-in-Tariff (FiT). In this system, the small-scale systems, which are usually installed for the residential and C&I sectors, have higher incentives, and the power purchase rate is greater than others. The FiT is often updated by the ministry of energy (MoE) as the inflation in Iran increases to keep the payback and NPV of the projects suitable. The power is purchased under guaranteed FiTs for 20 years, and the base rate is adjusted regularly within the contract period.

The last MoE announcement for the solar systems is as follows:

Solar PV Systems	Feed in Tariff
5 kWp rooftop systems (Only for poor and deprived people)	0.064 $/kWh
Capacity of 20 kWp and less	0.051 $/kWh
Capacity of 20 kWp to 200 kWp	0.048 $/kWh

15. Highlights In MENA's Leading Solar PV Markets

Blue and Green Hydrogen

Blue Hydrogen is already produced and used in some chemical industries in Iran, which is also developing some plans and programs for green hydrogen.

The Renewable Energy and Energy Efficiency Organization of Iran (SATBA) works on developing hydrogen regulations. Also, some studies have been devoted to the introduction of Iran as an energy hub in the region, which will be possible upon the lifting of sanctions

Cryptocurrency and Mining

SATBA has provided a new regulation for Bitcoins Mining and Generate the power for Bitcoins farms from renewable energy sources.

III. PROJECTS UPDATE IN 2022

5 MW Solar Rooftop Systems

As the government has focused on enabling the residential sector, 1000 units of 5 kWp solar systems were installed in 2022. This plan will continue in the next years till a total of 10,000 systems are installed. Another positive point of this plan is that a remarkably generous loan is also offered to the homeowners for the initial costs of the system.

50 MW Large-Scale Projects

Due to the power shortages last summer and government pressure on large industries to shut down their production lines, the ministry of energy pushed them to construct solar power plants to compensate for their lack of electricity in summertime. In response, many industries started to build solar farms. The construction of five power plants, each 10 MW in size, has started this year, mainly by mining companies. Many of these power plants are expected to install bifacial PV modules.

15. Highlights In MENA's Leading Solar PV Markets

IV. CHALLENGES AND OUTLOOK

The structure of the electricity network in Iran should be appropriately modified to facilitate the development of renewable energies. At the moment, there is significant potential for the development of solar power plants. According to the grid connection studies, suitable lands are selected and ready to be handed over to investors. No legal framework for energy storage and large-scale batteries exists yet, which requires further investigation. Despite the presence of knowledgeable experts and enthusiastic investors in Iran, the biggest challenge in the development of renewable energy is the imposed sanctions and the inflation rate, which sometimes makes solar projects unattractive to investors, according to economic studies. Foreign companies are likely to invest due to suitable radiation and appropriate tariffs upon the resolution of the aforementioned market barriers.

There are two main barriers to speeding up the renewables in Iran. The first is the existence of generous subsidies to the energy and power sector. This means that the price of electricity is lower than its production cost, and this issue leads to low interest in investing in renewables. When the electricity prices increase more than the LCOE of renewables, the demand for renewable systems will naturally increase. The second are the sanctions against Iran causing inflation and price volatility, which in turn increases the capital cost of renewable power plants.

However, Iran has a very good solar radiation potential, and its climate conditions are better for solar than many countries, leading to better PV module performance. Moreover, a convenient grid structure is expanded all over the country that facilitates the grid connection of renewable power plants and exports electricity to neighbouring countries. The regulations and instructions have made the market ready for investors to enter and construct renewable power plants. Though considering a foreign investment, the government should issue payment guarantees to assure investors.

EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN IRAN

Mahdi Shakouri
Industrial energy efficiency and decarbonisation consultant

"Iran has a significant potential for solar energy due to its high irradiance levels but has yet to fully capitalise on this potential. Currently, Iran's installed capacity of renewable power plants (excluding hydropower) is 970 MW, which is just 1% of the total installed capacity. However, the Ministry of Energy has a target to reach 10 GW of renewable and clean power by 2025, including 7 GW of solar power plants and 3 GW of wind power plants. To support this goal, several legislative enablers exist, including power purchase agreements and a tendering process for the construction of renewable energy power plants.

A recent tender for the construction of 1.5 GW of solar power plants was held, with 12 companies named winners. The next stage of the tender, for 2.5 GW, will be held soon, followed by a tender for the remaining 6 GW. This expansion of renewable energy in Iran has the potential to reduce carbon emissions and create sustainable, green jobs in the solar power plant supply chain."

15. Highlights In MENA's Leading Solar PV Markets

E. IRAQ	Waleed K. AlHallaj - Head of Business Development - MENA - Amarenco Group	
Total power capacity (2020)	RE installed capacity	RE target by 2030
31,278 MW	2,490 MW	33%

Source: IRENA

I. CURRENT SITUATION:

Due to the continued absence of renewable energy legislation in Iraq, exact figures cannot be provided for the total capacity of installed renewable energy. Meanwhile, Iraq continues to suffer from the inability to meet the electricity demand and, consequently, an unstable electricity supply.

Iraq continues developing strategies to achieve energy security, reduce power production costs, and cut electricity imports, leading to the announcement of plans to develop utility-scale solar power plants with a total capacity of 12 GW to reach 33% of clean energy sources by 2030.

In general, the Iraqi market is promising and has enormous potential due to Iraq being blessed with ample solar radiation and the fact that Iraq is an industrialised country with high energy demand.

The announcement of the large utility projects by the Iraqi government is expected to drive growth, and it is on track to become one of the most important solar energy markets in MENA by 2030.

III. PROJECTS

755 MW Renewable Project

In 2022, the first round of the investment opportunity for a 755 MW renewable project was announced in seven locations in a reverse auction on the Ministry's website, and this will be followed by other rounds within the ministerial program to supply the national electric grid with a capacity of up to 2000 MW.

2 GW Renewable Project

In 2021, Iraq's Ministry of Electricity & National Investment Commission signed an agreement with Masdar to develop a 2GW renewable energy project. In 2022, there was progress it entered the advanced development stage.

The project will be implemented in two phases; the first phase includes five solar PV projects in five locations, Dhi Qar governorate (450 MW), Ramadi (100MW & 200MW), Mosul (100MW), and Amarah (100MW), and the second phase will deliver another 1GW in the future.

IV. CHALLENGES AND OUTLOOK

The solar energy market in Iraq faces a major bankability challenge, which affects the progress of large projects that were announced in previous years and the overall progression of the market. More work is required to remove these hurdles to growth.

The distributed generation market in Iraq depends almost entirely on diesel generators. Furthermore, there is an apparent price difference between the official subsidised diesel price of 450 Iraqi dinars per litter compared to the black market, which on occasion could be more than 200% higher. These factors are expected to drive growth in distributed solar (C&I and Residential) faster. It is expected to be one of the biggest drivers of the substantial expansion in distributed solar in the coming years.

15. Highlights In MENA's Leading Solar PV Markets

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN IRAQ

Waleed K. AlHallaj
Head of Business Development - MENA
Amarenco Group

"Even though Iraq has a high rate of electrification, it is obvious that the national grid has had issues with stability throughout the years. This has been a minor issue as fossil fuel is heavily subsidised, and diesel generators usually cover the shortages that vary from one area to another. Having an official diesel tariff of around 450 IQD (0.31$) per litter made it hard for renewables to compete over the years. During 2022 the black market (unsubsidised) tariff climbed to almost double the official tariff by the end of 2022, resulting in many commercial, industrial, and residential users looking for cheaper, more reliable, and sustainable sources of electricity.

Going over the official import-export data, we can see an obvious increase in the demand for solar photovoltaic panels, inverters, and other accessories in 2022; this growth is expected to continue in the coming years. Adding Photovoltaic to the existing diesel generators to reduce fuel consumption can have an ROI of over 20% at the current diesel prices.

The residential, commercial, and industrial momentum is being pushed by a government that is publicly promoting renewables by employing green funding programs through the central bank and signing major MOUs for giga-scale projects. I believe Iraq will be a significant market for renewables, especially solar PV, in 2023."

Courtesy: Noor Toubas - Palestine - SMA Solar Technology

15. Highlights In MENA's Leading Solar PV Markets

F. JORDAN

Abdalrhman Alqatawneh - General Manager - AQ Electric

RE share in electricity generation 2022	RE target by 2030	RE capacity (2022)
30%	**50%**	**2,526 MW**

Source: The Jordanian Ministry of Energy and Mineral Resources.

I. CURRENT SITUATION:

In 2022, Jordan made significant progress in increasing the share of renewables in its electricity generation, with a figure of 30% compared to 26% at the end of 2021. This was achieved through the installation of more than 52,000 renewable energy systems using wheeling and net-metering systems.

As a result of these efforts, Jordan currently ranks first in the Arab world in terms of the share of renewables (including solar and wind) in its electricity generation, with Morocco in second place and Egypt in third. The installed capacity is distributed among 1,498 MW from commercial projects under power purchase agreements (PPAs), which constitute 59% of the total installed capacity. 1,027 MW comes from renewable energy systems owned by subscribers to cover their consumption using net metering and wheeling systems, representing approximately 41% of the total installed capacity.

Jordan has ambitious plans to further increase the percentage of electricity generated from renewable energy sources, with a target of over 50% by 2030.

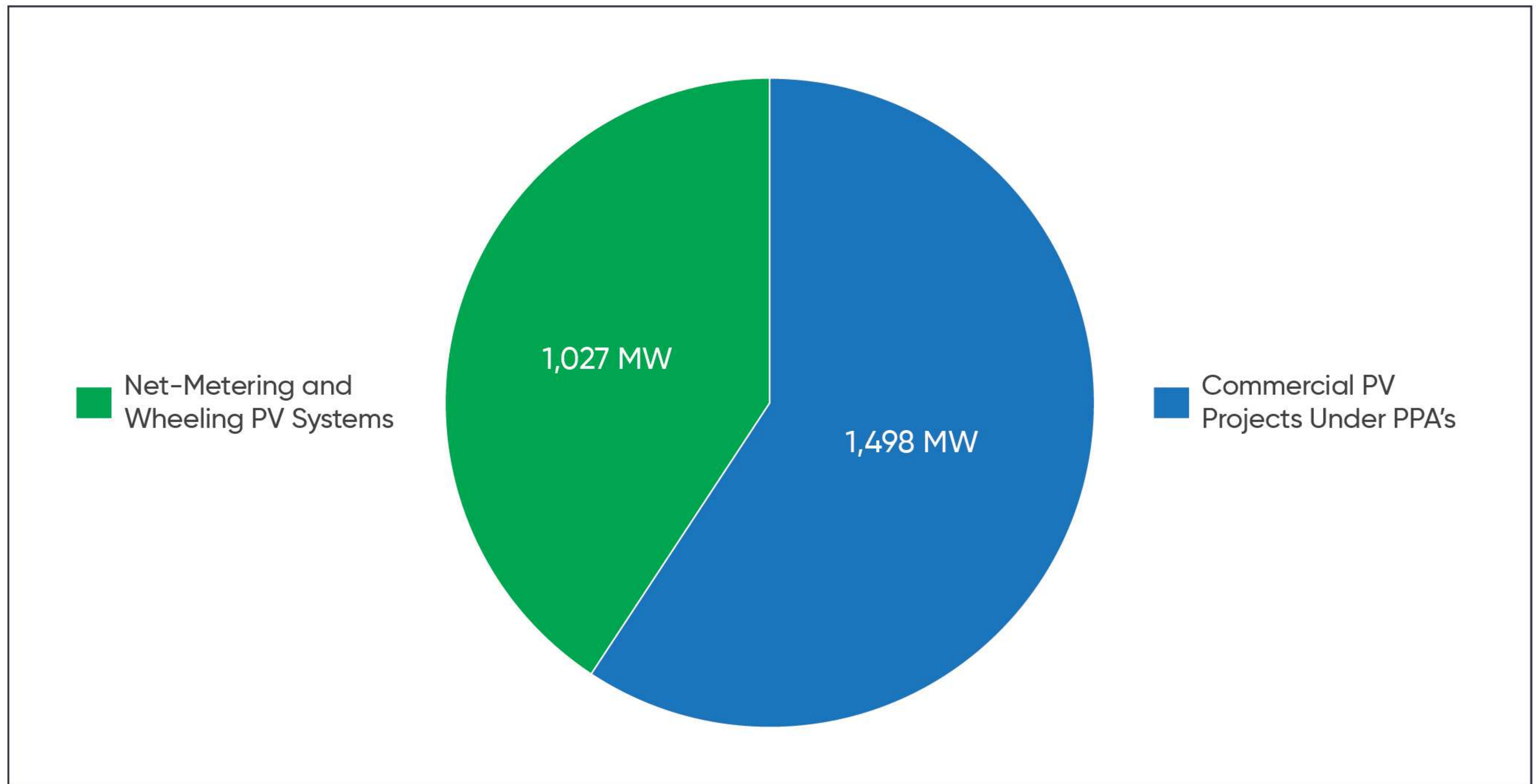


Figure F: RE Generation Capacity by 2023 Jordan

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Resume Granting Project Approvals for More than 1 MW.

In 2019, Jordan stopped granting permissions for renewable energy projects over 1 MW using wheeling or net-metering legislation. This was due to the Jordanian government's temporary halt on new tenders and projects for electricity generation from any source until studies by the Ministry of Energy and Mineral Resources were completed. By May 2022, Jordan agreed to set up renewable energy projects over 1 MW to serve new investors or expand existing consumption. The government has established a framework for these initiatives, which require investment in a new industrial project or expansion of an existing one. An energy performance evaluation of the proposed project or expansion must be submitted before it can begin with implementation expected in 2023.

Energy Storage Legislation

Jordan has started working on preparing legislation for energy storage systems, but that has yet to be issued, and is now expected in 2023.

National Climate Change Policy

The Council of Ministers has issued the Kingdom's National Climate Change Policy for the years 2022-2050, which aims to reduce greenhouse gas emissions in all sectors of the economy to contribute to the global effort to achieve climate stability.

Subsidising Programs for the PV Systems in the Rresidential Sector

The Ministry of Energy and JREEEF have resumed the second phase of their program to subsidise residential PV and heater systems installations. The program offers a 30% subsidy for solar systems and partners with various financing options in Jordan to cover the rest of the costs. This initiative promotes the use of renewable energy in the residential sector and aims to increase clean energy adoption in Jordan.

Energy Efficiency Subsidising Program for the Tourism sector

JREEEF is partnering with the Aqaba Special Economic Zone Authority to offer an energy efficiency subsidy program for hotels in Aqaba. This phase will provide $2.11 million in funding to 12 local small and medium hotels to implement energy-efficient solutions. JREEEF will also provide free technical assistance and oversight to ensure the full benefits of the interventions. The United Nations Development Programme (UNDP) is providing a grant of 100,000 dinars for energy audit studies and logistical and technical support. This initiative aims to promote energy-efficient practices and reduce carbon emissions in the tourism industry in Aqaba.

Launching "EPC of Solar Projects Guideline and O&M Best Practice Guideline"

On 22 November 2022, SolarPower Europe, together with EDAMA, the Jordanian Association for Energy, Water & Environment, and the Jordanian-German Energy Partnership launched guidelines for the engineering, procurement, and construction (EPC) of solar projects and Operation & Maintenance (O&M) Best Practice Guidelines.

Industrial Sector Subsidised Program

JREEEF launched the third phase of the program for the industrial sector at a total cost of 4 million dinars. The program offers several services, including

- Covering 50% of energy audit studies (up to 10,000 dinars) conducted by licensed energy auditing companies, the factories are divided into three categories based on the consumption of the industrial facilities.
- Providing comprehensive coverage of bank loan interests for five years (up to 350,000 dinars) through agreements with 12 commercial and Islamic banks.
- Covering 70% of the loan guarantee according to the agreement signed with the Jordan Loan Guarantee Corporation.
- Give technical support services throughout the project phases were provided by the JREEEF in collaboration with the Jordan Chamber of Industry.

III. ELECTRICAL CONNECTION PROJECTS

In order to achieve stability and support the commissioning of new renewable energy projects, Jordan needs electrical interconnections with other countries. These interconnections can provide a backup source of power during outages or disruptions, and also enable the trade of excess electricity to optimize power generation and improve sustainability. Electrical interconnections are essential for maintaining stable national electrical grids and promoting the adoption of clean energy.

15. Highlights In MENA's Leading Solar PV Markets

Jordan and Iraq

The Electrical Interconnection Project between Jordan and Iraq aims to enhance the stability of the electrical systems in both countries. The first phase includes a 330 km transmission line, transformers, and 150 MW of electricity to Iraq. The project will begin operating in 2023, initially providing power to western Iraq. Later phases aim to increase capacity to 500 MW and 900 MW.

Jordan and Palestine

As of July 2022, Jordan has increased its electrical exports to Palestine from 40 MW to 80 MW via the Al-Rama station.

IV. CHALLENGES AND OUTLOOK

Jordan has made significant strides in the development of its renewable energy sector, with the agreement in place to establish projects with a capacity of more than 1 MW after the suspension decision in 2019. However, there are challenges in the implementation of this decision.

As previously mentioned, according to the Ministry of Energy, the requirements for investment in the sector include the establishment of a new industrial project or the expansion of an existing one, as well as the submission of an energy performance evaluation study prior to the commencement of the project. These conditions can be difficult to meet, which can act as a barrier to entry for new investors and prevent existing investments from expanding to meet higher demand.

In order to effectively incorporate renewable energy systems into the electrical grid, it is necessary to strengthen the capacity and stability of the grid. There has been discussion about the government's plan to add storage systems to the grid by 2027, although no official confirmation has been given. It is important to continue exploring and implementing strategies to improve the capacity and stability of the grid in order to support the integration of renewable energy systems.

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN JORDAN

Mohammad Shehadeh
CCO
Philadelphia Solar

“Jordan has been making significant efforts to transition to a green economy. This includes the installation of solar and wind power, customs exemptions for electric vehicles, and issuing licenses for green hydrogen and E-Methane production. According to the Arab Future Energy Index (AFEX) for 2022, Jordan has the region's highest percentage of renewable energy (excluding hydropower), with a mix of 29% in its electricity.

To further increase the contribution of renewable energy in Jordan, it is important to continue expanding direct installation to the grid, especially with the support of storage solutions. Additionally, promoting the adoption of electric vehicles and increasing the use of green hydrogen and its by-products, such as green ammonia, can also help the country move towards a green economy. Regulation will be crucial in supporting this transition and should be regularly updated to incorporate new technologies.”

15. Highlights In MENA's Leading Solar PV Markets

G. LEBANON

Fadi Al-Makdessi - Technical Sales Manager - GoodWe Technologies Co. Ltd.

RE target by 2030	RE capacity target by 2030	RE capacity target by 2024
30%	3,000 MW	1.000 MW

Source: IRENA & The Lebanese Center for Energy Conservation.

I. CURRENT SITUATION:

Since the beginning of the economic crisis in Lebanon in 2019, inflation has skyrocketed, and the value of the currency has deteriorated. This has made the central bank stop subsidies on fuel imports. In parallel and due to the political sensitivity and the government's inability to increase energy prices, persistent power cuts continue daily in certain regions.

Unwilling to rely entirely on private generators, residential and industrial owners have opted for solar energy, and therefore, 2022 saw exponential growth in the solar PV and BESS segments.

The shares of renewables in electricity generation are expected to increase to 1,000 MW by the end of 2024 and reach 3,000 MW by 2030*, which would be a good step toward solving the electricity problems of Lebanon.

According to the last announced statistics in 2020, Lebanon's cumulative PV installation reached 93 MW. Lebanon plans to reach 30% of the total electricity generated by RE by 2030 and to reach 500 MW rooftop solar capacity and 2500 MW utility-solar capacity by 2030.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

The Distributed Renewable Energy Production Law

On the 23rd of March, 2022, the Distributed Renewable Energy Production Law was approved; it allows renewable energy generators to sell electricity directly to the end users, electricity distributors or other electricity suppliers through on-grid/off-grid PPA.

Granting Solar Energy Loans

The Lebanese Center for Energy Conservation - LCEC signed an MOI with the Housing Bank to support mechanisms for granting solar energy loans in Lebanon at the technical levels to contribute to the provision of sustainable electricity. On June 20, Housing Bank started providing solar energy loans, and the LCEC is responsible for organising and supporting mechanisms for granting these solar loans.

III. PROJECTS:

Public-Private PPA for 165 MW Solar Energy Projects

On 12th May 2022, the Council of Ministers awarded 11 licenses to several consortia to establish solar energy projects with a capacity of 165 MW at a bid price of \$0.057-\$0.0627/kWh in PPA. However, these projects are facing bankability challenges, making developers incapable of securing loans and start construction.

*Source:
Eng. Pierre El Khoury - head of the Lebanese Center for Energy Conservation.

15. Highlights In MENA's Leading Solar PV Markets

IV. CHALLENGES AND OUTLOOK

Challenges:

- Continuous deterioration of the Lebanese Lira makes it harder for people to import components and raw materials.
- Failing banking sector creates a challenging financial environment for developers and industrialists seeking to secure loans to invest in large solar projects.
- No accurate statistics or tracking of solar or renewable energy installations is available, which makes global suppliers, developers, and EPC companies reluctant to invest in the market.
- High CAPEX costs for residential owners due to the need for batteries to operate in off-grid mode.
- Low adoption of grid-feed as national grid energy is rarely provided.
- Lack of technical expertise and quality control causing many problems at installation levels.
- Extremely diversified and uncontrolled supply sources, causing the spread of fake brands with growing concerns about the inability to provide adequate after-sales services.

Outlook:

- Solar PV sector to continue its growth, mainly driven by diesel-hybrid applications.
- The market will further mature with the consolidation of EPC companies and installers together with the reduced number of component suppliers.
- Government to employ further regulations to ensure safe installations and maintain grid quality.

15. Highlights In MENA's Leading Solar PV Markets

H. MOROCCO

Sophia Hasnaoui - Business Development Manager - Yellow Door Energy

RE share in electricity generation by 2022 (excluding hydropower)	RE target by 2030	RE capacity by 2022
20%	52%	4,151 MW

Source: Moroccan Ministry of Energy.

I. CURRENT SITUATION:

The Moroccan government supports the country's strategy of transition to renewable and clean energy, by cancelling some subsidies directed at fossil fuels and taking necessary measures to reduce carbon emissions.

Morocco considers strengthening its energy sovereignty a national priority, seeking to enhance its progress in the development of renewable energy and working to support efforts to transition to a carbon-neutral economy to attract more domestic and foreign investments to the sector.

In 2022, Morocco managed to add 203 MW of renewable energy to the total electrical generation capacity. The share of renewables in the electricity generation capacity reached 20%, not including hydroelectric power. Electricity generation capacity from renewable sources reached 38% of total electricity generation capacity, amounting to 4,151 MW, with the distribution between the various renewable sources as follows;

- Hydroelectric power (1770 MW)
- Wind energy (1551 MW)
- Solar energy (830 MW)

Morocco is moving steadily toward reaching the share of renewables in electricity generation to 52% by 2030, and It's expected to add about 5,287 MW of renewable energy by 2026.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Self-Production Regulation

The Moroccan Parliament has unanimously approved Law No. 82.21, a draft law related to the self-production of electric energy, during a legislative session.

Energy Security Council

The Moroccan Ministry of Energy and Sustainable Development intends to establish an Energy Security Council to monitor the country's energy situation and energy sovereignty.

Carbon Tax

The Carbon border Adjustment Mechanism unveiled a legislative proposal expected to enter into force on January 2023. This measure would apply to imported projects and is expected to have significant consequences on a country like Morocco as the EU remains the most significant trade partner.

Wheeling Regulations

Moroccan businesses will finally be able to generate solar power on their premises or through wheeling since the Medium Voltage interconnection is finally now possible for developers. This long-awaited law came 12 years after Law 13-09, which enabled businesses to connect their renewable energy sources through high voltage connection only. The implementation of the regulation will definitely shape the Moroccan C&I market in the next couple of years.

III. PROJECTS:

34 MW

AMEA Power started the construction of a 34 MW solar plant with its partner, Green Power Morocco GPM, with an estimated annual production of 67 gigawatt-hours annually, which will be allocated exclusively to the company that provides sewage, drinking water, and electricity distribution services in Tangier Province.

15. Highlights In MENA's Leading Solar PV Markets

Smart-Grid

The US Trade and Development Agency USTDA plans to support the development of the first smart grid in Marrakesh which will be the first in Morocco.

Al-Kedia Al-Bayda station Expansion to 100 MW

The European Bank for Reconstruction and Development (EBRD), in cooperation with the Climate Technology Fund of the Climate Investment Fund (CIF), has announced the provision of loans to finance the renovation and expansion of the Kediat El-Baida wind energy project to reach 100 MW.

Noor Atlas (260 MW) EPC and O&M tender

The Moroccan Agency for Sustainable Energy (MASEN) issued a tender to select EPCs and O&M for the Noor Atlas project (260 MW). The Noor Atlas solar energy program consists of 7 sites in the south and east of Morocco. The program is divided into two groups:

The first group includes five photovoltaic stations, whose capacities are as follows:

- A 3 stations with a capacity of 42 MWs each, in Ain Bani Muthar, Injil, and Boudneeb.
- A station in Awtat Al-Haj with a capacity of 36 MW
- A station in Buanan with a capacity of 30 MW.

The second group of the program includes two solar photovoltaic plants with a capacity of 36 MW each in Tan-Tan and Tata.

Transfer renewable energy from Morocco to the United Kingdom

Octopus Energy signed a strategic financial partnership agreement with Xlinks, which is responsible for implementing the Morocco-UK Power Project, which aims to generate electricity from renewable energy in Morocco and transfer them to the United Kingdom via submarine cables within the framework of implementing the British strategy to enhance energy security in the country.

117 MW

The French company "Voltalia" won a contract to implement two solar photovoltaic projects with a total capacity of 117 MW in Morocco.

- Project in Ain Beni Mathar (69 MW)
- Project in Guercif (48 MW)

72 MW

AMEA Power wins the bid to develop two solar energy projects with a capacity of 72 MW in Morocco.

IV. CHALLENGES AND OUTLOOK

Morocco is expected to add 4.4 GW of renewable capacity between 2022 and 2027, with solar PV, wind, and hydropower leading the way. This growth will be driven by the government's competitive independent power producer (IPP) auction program, as well as corporate power purchase agreements (PPAs) supporting onshore wind development and state-owned projects and installations for the production of renewable hydrogen contributing to solar PV expansion.

This year's forecast for onshore wind is more optimistic than last year's due to the expansion of existing projects and the announcement of new corporate PPA projects. However, the forecast for concentrated solar power (CSP) has been revised downward due to increasing uncertainty regarding the government's plans for solar thermal. The last tender for a CSP project was opened in 2019, but the project has not yet been awarded.(*)

Courtesy: 21kW Solar Shade Sreen - Mirai Solar - Saudi Arabia - Haala Energy

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EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN MOROCCO

Fadwa Elatrach
Director of strategy & Development
Moroccan Agency for Energy Efficiency (AMEE)

"Morocco has made significant progress in transitioning to renewable energy in recent years, intending to produce 52% of its energy from renewable sources and increase energy efficiency by 20% by 2030. In order to achieve this, the country has been investing in renewables since 2009 and has established financial mechanisms to stimulate private sector involvement and support public-private partnerships. These efforts have helped Morocco become a leader in renewable energy and energy efficiency, and the country has been able to penetrate regional and international markets.

One of its standout achievements is the Nour Ouarzazate Solar Power Plant, the largest solar farm in the world. Morocco is also planning to use its abundant renewable resources to position itself as a global green hydrogen hub. To continue its progress in transitioning to green energy, Morocco must maintain its commitment to supporting current and future sustainable projects."

15. Highlights In MENA's Leading Solar PV Markets

I. OMAN

Maryam Ahmed Yousef Al Nofli - Faculty Member
at the University of Technology and Applied Science - Shinas

RE target by 2030	RE target by 2040	RE target by 2023
30%	**13,400 MW by 2040**	**11%**

Source: IRENA

I. CURRENT SITUATION:

The Sultanate of Oman is well-positioned to take advantage of renewable energy sources due to its favourable geography and climate. As part of its "Vision 2040" plan to become one of the top 40 developed countries, Oman has set a number of strategies to increase the share of renewable energy in its energy mix. The government has implemented a range of measures, including royal decrees, orders, directives, initiatives, regulations, and laws, to encourage the use of renewable energy in the country.

In line with the United Nations' energy transition goals, Oman is working to increase the percentage of renewable energy consumption and reduce its reliance on natural gas in electricity generation. By 2030, renewable energy is expected to account for 30% of the total energy demand on the main grid, helping to improve the environmental performance index. Renewable energy-based industries also have the potential to support the economic growth of the country, and the Ministry of Energy and Minerals is actively promoting projects such as solar independent power producer (IPP) projects, wind farms, waste-to-energy facilities, and green hydrogen projects. Foreign investors are also welcome to transfer technology, conduct research and development, sell equipment and services, and participate in the privatisation of government assets.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

The Law for the Regulation and Privatization of the Electricity and Related Water Sector, also known as the Sector Law, was established by Royal Decree 78/2004 and serves as the foundation for the rules governing renewable energy in the Sultanate of Oman. According to the Sector Law, the Authority for Public Services Regulation (APSR) is responsible for developing regulations related to the implementation of the government's renewable energy policies. The Omani Government, through the Oman Power and Water Procurement Company (OPWP), procures new capacity, including renewable energy, through a competitive process in which local and foreign developers and sponsors can participate.

The Ministry of Energy and Minerals (MEM) is responsible for developing the government's renewable energy strategy, which is then implemented by the APSR through legislation and the OPWP through tenders for renewable energy projects. As part of its Vision 2040 plan, Oman aims to reduce its reliance on oil and increase the use of natural and renewable resources. According to the OPWP, the predicted renewable energy mix for 2030 will be 21% solar energy, 6.5% wind power, and 2.5% waste energy.

The Authority for Electricity Regulation of Oman (AER) also conducted research on solar energy density in Oman in 2009, which found that the Sultanate has some of the highest levels of solar density in the world. The government is now working to capitalise on this resource to generate power in a more environmentally friendly manner.

Courtesy: Red Sea Project - Saudi - SUNPURE

15. Highlights In MENA's Leading Solar PV Markets

III. PROJECTS:

Ibri Solar Power Plant (500 MW)

In early 2022, the Sultanate of Oman inaugurated the largest clean energy production facility in the country. This facility, which has a capacity of 500 megawatts and an estimated investment cost of $403 million, is capable of providing electricity to 50,000 homes and reducing carbon dioxide emissions by 340,000 tons annually. The power plant, known as the Ibri 2 station, was built on an area of 13 million square meters and utilises approximately 1.5 million double-sided solar panels, over 7,000 kilometres of cables, and 1,812 robots for panel cleaning. This is the first project within the Sultanate's renewable energy program to be developed using the independent power producer (IPP) model, and it is also the first solar power station connected to the national grid in the Sultanate.

Manah 1 and 2 Solar Projects

The Oman Power and Water Procurement Company (OPWP) announced the launch of two solar energy projects in Oman called Manah Independent Power Stations 1 and 2, which would be built, owned, and operated by the private sector. Power Stations 1 and 2 will be built in two adjacent locations in Al Dakhiliyah Governorate, with a combined capacity of 500 MW. Commercial operations are scheduled to begin in the fourth quarter of 2023 and the first quarter of 2024, respectively.

17 Mw Pv Station to Operate a Water Desalination Plant

TotalEnergies and Veolia signed a cooperation agreement with the aim of starting the construction of the largest photovoltaic power plant dedicated to operating a water desalination plant in the Wilayat of Sur in the Sultanate of Oman, with a capacity of the solar plant of 17 MWp, to be the first project. And the largest of its kind in the region.

150 Mw Waste Power Plant

The Oman Environmental Services Company "Be'ah" signed a memorandum of cooperation with the Oman Power and Water Procurement Company to implement the energy-from-waste plant project.

The expected production capacity of the energy-from-waste plant is about 130 MW to 150 MW, as it will process 4,500 tons of municipal waste per day, and the construction cost of the project is $1 billion.

Receiving Requests for Technical Advisory Services for the Development of Ibri 3 (500 Mw)

The Oman Power and Water Procurement Company have received requests for technical advisory services for the development of the Ibri 3 Independent Solar Project with a capacity of 500 MW.

Courtesy: Nestle Waters - 1.4 MWp - Yellow Door Energy

15. Highlights In MENA's Leading Solar PV Markets

IV. CHALLENGES AND OUTLOOK

Despite progress in establishing renewable energy sources in the Sultanate of Oman, large-scale development faces numerous hurdles. Even though their importance varies from country to country, these problems can be put into four main categories: institutional, technological, cultural, and market-related. Among the most important challenges in the field of renewable energy (RE) in the Sultanate are the following:

- Reliable data and references are necessary for investment and financing agencies to approve RE projects.
- Despite falling conversion device prices, the relatively high cost of RE technologies in comparison to conventional energy is still evident. For example, the prices of solar cell panels decreased by half, but the costs of solar power plants are still much higher than those of conventional energy.
- To switch from using traditional energy sources to renewable energy to make electricity, the government has to give money, which is an extra burden on the government.
- The percentage of renewable energy contributions to the national energy mix has strategic and long-term implications.

Oman has a significant possibility of using RE, as solar, wind, biomass, and green hydrogen technologies can reach lower costs soon. The efficient application of these technologies would necessitate the development of a competent skill base and increase the level of skilled employment. It would help expand and diversify the economy, as well as the energy sources, in line with the goals of Oman Vision 2040.

15. Highlights In MENA's Leading Solar PV Markets

J. QATAR

Ammar Abdelghani - Managing Director -Javlin New Energy

RE target by 2030	RE capacity by the end of 2024	Total Power Capacity by 2021
20% from solar	**1.675 MW**	**10,614 MW**

Source: IRENA & Qatar Energy & Country Economy.

I. CURRENT SITUATION:

During COP26, Qatar has committed to reducing 25% of its greenhouse gas emissions by 2030, a commitment reaffirmed during COP27. To deliver on its promise, Qatar plans to announce another 2 GW solar plant in 2023 and another 1.4 GW in 2026, further reducing its reliance on natural gas for electricity generation. Having said that, it is worth mentioning that the country intends to build another recycling facilities to help in reducing greenhouse gas emissions emitted from landfill and generate roughly 1 GW of electricity. Finally, Qatar has begun exploratory discussions with international companies in order to assess the feasibility of adding hydrogen to the energy mix.

In April 2022, Qatar released its green building regulation, which outlines new requirements for new buildings to obtain a completion certificate. Sustainability and carbon reduction has been the core of this plan, stipulating that all new building must obtain design and built GSAS certification offered by GORD. This will require an extensive audit of the design and materials to be used and will take into consideration greenhouse gas emissions based on scopes 1, 2, and 3. Existing industrial and retail buildings are also required to obtain Operation GSAS certificates as a condition for renewing licenses.

The Football World Cup 2022 has showcased the determination of Qatar to deliver on its commitment. All stadium has received a 5-star design and built sustainability certificate, which is administered by GORD. Carbon reduction extended beyond the stadium; the entire fleet of buses was powered by electricity reducing carbon emissions drastically. Museums floated tenders to purchase offsetting carbon credits, and Qatar airways launched a platform to sell offsetting carbon credits.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Net Metering

Net metering regulation has been drafted and is expected to come online within 2023.

New Tariff

Electrical tariffs are expected to increase by 50% on governmental buildings in 2023. A new tariff scheme is also being developed and will be applied to remaining industries by the end of 2023 or early 2024.

III. PROJECTS:

Al Kharsaah Solar Power Plant (800 MW)

By October 2022, Qatar has commissioned the Al Kharsaah solar power plant, with a total capacity of 800 MW. It includes more than one million and 800 thousand solar panels, making it the largest solar station in the world equipped with solar tracking systems and robots to clean the solar panels at night using treated water in order to enhance the efficiency of the station.

876 MW Power Plants

Qatar signed an agreement with Samsung CT to build new 876MW power plants in Rass Laffan and UM-Saied. This project is expected to be commissioned by the end of 2024 and hold a price tag of 600 million USD. The two stations will provide energy for the facilities of the industrial complex owned by Qatar Energy Company and the national electric grid in Qatar.

GORD (Gulf Organization for Research and Development)

GORD is spearheading the country's effort to reduce its carbon footprint and assist Qatar in delivering on its commitment. The first collaboration came in 2019 when

15. Highlights In MENA's Leading Solar PV Markets

the supreme committee entrusted with organising the world cup signed an agreement with GORD to develop assessment standards to measure carbon reduction, work with organisations within and outside Qatar to implement carbon reduction projects, and issue offsetting carbon projects for the FIFA world cup. This culminated in the development of 1st carbon offset credits platform in the MENA region. Currently, Global Carbon Council, a GORD subsidiary, is validating and verifying more than 1500 projects for this purpose.

GORD also developed the global sustainability and accrediting system, GSAS, here in Qatar. It offers different certificates such as GSAS design and Builds GSAS construction materials and GSAS operation. It also offers many training programs for companies to assist in reducing their carbon footprint.

IV. CHALLENGES AND OUTLOOK

Changing people's perspectives regarding Renewable energy is the main challenge we have in Qatar. Usually, the decision to switch to renewables, e.g. solar, is often viewed from a financial point of view rather than an environmental one. However, like every MENA country, Qatar requires governmental intervention to effect change. It is worth mentioning that Qatar and all GCC countries rely heavily on water desalination for their water needs. Currently, sea pollution is at such a high level that it threatens our way of living. Water is what keeps us alive, and if we don't start to reduce sea pollution, we will face an existential crisis.

Switching to Solar energy makes sense, especially since Qatar has the highest CO2/KWH emission. However, the low electricity tariff makes such a switch financially infeasible at present. Despite this, there is noticeably more interest in solar energy due to the higher demand for electricity which the grid can't fulfil due to transformers reaching capacity. This will require higher capital expenditure and maintenance costs than solar, so hopefully, it will kickstart the transition to solar.

We do believe that the future is bright. Qatar vision 2030, commitments toward carbon emissions reduction, and new regulations will open the door for more investments in the renewable industry. I genuinely believe that Qatar, in the near future, will come to be the new big thing in solar.

Courtesy: H4 Robotic Cleaning Solution - Ecoppia

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K. SAUDI ARABIA

Moneef Barakat - CEO - Solarabic

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**

Source: Vision 2030 & Climate Transparency org.

I. CURRENT SITUATION:

Saudi Arabia is expected to add 10 GW of renewable capacity between 2022 and 2027, with solar PV leading the way. This growth will be driven by four procurement mechanisms: competitive auctions, unsolicited bilateral utility contracts, corporate power purchase agreements (PPAs), and state-owned projects. The forecast for this growth has been revised upward from previous estimates due to progress made under all four business models and the announced climate commitments during COP27.

For competitive auctions, PPAs have been signed for half of the projects in Round 3, and Round 4 opened in September 2022 with higher-than-expected volumes on offer. The country's first corporate PPA project was commissioned in 2021 after the implementation of a new Private Sector Participation Law that allows developers to sell directly to consumers. This regulatory change is expected to facilitate the growth of future corporate PPA projects.

Additionally, the government has announced plans to develop another 2.3 GW of renewable capacity through bilateral contracts under the Public Investment Fund and build state-owned projects in industrial cities. However, the pace of auctions for onshore wind remains to be determined, as it took four years to commission the Round 1 projects, and the capacity earmarked for wind in Round 3 is yet to be awarded. Source IEA,

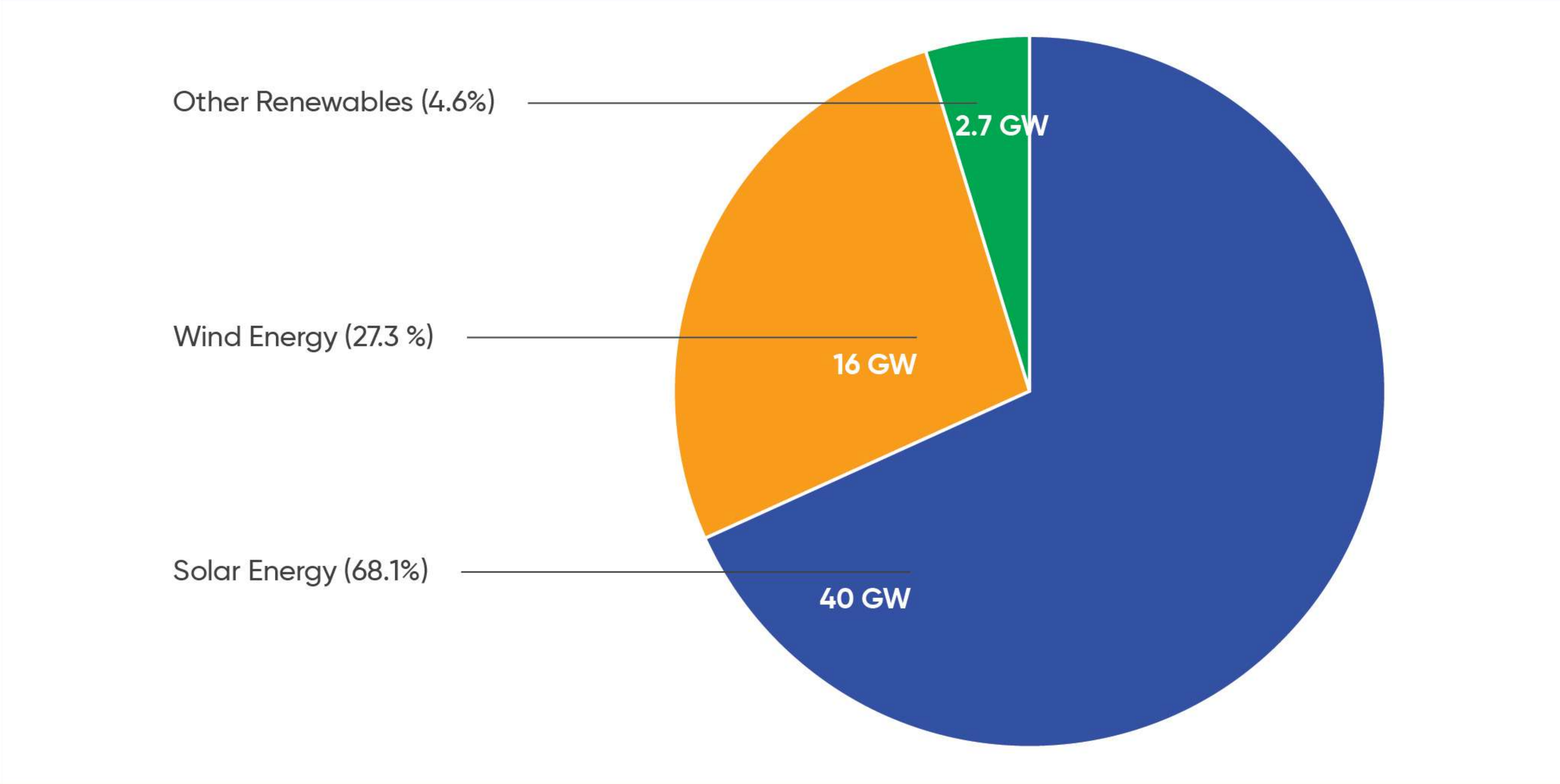

Figure K: Clean Electricity Generation Capacity by 2030 Saudi Arabia

The total generating capacity of the National Renewable Energy Program projects in the Kingdom is expected to reach approximately 5.6 million megawatt-hours, with clean electricity generation capacity increasing to around 58.7 GW by 2030. Of this, 40 GW will come from solar energy, 16 GW from wind energy, and 2.7 GW from other renewables.

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II. UPDATES ON REGULATIONS AND FRAMEWORKS

The Water and Electricity Regulatory Authority Approves the Regulatory Framework for Renewable Energy for Self-consumption

The Saudi Water and Electricity Regulatory Authority approved the regulatory framework for renewable energy for self-consumption, with the aim of specifying the requirements for electricity generation systems from renewable energy for self-consumption, whether they are connected to the grid or not.

This regulatory framework applies to all technologies of renewable energy generation systems of any capacity exceeding 1 kW that are used for self-consumption purposes in the Kingdom of Saudi Arabia, with the exception of small solar photovoltaic systems whose capacity does not exceed 2 MW, where the regulatory framework applies requirements specific to small solar photovoltaic systems.

The framework also specified the categories that are required to adopt it:

1. Service providers.
2. Eligible consumers.
3. And, any other entity related to;
   - Connecting renewable energy generation systems to the grid.
   - Develop and operate renewable energy systems.

Net Billing System

The net billing system is a mandatory energy exchange and clearing arrangement between the eligible consumer and the service provider. The eligible consumer can benefit from the financial balance of the net billing of several consumption accounts belonging to the same consumer and the same service provider. The eligible consumer can also benefit from net billing and energy consumption across multiple facilities where renewable energy generation systems are installed.

In addition, the eligible consumer can benefit from net billing arrangements that include consumers in the same building or facility through the sub-meters of the main meter (shared self-consumption). The framework shows that energy can be considered self-consumed if it is produced and consumed during the same measurement period, and the surplus energy produced from the renewable energy generation system is exported to the grid and recorded in the billing system as a financial balance.

The framework also explained how the self-consumption invoice would be calculated and its conditions. In addition, the framework included groups of accessories that are mainly related to the materials it contains.

Courtesy: Dronebase

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Saudi Aramco Sustainability Report

Saudi Aramco published its first sustainability report, explaining its plans for the coming years to achieve carbon neutrality in its operations and promote a circular carbon economy, as well as its investment in renewable and clean energy sources and blue ammonia. The report focused mainly on climate change and energy transition, business safety and people development, environmental impact reduction, and societal value maximisation.

Reducing Carbon Emissions

The report addressed Aramco's goals for the coming years in terms of reducing carbon emissions in the exploration and production sectors, as Aramco aims to reduce these emissions by at least 15% by 2035 compared to 2018.

It also seeks to promote a circular economy of carbon and other greenhouse gases, which fall mainly under the first and second scopes, resulting from its operations related to exploration, production, refining, processing, and marketing. This will be done by reducing about 50 million metric tons of carbon dioxide equivalent gas annually and capturing and storing 11 million metric tons of carbon dioxide equivalent by 2035.

Renewable and Clean Energy Projects

The company seeks to invest in renewable energy sources and clean energy production by installing projects with a capacity of 12 gigawatts by 2035, in addition to producing blue ammonia and blue hydrogen.

Environmental, Social and Governance Issues (ESG)

The report not only dealt with the environmental aspects of sustainability but also included the social and governance aspects of the company, as a number of standards and performance indicators were identified and prepared, and more than 150 issues related to these issues within the company were evaluated and prepared.

15. Highlights In MENA's Leading Solar PV Markets

Regional Voluntary Carbon Market Company

The Public Investment Fund and Tadawul Group announce the establishment of a regional voluntary carbon market company to help companies reduce their carbon emissions.

Sustainability Fund

Aramco announced the establishment of a $1.50 billion sustainability fund with the aim of investing in sustainable technologies that support the comprehensive energy transition.

III. PROJECTS:

Launch of Five Energy Projects Totalling 3,300 MW

The Saudi Energy Procurement Company announced the launch of five energy projects with a total capacity of 3,300 MW within the fourth phase of the National Renewable Energy Program.

The new projects include three wind energy projects with a total capacity of 1,800 MW, distributed as follows:

- Yanbu - 700 MW
- Al Ghat - 600 MW
- Waad Al Shamal - 500 MW.

In addition to two solar projects (1,500 MW), distributed as follow:

- Al Hanakiya - 1,100 MW
- Tabarjal projects - 400 MW

The Second Shuaiba Solar Power Station - 2,060 MW

ACWA Power has entered into a partnership with Badeel to build the second Shuaiba solar power station in the Kingdom of Saudi Arabia. The station will be the largest of its kind in the Middle East and North Africa, with a capacity of 2,060 MW. The plant will be able to produce electricity at a cost of 6.72 halala per kWh, or about 1.8 cents (US Dollar) per kWh.

The second Shuaiba solar power station will be located in the Shuaiba district of Makkah Al-Mukarramah in Saudi Arabia. ACWA Power and Badeel will both hold a 50% ownership stake in the station and will also be responsible for building, owning, and operating the plant. The project is expected to be completed in several phases, with the final phase scheduled for completion in the fourth quarter of 2025.

To develop the second Shuaiba station, ACWA Power and Badeel have established a joint venture company called the Second Shuaiba Electric Power Company. The company has also signed the station's energy purchase agreements with the Saudi Energy Purchase Company.

Awarding of PPA for 2 Renewable Energy Projects - 1,000 MW

The Saudi Ministry of Energy has granted power purchase agreements (PPA) to two solar energy projects with a combined capacity of 1,000 MW located in the Qassim and Ramah regions in the Riyadh region.

Al -Rass Solar Energy Project - 700 MW

The project is in Al Qassim, and It is affiliated with the alliance of ACWA Power, SPIC, and the Water and Electricity Holding Company (WEHC). It is a 700 MW project, and the investment in it is approximately 1.7 billion Saudi riyals, and the cost of purchasing electricity will be 5.62 halala per kWh.

Saad Solar Energy Project - 300 MW

The project is in Ramah Governorate; the signing was with Al-Ghazala Power Company, which is affiliated with the alliance of "Jinko Power Hong Kong Limited", "Jinko Power Middle East Holding Company" and "Jinko Power Dhafra Holding Company".

The total capacity of the project is 300 MW, and the investment in it was about 800 million Saudi riyals. The cost of purchasing electricity will be 5.56 halala per kWh ($0.015 per kWh).

Jubail 2 PV Power Plant - 110 MW,

The Saudi Al Fanar Company, has been awarded a contract by the Saline Water Conversion Corporation (SWCC) to build a 110 MW photovoltaic power plant. The plant will supply clean electricity to the Jubail 2 desalination plant, which is wholly owned by SWCC. The project will include a 380 kV substation and 172 km of overhead transmission lines and is expected to cost up to 1.2 billion Saudi riyals.

PPA for Layla Solar Project - 91 MW

ACWA Power signed PPA with the Saudi Energy Purchase Company worth 401 million Saudi riyals for 30 years for the Layla solar project 91 MW, the project is scheduled to be commissioned in the first quarter of 2024.

15. Highlights In MENA's Leading Solar PV Markets

World's Largest Solar Steam Plant

Ma'aden company signed an MOU with Glass Point to develop the world's largest steam production plant using solar energy on the roof of Ma'aden's alumina refinery.

Maaden Solar 1 will be the world's largest solar steam production plant and the first station of its kind to be established in the Kingdom of Saudi Arabia. Upon completion, it will help reduce carbon emissions by more than 600 thousand tons annually, representing more than 50% of the carbon emissions of its "alumina refinery" and 4% of the total carbon footprint of Ma'aden.

First Desalination Plant Powered 100% by RE

ENOWA Water Energy and Hydrogen Company, a subsidiary of NEOM, announced the signing of an MOU with the French Veolia and the Japanese ITOCHU to establish the first desalination plant powered by 100% renewable energy in the world.

This desalination plant will be established in the industrial city of Oxagon, with a production capacity of 500 thousand cubic meters of desalinated water per day by 2025, and thus contribute to meeting about 30% of the total water demand in the city of NEOM. The desalination plant is scheduled to start production By 2024.

King Abdulla Economic City - 12.5 MW

King Abdullah Economic City signed an agreement with Safir Company to establish a solar power plant with a capacity of 12.5 MW in the Economic City.

Biggest Carbon Capture Centre in the Middle East

The Saudi Energy Minister revealed the signing of an agreement with Saudi Aramco to establish the largest centre for carbon capture, storage, and use in the Middle East.

PV Hardware Factory in Jeddah

The Spanish company PV Hardware, a leading solar tracking system solutions provider, has opened a new factory in Jeddah with a production capacity of 8 GW annually.

15. Highlights In MENA's Leading Solar PV Markets

IV. CHALLENGES AND OUTLOOK

Saudi Arabia is actively working to increase the use of renewable energy as part of its goal to reduce reliance on fossil fuels and achieve net zero carbon emissions by 2060. Although there may be challenges in the future, such as competition with fossil fuels and the pace of the adoption of net billing system by consumers, the government has taken steps to improve legislation and increase the self-consumption limit to include large capacities over 2 MW in order to boost the distributed generation (DG) market.

The utility-scale market in Saudi Arabia is currently one of the most important in the Middle East and North Africa region, with annual additions of approximately 1-1.5 GW. Overall, Saudi Arabia is making progress in increasing the use of renewable energy and reducing reliance on fossil fuels.

The Saudi government has taken significant steps in recent years to address the challenges and encourage the development of renewable energy projects. These efforts include the establishment of the Saudi Renewable Energy Project Development Office to oversee the development of renewable energy projects and the launch of the Solar Energy Plan, which aims to install 27.3 GW of solar capacity by 2030. Additionally, the Kingdom plans to launch the greenhouse gas certificates market in 2023 as part of its efforts to reduce carbon emissions. Overall, Saudi Arabia is making notable progress in increasing the use of renewable energy and reducing reliance on fossil fuels.

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN SAUDI ARABIA

Khaled Sharbatly
CEO-Desert Technologies Investments

"The Kingdom of Saudi Arabia's Ministry of Energy has set ambitious targets for renewable energy development. While conventional energy now accounts for the majority of the country's energy mix, the Kingdom's goal is to generate 50% of its energy from renewable sources by 2030.

The expansion of renewable energy in the Kingdom through private-sector investment and public-private partnerships can also enable the establishment of a new industry for renewable energy technologies in the Kingdom.

Because of the Kingdom's unique geographical and climatic characteristics, renewable energy sources have become economically attractive. This contributes to Saudi Arabia's efforts to diversify the country's energy mix. As a result, as the local market grows more competitive, it is achieving the world's lowest prices for renewable energy projects. Wind and Solar PV power generation, along with Green Hydrogen, in particular, increase Saudi Arabia's attractiveness as a foreign investment destination."

Courtesy: Dronebase

15. Highlights In MENA's Leading Solar PV Markets

L. SUDAN

Mohammad Elgadal, Energy Researcher - Energy Research Center (ERC)

RE installed capacity by 2022	RE target by 2030	RE target by 2030
200 MW	2,936 MW by 2030	20%

Source: World Bank & IRENA and Experts.

I. CURRENT SITUATION:

Sudan still suffers from the lack of grid access to all regions of the country and the inability of the government to cover energy demand, especially with the high increase in energy demand by 12% annually.

According to the latest statistics of the energy sector in Sudan, the percentage of installed solar energy in Sudan amounted to 200MW. However, the number is expected to be much higher, given that most installed projects are off-grid.

The domestic sector is considered to be one of the largest energy-consuming sectors in Sudan, as it consumes 52% of the energy, and 40% of the energy is used in refrigeration and air conditioning operations due to the prevalence of hot weather in Sudan.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Small PV Systems Interconnection Regulation has been approved

On November 2022, the Sudani government announced small-scale net-metering regulation for projects with a capacity under 1MW.

Electrical connection

The World Bank is financing a project to connect Sudan to the electricity network of Africa. Sudan imports 200 MW from Ethiopia and is working on expanding a 300 MW transmission line from Egypt.

III. PROJECTS:

- By November 2022, AlShamal Cement Factory - Atbara/Sudan station (54 MW) has been commissioned, this is considered to be the single largest solar plant in Sudan to date.
- The Sudanese Ministry of Energy and Oil has invited companies to express interest in providing engineering and design services for solar irrigation systems in North and West Kordofan. Link.
- The Sudanese Ministry of Energy and Oil has announced a tender for the implementation of the first grid-connected solar photovoltaic plant on the roof of a car park with a capacity of 600 kW peak.
- Sudan plans to implement a solar wind power plant in Dongola 100 MW, at the cost of $125 million.

IV. CHALLENGES AND OUTLOOK

Sudan is counting on renewable energy projects to fill the power plants' deficit and secure its citizens' needs from the growing demand for electricity. The participation of the private sector in power generation projects still needs to be improved despite the government's facilities to invest in the energy sector.

15. Highlights In MENA's Leading Solar PV Markets

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN SUDAN

Ahmed Abusin
Renewable Energy Engineer
UNDP Accelerator Labs

"Sudan has vast potential for renewable energy, as it has a high expected demand in the next decade to meet the increasing energy needs of households, agriculture, and industry. With its abundance of solar and wind resources, renewable energy is a suitable option for a country that is difficult to power through central power stations due to its large size.

However, several challenges must be addressed to effectively tap into Sudan's renewable energy potential. One challenge is the need for a long-term plan in the renewable energy sector by the government. Another challenge is the need to upgrade the electricity infrastructure to accommodate the new energy sources. Additionally, customs and tax exemptions could be used to encourage the use of renewable energy. The banking sector & foreign investors also need to be encouraged & better facilitated to improve investment in the sector. These efforts would help Sudan take advantage of its renewable energy potential and contribute to the country's economic growth."

Courtesy: 29kW Solar Shade Screen - Mirai Solar - Saudi Arabia - Haala Energy

15. Highlights In MENA's Leading Solar PV Markets

M. TUNISIA

Jwana Abusafieh - Sungrow Middle East

RE installed capacity by 2022	Targeted RE capacity by 2030	RE target by 2030
472 MW	3,800 MW	30%

Source: International Trade Administration & Ener Data & RCREEE.

I. CURRENT SITUATION:

Tunisia seeks to achieve energy independence, diversify the energy mix for electricity production, and reduce the cost of subsidies allocated to the energy sector, through the implementation of alternative energy projects. Because currently, natural gas is used to generate 97% of electricity, while renewable energy sources contribute only 3% to Tunisia's electricity generation.

The continued reliance on natural gas for electricity generation threatens the security of supplies, especially after production recorded a sharp decline. This has prompted the Tunisian government to search for more reliable sources, and solar is likely to be the ideal solution.

Tunisia aims to increase the share of renewables in electricity generation to 30% by 2030, as it plans to produce 3,800 MW of renewable energy projects. If implemented, this large volume of renewable energy will crucially help reduce the country's energy dependency and the carbon footprint of electricity generation. Integrating more cost-efficient and domestic energy sources, in addition to the growth in renewable energy projects, will help reduce Tunisian Electricity and Gas Company's (STEG) vulnerability to global oil price volatility.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

New Tariff

In May 2022, The Tunisian Electricity and Gas Company started implementing a new electrical tariff and raising the prices of electricity and fuel, aiming to mitigate the effects of the energy deficit in light of the continuous rise in global oil prices. The announcement of this decision came within the framework of a new package of Economic reforms implemented by the Tunisian government.

III. PROJECTS:

Tenders for 1.7 GW PV and Wind Projects

The Tunisian Ministry of Mines and Energy has announced three tenders for the production of photovoltaic and wind energy, with a combined capacity of approximately 1.7 GW.

First Tender

The first tender consists of 8 photovoltaic solar energy projects, each with a maximum capacity of 100 MW.

Second Tender

The second tender consists of 8 wind energy projects, each with a maximum capacity of 75 MW for grid injection. These projects will be offered in four rounds, with two projects per round, from 2022 to 2025.

Third Tender

The third tender consists of photovoltaic solar energy projects with an undetermined capacity to be implemented in the Al-Hishah and Al-Khabna areas.

The Deadlines

These projects will be offered in four rounds, with two projects per round, between 2022 & 2025. The deadlines for each round are as follows:

15. Highlights In MENA's Leading Solar PV Markets

- First round: June 15, 2023
- Second round: March 2024
- Third round: November 2024
- Fourth round: September 2025

The Ministry invites developers interested in participating to submit expressions of interest before the deadline of May 18, 2023.

Five New Solar Power Plants Totalling 500 MW

In March 2022, The Tunisian government signed power purchase agreements for five new solar power plants with a total capacity of 500 MW as follows;

- 200 MW in Tataouine.
- 50 MW in Tozeur.
- 50 MW in Sidi Bouzid.
- 100 MW in Kairouan.
- 100 MW in Gafsa.

The total value of investments is estimated to be a little over 1 Billion Tunisian Dinars ($407 million) from SCATEC, ENERGIE NARVEA, and TEBA AMEA.

2,000 MW New Renewable Energy Projects between 2022 - 2025

The Tunisian government announced its plans to issue tenders for renewable energy projects with a total capacity of up to 2,000 MW from 2022-2025.

First Floating Solar Plant in Tunisia, the Middle East, and Africa

In June, the first floating solar plant in Tunisia, the Middle East, and Africa was commissioned, with a production capacity of 265 MWh annually, in the Beheira 3 area in Tunis. The floating solar station extends over an area of 2,500 square meters, and its installed capacity is estimated at 200 kWp, sufficient to meet the needs of about 130 homes. This station will offset 120 tons of annual carbon dioxide emissions.

Commissioning Tataouine Solar Power Station (Al-Qardab) - 10 MW

In November, Tataouine solar power station 10 MW was Commissioned to the electrical grid of the Tunisian Electricity and Gas Company (STEG), and by December 2022, it was connected to the grid.

IV. MAJOR CHALLENGE:

Tunisia has a relatively small but growing renewable energy sector. The country has a target to increase its renewable energy capacity to 30% by 2030, focusing on solar and wind energy.

As of 2022, Tunisia has signed power purchase agreements (PPAs) with a number of large-scale solar photovoltaic (PV) plants, including the 50 MW Sidi Bouzid solar plant, the 100 MW Kairouan solar plant, the 200 MW Tataouine plant, the 50 MW Tozeur plant, and the 100 MW Gafsa plant.

The regulatory environment for renewable energy in Tunisia is fairly supportive, and the government has taken a number of steps to encourage the sector's development. However, there are still challenges to the development of renewable energy in the country, including Economic instability and the need for financing.

Overall, the renewable energy sector in Tunisia is still in its early stages, but the government is actively promoting the development of renewable energy sources, and there is potential for significant growth in the coming years.

Courtesy: Robotics - Solbotix

15. Highlights In MENA's Leading Solar PV Markets

N. TÜRKIYE (TURKEY)

Musa Tecirli - Growth Manager - Yellow Door Energy

RE% from electrical generation 2022	RE Target	Energy use per capita
54%	**Net Zero by 2053**	**2,847 kWh/year**

Source: IEA & Global Solar Atlas.

I. CURRENT SITUATION:

The republic of Turkey, renamed Turkiye since May 2022 has ranked 5th in Europe and 12th in the world in terms of installed capacity in renewable energy. Wind and solar have 11% and 9% share, respectively, in Türkiye's installed power. In 2022, additions from solar and wind energies reached almost 3 GW, which exceeds the target to add 1 GW from solar energy and 1 GW from wind energy every year.

Both renewable energy and energy efficiency have a very important role in reducing the effects of climate change. Türkiye pledged to work on the outcomes of the Paris Agreement as one of the participating parties and set the goal of reaching net zero emissions by 2053.

Türkiye is working to reduce the dependence on fossil fuels by focusing on renewable energy and energy efficiency to avoid greenhouse gas emissions. There is a well-organized and managed market for renewable energy in Türkiye. The funding requirement may be the gap for new investments and further transition toward the 2053 net-zero goal.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Update on Wheeling Regulation

Türkiye amended the wheeling legislation and allowed the transmission of energy without any distribution area restrictions, allowing the generation and consumption points to be in different regions.

Renewable Energy Investment Incentives

The Turkish government has announced subsidies for renewable energy investments, as corporations receive tax deductions on corporate income and tax exemptions, depending on the location of the investment. The renewable energy generation facilities benefit from the General Investment Incentive Scheme, which covers exemption from VAT and Customs Duties for all machinery and equipment used in the relevant power plant, regardless of the region where investment takes place.

Double the Self-Consumption Limits for Corporate

The self-consumption limit for corporations used to be defined by contracted power, but now it has been doubled takes place.

New Buildings Obligated to use Renewable Energy

Türkiye has issued legislation mandating all buildings with a construction area of more than 5,000 square meters to generate at least 5% of the energy they use from renewable sources such as solar and wind power. Also, they have to be insulated with thicker materials to improve energy efficiency. Authorities will not issue permits to buildings that fail to meet these energy-saving requirements. The transition will be increasingly aggressive. In 2025, the scope of the project will be widened to cover buildings with more than 2,500 square meters of construction area, and the percentage of use of renewable sources will increase to 10%.

Storage Regulation Update

In 2021, the Energy Market Regulatory Authority (EMRA) issued a regulation that permits energy companies to develop energy storage facilities, whether standalone, paired with grid-tied energy generation, or for integration with energy consumption – such as at large industrial facilities.

In 2022, they started working on updating energy storage legislation, and it is expected to be issued soon. Energy laws are being adapted further to accommodate energy storage applications that enable the management and addition of new renewable energy capacity while mitigating grid capacity constraints.

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III. PROJECTS:

FIT Projects:

- **YEKA 1:** Türkiye's biggest solar plant, the Karapinar Solar Power Plant (SPP), has been developing. The first couple of phases are completed. The current installed capacity is 750 MW. When the entire project comes to completion, the total capacity will be 1 GW.
- **YEKA 3:** Türkiye's 1 GW solar energy tender was awarded. It was oversubscribed more than eighttimes. 131 project proposals with a combined capacity of 9,4 GW submitted for review for YEKA 3.
- **YEKA 4:** 1 GW YEKA 4 tender was awarded in 2022.
- **YEKA 5:** YEKA 5 tender was announced but delayed in 2022. It was expected to be awarded in 2023.

Distributed Solar:

- Tosyali Group announced the world's largest solar rooftop project with a capacity of 140 MW

IV. CHALLENGES AND OUTLOOK

Türkiye's solar market is expected to grow significantly due to positive regulatory updates and high oil & gas prices. There is a strong direction from the government to reduce the dependency on imported oil and gas.

Corporations are incentivised to make renewable investments to generate their own electricity. Recent changes in wheeling, increase in self-generation capacity and mandatory supply from renewables encourage further growth.

Financing: Due to the economic fluctuations, support of funds to deploy solar projects was limited. The tenure of financing is very short, and the high-interest rates hinder the possibility of rapid growth in solar projects.

Grid: Even though Türkiye wants to expand and add more renewable energy projects to the electricity production capacity, grid enhancements are vital to integrate more renewable power in the network. Currently, investors suffer due to the grid's lack of sufficient connection and transmission capacity.

▸ EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN TURKEY

Serkan Kaniturk
Chief Technology Officer (CTO)
Detra solar

"Turkey has seen significant growth in renewable energy in recent years due to resource availability, strong energy demand, and supportive government policies. Renewable electricity generation has almost tripled in the past decade, and solar power capacity is expected to reach 11 GW by 2022, 13 GW in 2023, and 30 GW by 2030. However, financing remains a challenge in the industry, and the Renewable Energy Support Mechanism (YEKDEM) has helped increase investments in renewable energy projects.

There has also been an increase in rooftop solar energy investments, with at least 20 GW of technical potential in buildings; there is an expectation that at least 10 GW will be commissioned in the coming years. This growth is expected to lead to an increase in sectoral employment and a qualified workforce, as well as the development of domestic module technologies and manufacturing industry capacity, helping Turkey become a regional solar energy leader."

15. Highlights In MENA's Leading Solar PV Markets

O. UNITED ARAB EMIRATES

Waleed K. AlHallaj - Head of Business Development - MENA - Amarenco Group

RE target by 2030	RE installed capacity by 2021	RE target by 2030
30% by 2030	**2,706 MW by 2021**	**14,000 MW**

Source: MOEIUAE & Global Energy Prize.

I. CURRENT SITUATION:

The United Arab Emirates (UAE) is making significant progress in increasing the use of renewable energy and reducing its reliance on fossil fuels. The country has set ambitious targets to increase the share of renewable energy in its total energy mix, with the goal of producing 50% of its electricity from clean energy sources by 2050.

To achieve this goal, the UAE has implemented several initiatives and projects to promote the use of renewable energy. This includes the establishment of the Dubai Clean Energy Strategy 2050, which aims to provide 75% of Dubai's total power capacity from clean energy sources by 2050. The UAE also has a number of large-scale renewable energy projects underway, including the Mohammed bin Rashid Al Maktoum Solar Park, which aims to generate 5,000 MW of electricity by 2030, with the UAE achieving net zero by 2050.

In addition, the UAE has made significant investments in research and development to improve the efficiency and affordability of renewable energy technologies. This includes the establishment of the International Renewable Energy Agency (IRENA) in Abu Dhabi, which aims to support the global transition to renewable energy and promote the adoption of clean energy technologies.

Overall, the UAE is making strong progress in increasing the use of renewable energy and is well on track to achieving its ambitious targets for clean energy generation.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

The Federal Law for the Connection of Renewable Energy to the Electrical Grid

The Ministry of Energy and Infrastructure has announced the adoption of a federal law to regulate the connection of distributed renewable energy production units to the electrical grid. This law is meant to encourage individuals to produce electrical energy from renewable sources, helping the country to achieve its goals by promoting the diversification of renewable energy sources within the country and the optimal use of natural resources. By doing so, the law seeks to reduce emissions and achieve climate neutrality.

New Energy Transition Regulations in Abu Dhabi

The Department of Energy in Abu Dhabi (DoE), in cooperation with the Environment Agency in Abu Dhabi, announced the launch of new regulations, the first of their kind in the Middle East, to lead the energy transition in the UAE and increase the proportions of energy generation from clean sources to reach carbon neutrality in the country by 2050.

These regulations are the first legally binding regulatory framework for clean and renewable energy in the electricity sector in the Middle East. These regulations aim to increase the percentage of electricity generation from renewable and clean energy sources to 60% in the Emirate of Abu Dhabi by 2035 and to reduce 75% of carbon emissions for every megawatt-hour of electricity produced.

Sustainability in the Industrial Sector

The Ministry of Industry and Advanced Technology in the UAE recently announced the completion of a partnership agreement with Schneider Electric. This partnership would promote sustainability within the industrial sector through various initiatives. These initiatives include conducting field assessments of sustainability for 50 industrial companies, hosting a series of webinars on digital transformation and energy efficiency, and launching an internal training program for 50 Emiratis. These efforts are intended to support the transition towards more sustainable and efficient industrial practices in the UAE.

15. Highlights In MENA's Leading Solar PV Markets

Smart Grid Strategy - Phase Two

The Dubai Electricity and Water Authority (DEWA) has successfully accomplished the objectives of the initial phase of its smart grid strategy and is now moving towards achieving the goals outlined in its updated smart grid strategy for the period 2021-2035. This updated strategy is characterised by its high level of flexibility and ability to adapt to rapid changes and developments, ensuring DEWA's continued excellence and strengthening its global leadership in this area. The smart grid strategy aims to enhance the reliability, efficiency, and sustainability of DEWA's power and water systems, as well as support the integration of renewable energy sources and the adoption of advanced technologies.

III. PROJECTS:

Al Dhafra Solar PV - 2,000 MW

The Al Dhafra Solar PV project in Abu Dhabi is the largest single solar site in the world. It is being overseen by China National Machinery Engineering Co., Ltd., with a total production capacity of 2.3 GWh. Jinko Solar has recently supplied the first batch of 25 MW of high-efficiency n-type TopCon solar panels for the project. As one of the suppliers of photovoltaic solar panels, Jinko Solar will provide 630 MW of its latest innovative n-type Topcon panels for the project.

As for the solar tracker systems, Arctech has entered into an agreement with China Machinery Engineering Corporation (CMEC) to supply 2.1 GW of solar tracking systems for the Al Dhafra PV2 solar photovoltaic plant in Abu Dhabi.

The project is expected to be connected to the grid in mid-2023. After connection, the project will provide clean and renewable energy to more than 110,000 local households and will effectively solve the electricity consumption problem of the population.

The 6th Phase of Mohammed bin Rashid Al Maktoum Complex - 900 MW

The Dubai Electricity and Water Authority (DEWA) announced the beginning of the work on the sixth phase of the solar energy project for the Mohammed bin Rashid Al Maktoum complex and appointed a group of companies led by the international consulting firm Ernst & Young to provide advisory services, and decided to operate this phase between 2025 and 2027. DEWA received letters of interest to implement the sixth phase of the Mohammed bin Rashid Al Maktoum Solar Park.

The sixth phase of the complex will have a capacity of 900 MW, which will be produced from photovoltaic panels. It will be operated in phases starting from the third quarter of 2025. Upon completion, the complex's total capacity will reach 3,760 MW, with a plan to reach 5,000 MW by 2030.

The 5th Phase of Mohammed bin Rashid Al Maktoum Complex - 900 MW

The Dubai Electricity and Water Authority (DEWA) has announced the addition of an additional 300 MW of photovoltaic solar energy to the Mohammed bin Rashid Al Maktoum Solar Park as part of its fifth phase. This brings the total capacity of the fifth phase to 900 MW, with investments estimated at 2 billion and 58 million dirhams.

The project is being implemented by DEWA and is expected to be completed in phases by 2023. In addition to the 300 MW added this year, the authority also added 300 MW to the fifth phase last year.

Waste-to-Energy Plant - 90 MW

Tadweer, in cooperation with the Emirates Water and Electricity Company - EWEC, launched a tender for constructing a waste-to-energy plant in the Emirate of Abu Dhabi. With a capacity of about one million tons of waste annually, which corresponds to about a third of the waste generated by Abu Dhabi, the planned electricity production capacity is approximately 90 MW.

Al-Ajban Station - 1,500 MW

The Emirates Water and Electricity Company - EWEC opened the door for developers to submit requests for interest in the implementation of the 1,500 MW photovoltaic "Al-Ajban Station" development project, according to the independent product model.

The Al-Ajban station is located in the Emirate of Abu Dhabi and will produce clean electricity that meets the needs of 160,000 homes across the UAE. The station is expected to contribute to reducing more than 2.4 million metric tons of carbon emissions annually.

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The Largest Clean Energy Certification Transaction

Emirates Global Aluminum - EGA has signed a contract to purchase clean energy certificates from Emirates Water and Electricity Company - EWEC. The goal is to support the production of Celestial aluminium with solar energy. Emirates Global Aluminum - EGA has purchased clean energy certificates for 1.1 million MWh of electricity provided by Emirates Water and Electricity - EWEC.

IV. CHALLENGES AND OUTLOOK

The United Arab Emirates (UAE) has made significant progress towards increasing its dependence on renewable energy in recent years, with the goal of increasing the share of clean energy in its total power mix to 50% by 2050. Currently, the UAE is one of the fastest-growing utility-scale markets in the Middle East and North Africa region, with approximately 2,000 MW of renewable energy being installed annually. However, there are several challenges that the country is facing in achieving its goals.

One such challenge is the lack of regulation for the distributed generation (DG) market in the UAE outside the Dubai emirate. However, in November 2021, the UAE announced its intention to adopt a federal law regulating the connection of distributed renewable energy production units to the electrical grid in all 7 emirates. This is expected to greatly revitalise the DG market over the next few years, with an estimated annual increase of 400-500 MW annually once regulations are in place, compared to the current rate of around 60-100 MW annually. This will represent a significant leap for the DG market in the UAE.

In the utility-scale sector, the projects are primarily focused in Dubai and Abu Dhabi. The consolidation of these utility-scale projects makes it very hard for local developers and EPCs to grow in the local utility-scale sector.

EXPERT OPINION ON CURRENT & FUTURE DEVELOPMENT IN UAE

Romain Riche
International Development Director - MESIA

"Over the last 2 years, due to the surge in PV Modules prices, major solar developers experienced delays for module delivery from China, slightly delaying flagship projects in the region. Due to those challenges, the country cumulative installed capacity remains valued at around 3.5 GW by end 2022, but shall soon reach 6 GW capacity with the completion of the current mega-projects in Abu Dhabi (Al Dhafrah 1,500 MW) and Dubai (MBR Solar Park Phases 4 and 5 respectively 950 and 900 MW)

At the dawn of COP28 to be held in the country, new developments are likely to be announced. This year, EWEC will close the tendering of Al Aljban to add 1,500 MW of solar in Abu Dhabi. In Dubai, already getting 14% of its electricity from clean-energy sources, DEWA has now launched the tender of the 6th Phase of its mega-solar cluster to add an additional 1,800 MW.

When it comes to the distributed solar segment, while it has been popular in Dubai with its net metering policy, overall its development remains limited. In order to reach the ambitious target of the UAE Energy Strategy 2050, with a clean energy share of 44% by 2050, accelerated development and updated policies are required.

With the increase of solar penetration in the grid, I believe the implementation of adapted regulations is crucial to tackle current barriers. For instance, for utility-scale tenders mandating storage to increase the flexibility in coherence with other base load power plants. For small-scale, allowing behind-the-meter storage in association with time-of-day tariffs. Such regulations would allow a better use of the energy sources that exist on the grid and enable the economical and reliable operation of the electrical network with mixed generation assets."

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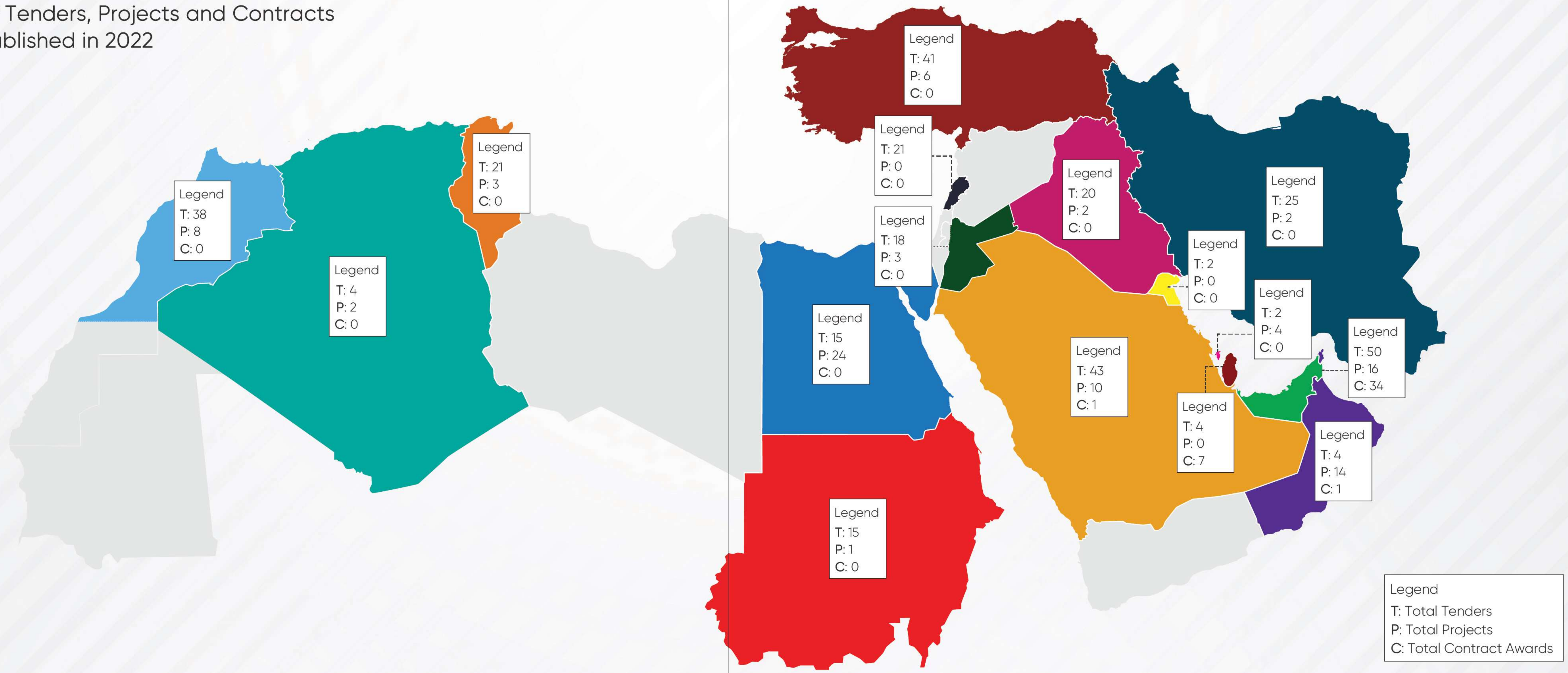
Statistics of Tenders, Projects and Contracts Awarded Published in 2022



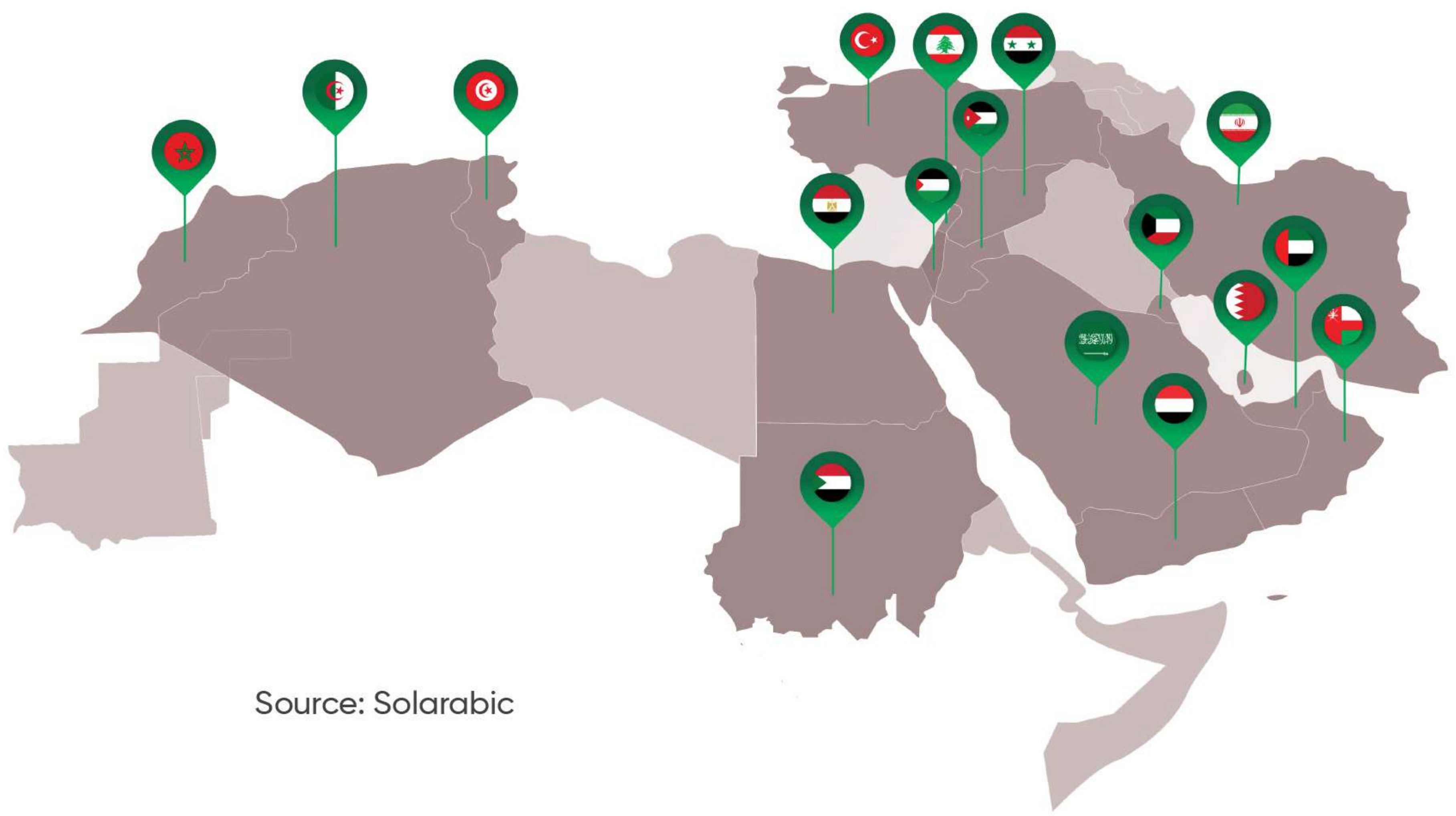
Country	Green Hydrogen			Carbon Credit			EV charger			Floating Solar			Energy Efficiency		
	T	P	C	T	P	C	T	P	C	T	P	C	T	P	C
Algeria	0	1	0	0	0	0	1	0	0	0	0	0	3	1	0
Bahrain	0	0	0	0	0	0	2	2	0	0	1	0	0	1	0
Egypt	2	18	0	0	0	0	9	0	0	0	0	0	4	6	0
Iran	0	0	0	0	0	0	20	0	0	0	0	0	5	2	0
Iraq	0	0	0	2	0	0	17	0	0	0	0	0	1	2	0
Jordan	0	1	0	0	0	0	12	0	0	0	0	0	6	2	0
Kuwait	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lebanon	0	0	0	2	0	0	12	0	0	0	0	0	7	0	0

Country	Green Hydrogen			Carbon Credit			EV charger			Floating Solar			Energy Efficiency		
	T	P	C	T	P	C	T	P	C	T	P	C	T	P	C
Morocco	0	4	0	1	0	0	18	0	0	0	0	0	19	4	0
Oman	2	13	1	0	1	0	2	0	0	0	0	0	0	0	0
Qatar	0	0	2	1	0	0	3	0	5	0	0	0	0	0	0
Saudi Arabia	1	6	1	0	0	0	15	3	0	0	0	0	27	1	0
Sudan	0	0	0	3	0	0	11	0	0	0	0	0	1	1	0
Tunisia	3	2	0	0	0	0	15	0	0	0	0	0	3	1	0
Turkey	0	0	0	0	0	0	14	0	0	0	0	0	27	6	0
UAE	3	12	0	0	0	0	42	1	10	3	1	12	2	2	12

Graph info - This Map Represents the Statistics as per 2022. Products in the Map Include Green Hydrogen, Carbon Credit, EV charger, Floating Solar, Energy Efficiency. Source: Tenders Info.

15. Highlights In MENA's Leading Solar PV Markets

RENEWABLE ENERGY LEGISLATION

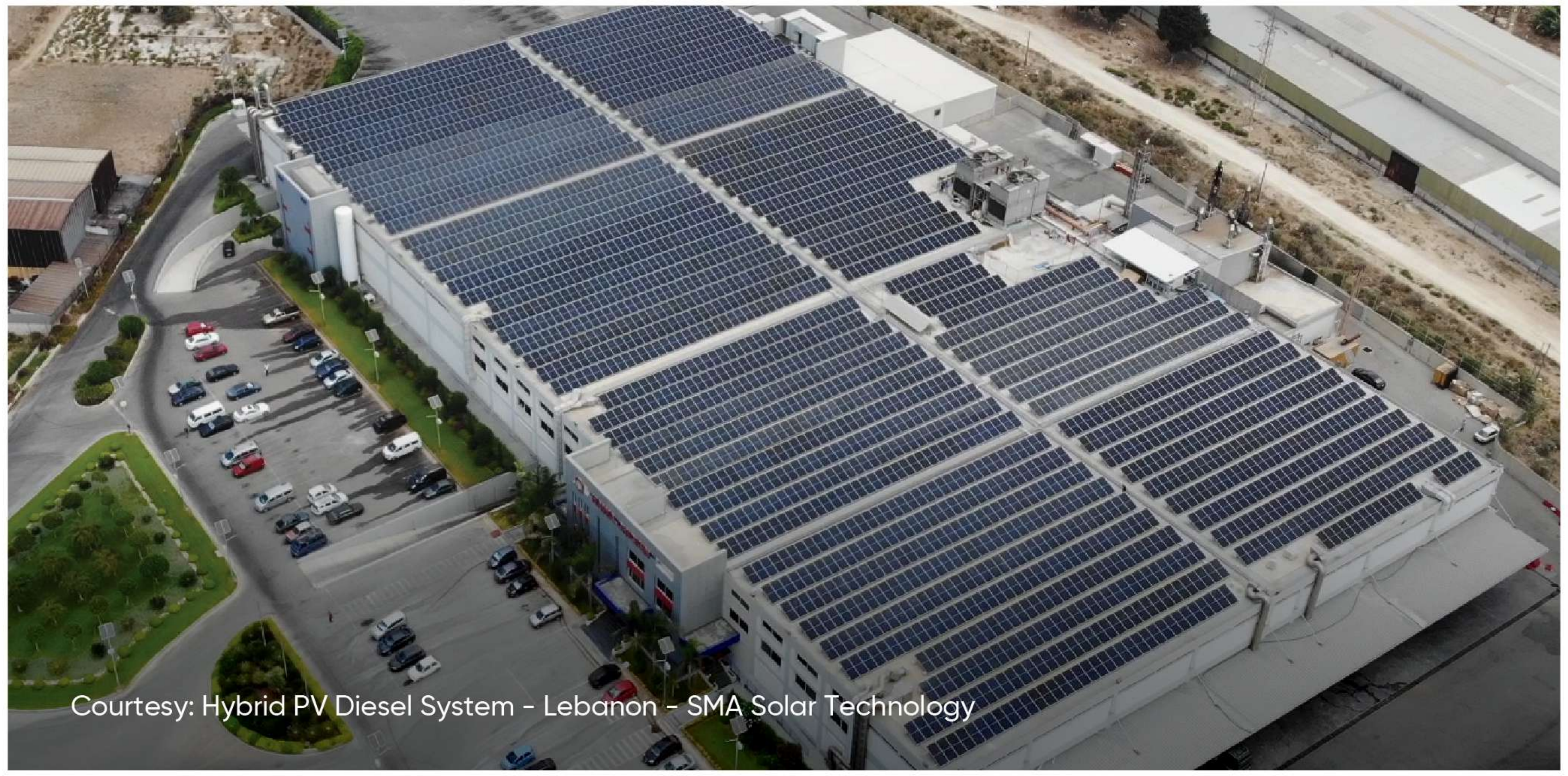


Source: Solarabic

The MENA region has the potential to be a major player in the global renewable energy market, thanks to its abundant solar and wind resources. However, in order for the region to fully realize this potential and harness its renewable energy resources effectively, it is crucial to have robust and comprehensive renewable energy regulations in place. Such legislation serves to create a stable and predictable policy environment that attracts investment and encourages the growth of the sector.

Moreover, the adoption of renewable energy is increasingly seen as a key strategy for mitigating the impacts of climate change and reducing reliance on fossil fuels. The MENA region is no exception to this trend, and renewable energy regulation can help to facilitate the transition to a more sustainable and low-carbon energy mix.

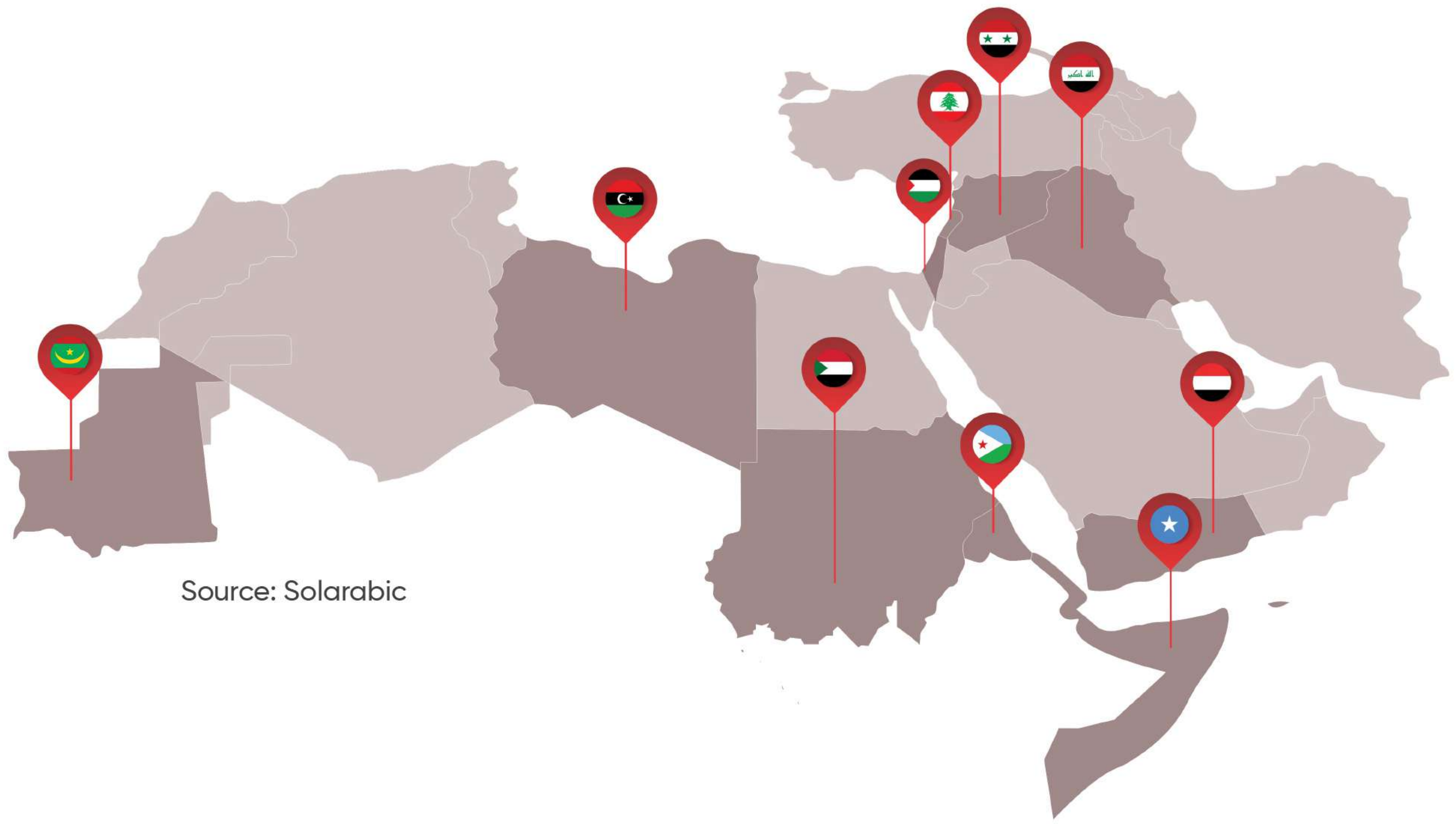
Of course, the specific needs and circumstances of each country in the region will influence the nature of its renewable energy legislation. Nevertheless, the importance of having well-crafted and effective regulations in place cannot be overstated. Without it, the potential for renewable energy development and growth in the MENA region may be limited.



Courtesy: Hybrid PV Diesel System - Lebanon - SMA Solar Technology

15. Highlights In MENA's Leading Solar PV Markets

COUNTRIES WITH ELECTRICITY SHORTAGE



Source: Solarabic

Lebanon

According to the World Bank, 100% of the people in Lebanon have access to the electrical grid. However, Lebanon has been suffering from electricity supply shortages for decades. The peak demand is 1.5 GW, which is higher than the generation capacity. The Lebanese government continues to be unable to provide reliable electricity to its citizens; interruptions sometimes last 22 hours a day. Hence, citizens have resorted to obtaining electricity from private electricity suppliers that depend on diesel. During the past two years, people have begun to rely on solar energy systems due to the high cost of diesel and its sometimes unavailability in the market.

Syria

According to the World Bank, 89.1% of the people in Syria have access to the electrical grid, but Syria suffers from lengthy power outages. The power outages, ranging from city to city, sometimes reach 23.5 hours daily. Electric generation problems began in Syria after the escalation of political unrest in the second half of 2012. This damaged the electric grid, destroyed power plants and caused a fuel supply shortage to the remaining functional power plants. The fuel shortage continues because of the state's inability to import fuel due to the sanctions imposed on it.

Iraq

According to the World Bank, 100% of the people in Iraq have access to the electrical grid. Iraq has suffered power outages for over three decades; in some regions, electricity is only available 12 hours per day. Iraqi citizens have resorted to obtaining electricity from private electricity suppliers that depend on diesel. For the past few years, people have begun to rely on solar energy systems due to the high cost of diesel.

Yemen

According to the World Bank, 73.8% of the people in Yemen have access to the electrical grid. Yemen has been suffering from a deterioration of electrical infrastructure due to the war since 2015. Even before the war, the electricity sector in Yemen covered only 40% of demand, limited mainly to urban areas. An estimated 15 million Yemenis in rural areas were never connected to the electricity grid.

Yemenis currently suffer from power outages averaging 14 hours per day. Meanwhile, solar power installations independent of the national grid in Yemen have grown to more than 500 MW in 2021, which already constitutes 50% of the remainder of the national grid.

15. Highlights In MENA's Leading Solar PV Markets

Sudan

According to the World Bank, 55.4% of the people in Sudan have access to the electrical grid. Sudan still suffers from the inability of the government to cover energy demand, especially with the increase in energy demand growing by 12% annually. The electricity outages extend for periods of about 10-12 hours per day, and Sudan seeks to solve this problem by moving towards renewable energy and encouraging foreign investments in power stations.

Libya

According to the World Bank, 69.7% of the people in Libya have access to the electrical grid. Libya has suffered from electricity generation problems as a result of strikes and political instability since 2011. Electricity generation facilities are often targeted as a means of political pressure by conflicting parties. Libyans suffer from continuous power outages that reach 5-6 hours per day in some areas and 12 hours in others. Power outages used to last for days in previous periods, but the Libyan government is working to develop solutions to solve problems successfully.

Mauritania

According to the World Bank, 47.3% of the people in Mauritania have access to the electrical grid. Mauritania suffers from continuous power outages, which it has worked to solve over the past years, and is currently seeking to adopt renewable energy as a solution to this problem.

Gaza Strip

The Gaza Strip suffers from power outages that last 13 hours per day. The reason for the electricity crisis in the most crowded city in the world is due to the blockade, political unrest, and the bombing of power stations as a result of the war.

Djibouti

According to the World Bank, only 61.8% of the people in Djibouti have access to the electrical grid and suffer from frequent power outages, especially in the summer. Most people resort to using an electric generator to avoid this problem, and the electricity bill is very high, especially when using air conditioning, which is necessary due to the high temperatures. Djibouti imports part of its electricity needs from Ethiopia, yet this is insufficient, and many of its villages often plunge into complete darkness. Djibouti also relies on geothermal energy to produce electricity, primarily in the Rift Valley region. Studies have confirmed the presence of "geothermal fluids" close to the surface, which can be beneficially utilised for electricity generation if financial and technological capabilities are made available. Djibouti seeks to be the first African country to rely on renewable energies 100 percent, especially since it does not have any fossil energy resources.

Somalia

According to the World Bank, only 49.7% of the people in Somalia have access to the electrical grid. And according to the local "Hiran" website, 9 million Somalis of the 15 million total population lack electricity services. The cost of electricity in Mogadishu is three times higher than the world's average price, but the expansion of the use of renewable energies has contributed to lower prices. Somalia is seriously heading towards adopting renewable energy to solve its electricity generation problems.

Courtesy: Bubble Luxotel Hotel - Wadi Rum, Jordan - SMA Solar Technology

Solarabic

Reference: Access to electricity (% of population) - Middle East & North Africa (excluding high income)

16. Conclusion

Despite the enormous progress that has been made over the course of the past three years against the headwinds of a global pandemic, supply chain disruptions and volatile oil & gas prices, there is much more that needs to be done. The goals that we, the MENA nations, have set for ourselves are ambitious, and in order to achieve them, the pace must accelerate. It is important to note that the solar industry continues to be financially viable, and every effort is being taken to increase operations' efficiency and the generating capacity's efficacy. In our report, we have highlighted the various tools of standardisation and automation being applied to bring about greater energy yields and extend the operating life of solar power plants.

However, in order for us to make a greater impact on regions with the most need, more support must be rendered to distributed solar. This requires more open regulation that fosters and facilitates this sector for both residential and commercial applications. Financing is an important factor for growth in distributed solar; this financing will need to be made available through subsidies, grants and private financing. While the MENA region has seen strong growth in developers providing private financing for distributed solar projects, it remains insufficient. The difficulty remains that the countries most affected by currency instability and energy inflation are the countries in most need of financing for distributed solar projects. "How?" remains the pertinent question. In addition, building the technical capabilities of the labour force to engineer, install and maintain solar energy projects is equally important. Given MENA's abundance of human capital, this aspect only requires a concerted effort to facilitate training and vocational programs.

The solar industry in MENA has every right to celebrate its laurels, but we have a tremendous amount of work yet to be done for us to meet our needs and our goals. The work, despite evidence to the contrary, has only now well and truly begun.

Courtesy: Nestle Waters - 1.4 MWp - Yellow Door Energy

17. Glossary of Terms

Term	Definition
$/tCO2	$ per ton of CO2
5G	Fifth-Generation technology standard for broadband cellular networks
ACCU	Australian Carbon Credit Unit
AER	Authority for Electricity Regulation of Oman
AFEX	Arab Future Energy Index
AI	Artificial Intelligence
Alba	Aluminum Bahrain
AMEE	Moroccan Agency for Energy Efficiency
AMH	American Mission Hospital
APM	Asset Performance Management
APSR	Authority for Public Services Regulation
AR	Augmented Reality
ARC	Anti-Reflective Coating
Bapco	Bahrain Petroleum Company
BASE	Basel Agency for Sustainable Energy
BESS	Battery Energy Storage System
BOS	Balance Of System
BTC	Bitcoin
C&I	Commercial and Industrial
CaaS	Cooling as a Service
CAD	Computer-Aided Design
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CCAF	Cambridge Center for Alternative Finance
CIF	Climate Investment Fund
CMEC	China Machinery Engineering Corporation
CMMS	Computerised Maintenance Man-agement Systems
CO2	Carbon Dioxide
CO2e	Carbon dioxide equivalent
COP	Conference of the Parties
CSP / CST	Concentrated Solar Power / Concentrated Solar Thermal
CTF	Cleaning Test Field
DAC	Direct Air Capture
DEWA	Dubai Electricity and Water Authority
DG	Distributed Generation
DoE	Department of Energy in Abu Dhabi, UAE

17. Glossary of Terms

Term	Definition
DSRPAI	Dartmouth Summer Research Project on Artificial Intelligence
EBRD	European Bank for Reconstruction and Development
EDF	Electricite De France
EGA	Emirates Global Aluminum
EL	Electro-Luminescence
EMRA	Energy Market Regulatory Authority
EPC	Energy Performance Certificate
ERC	Energy Research Center
ESCO	Energy Service Company
ESG	Environment, Social, and Governance
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicles
EWA	Electricity and Water Authority
EWEC	Emirates Water and Electricity Company
FiT	Feed-in-Tariff
FPV	Floating PV
G20	Group of Twenty comprising 19 countries and the European Union
GCC	Gulf Cooperation Council
GFI	Gapless Flexible Interconnection
GHG	Greenhouse Gas
GORD	Gulf Organization for Research and Development
GPS	Global Positioning System
GSAS	Global Sustainability Assessment System
Gt	Giga tonnes
GW	Giga Watt
GWh	Gigan Watt-hour
GWp	Giga Watt-peak
IEA	International Energy Agency
IEA-PVPS	International Energy Agency Photovoltaic - Power System Programme
IEC - TS	International Electrotech-nical Commission - Technical Specification
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Project
IQD	Iraqi Dinar
IRENA	International Renewable Energy Agency

17. Glossary of Terms

Abbreviation	Term
ISFH	Institute of Solar Energy Hamelin
IV	Current-Voltage
JREEEF	Jordan Renewable Energy & Energy Efficiency Fund
KAEC	King Abdullah Economic City
KAUST	King Abdullah University of Science and Technology
KPIs	Key Performance Indicators
LCEC	Lebanese Center for Energy Conservation
LCOE	Levelized Cost of Energy
LED	Light-Emitting Diode
LID	Light Induced Degradation
MACC	Marginal Abatement Cost Curve
EPC	Engineering, Procurement, and Construction
MASEN	Moroccan Agency for Sustainable Energy
MBR	Mohammed Bin Rashid
MEM	Ministry of Energy and Minerals
MENA	Middle East and North Africa
MEP	Mechanical, Electrical and Plumbing
ML	Machine Learning
MoU	Memorandum of Understanding
MRO	Maintenance, Repair, Operations
Mt	Metric tonne
Mtpa	Million tonnes per annum
MW	Megan Watt
MWp	Mega Watt-peak
NDCs	Nationally Determined Contributions
NPV	Net Present Value
NREA	Egyptian New & Renewable Energy Authority
NREL	National Renewable Energy Laboratory - US
O&M	Operations & Maintenance
OPEX	Operating Expense
OPWP	Oman Power and Water Procurement Company
OQ	Operational Qualification
PERC	Passivated Emitter and Rear Contact
PPA	Power Purchase Agreement
PPE	Personal Protection Equipment
QEERI	Qatar Environment and Energy Research Institute

17. Glossary of Terms

Abbreviation	Term
RE	Renewable Energy
ROI	Return On Investment
SATBA	Renewable Energy and Energy Efficiency Organization of Iran
SBTi	Science-Based Targets initiative
SCADA	Supervisory Control and Data Acquisition
SCZone	Suez Canal Economic Zone
SERIS	Solar Energy Research Institute of Singapore
SPP	Solar Power Plant
US	United States
SWCC	Saline Water Conversion Corporation
TOPCon	Tunnel Oxide Passivated Contact
tpa	tonnes per annum
TWh	Tera Watt-hour
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UNDP	United Nations Development Programme
UNFCCC	United Nations Frame-work Convention on Climate Change
USTDA	US Trade and Development Agency
UV	Ultraviolet
VAT	Value-Added Tax
VCM	Voluntary Carbon Market
VFD	Variable Frequen-cy Drives
WEHC	Water and Electricity Holding Company
YEKDEM	Renewable Energy Support Mechanism
STEG	Tunisian Electricity and Gas Company

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