MESIA
جمعية الشرق الاوسط لصناعات الطاقة الشمسية
Middle East Solar Industry Association
Empowering Solar across the Middle East

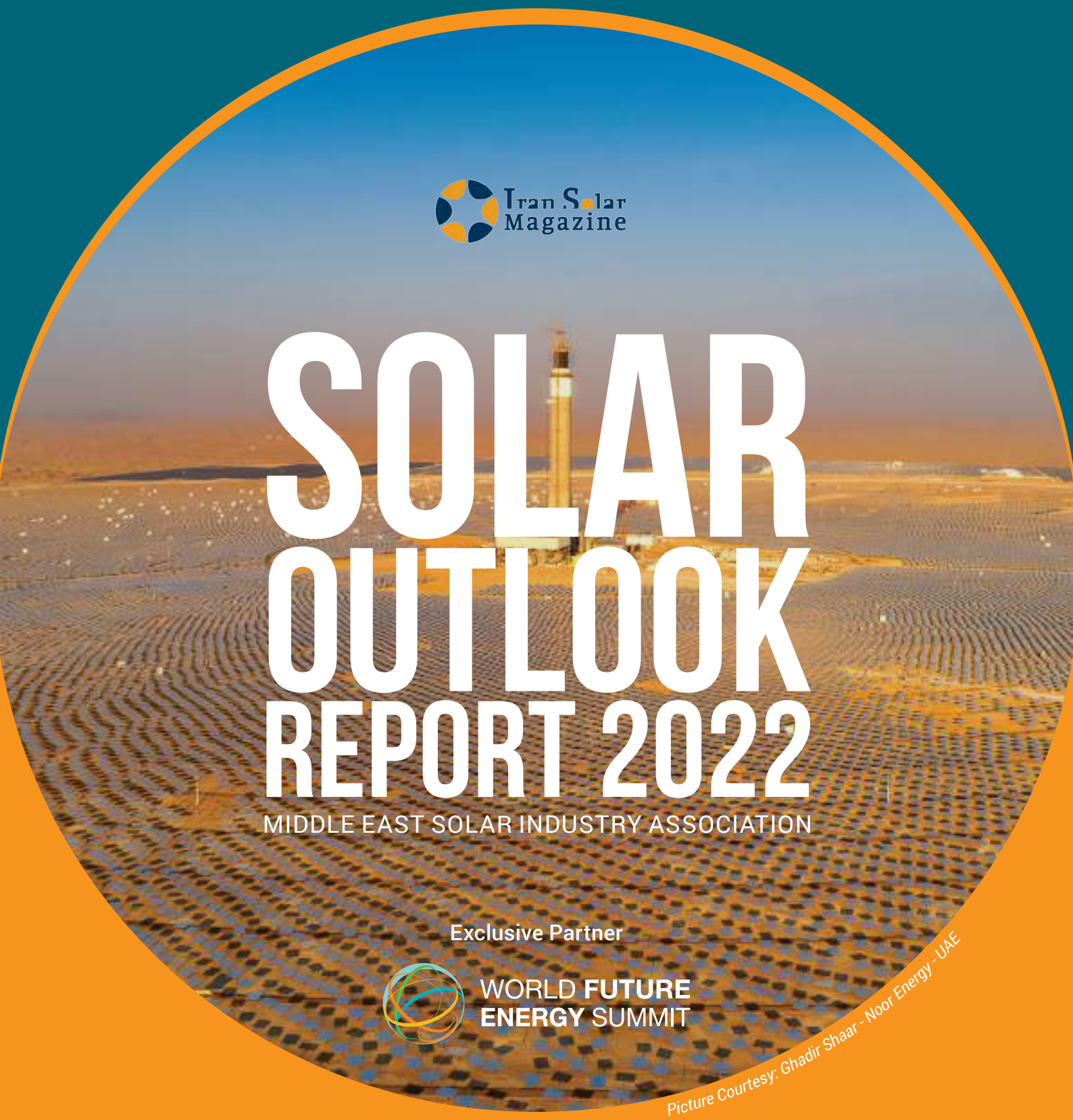
Iran Solar Magazine

SOLAR OUTLOOK REPORT 2022

MIDDLE EAST SOLAR INDUSTRY ASSOCIATION

Exclusive Partner

WORLD FUTURE ENERGY SUMMIT



Picture Courtesy: Ghadir Shaar - Noor Energy - UAE

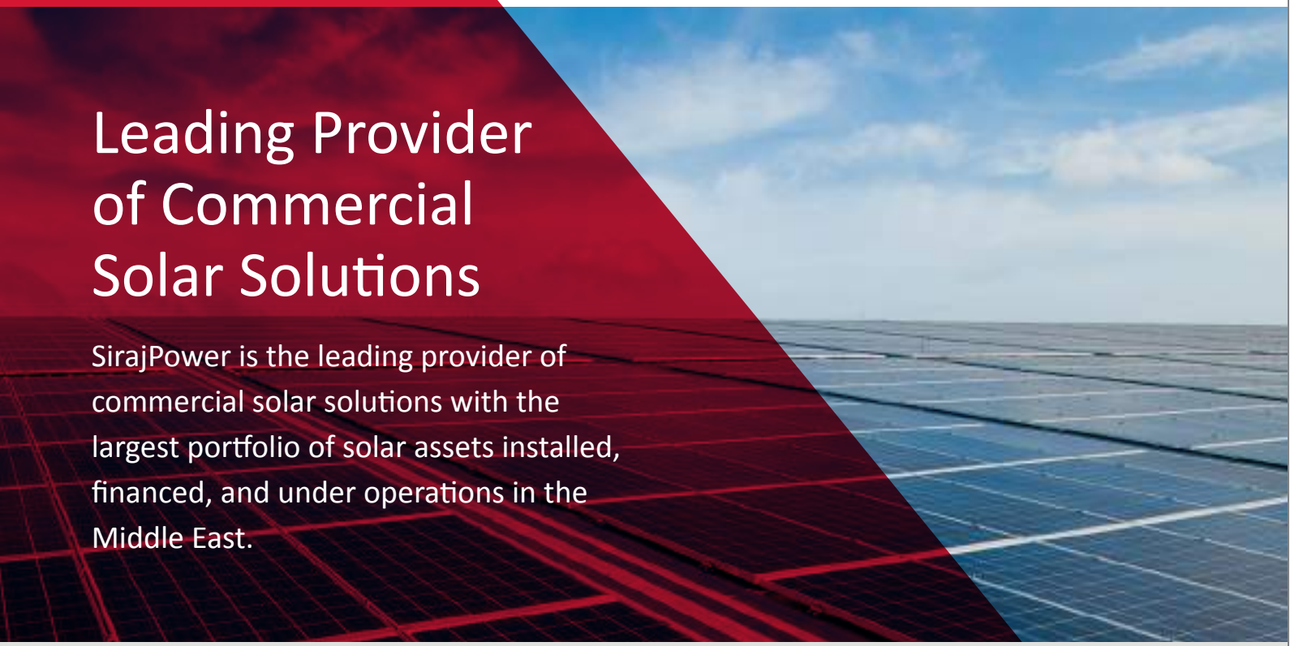
PUBLISH DATE

JANUARY 2022

Table of Contents

Honolulu Covanta - USA
Courtesy: S-5!

SirajPower



Leading Provider of Commercial Solar Solutions

SirajPower is the leading provider of commercial solar solutions with the largest portfolio of solar assets installed, financed, and under operations in the Middle East.

- Caters not only to On-Grid but also Off-Grid Systems
- Provides fully comprehensive Operations & Maintenance Services
- Expanded to Hybrid Systems and Mobile Storage Systems
- Presence in UAE, Saudi Arabia and Oman

TRACK RECORD OF PROVEN SUCCESS ACROSS THE UAE

No. 1
Leading provider of financed distributed solar in the Middle East

100MWp
Portfolio of distributed solar asset ownership

200+
Facilities under operations and maintenance

600,000+
Square meter area covered by solar installations

85,000+
Metric Tons of CO^2 emissions reduced each year

$50M
First of its kind non-recourse debt facility for deployment

sirajpower.com info@sirajpower.com 800-MYSOLAR

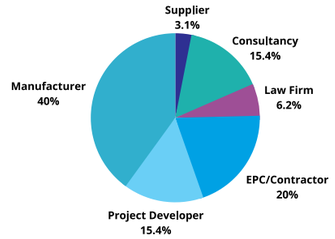
MESIA جمعية الشرق الاوسط لصناعات الطاقة الشمسية
Middle East Solar Industry Association

MESIA AT A GLANCE

MESIA is the only solar-focused, non-for-profit association, bringing together the entire value chain 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 workshops for solar professionals
3. Produce reports on market trends, latest technologies, standards, and best practices
4. Inform and create content to highlight solar developments in the region and for and about our members and partners
5. Assist in the development of policies intended to strengthen the local solar industry

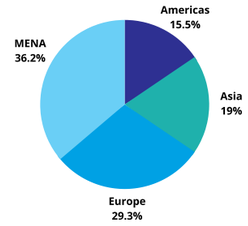
MEMBERS SEGMENTATION



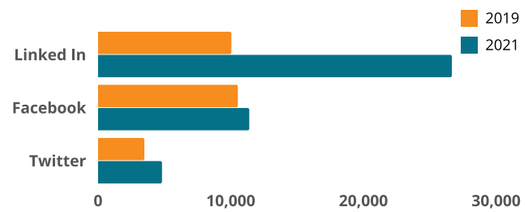
70+

COMPANY MEMBERS AND PARTNERS

MEMBERS BY HQ REGION



SOCIAL MEDIA AUDIENCE GROWTH BY CHANNEL



THE MESIA COMMUNITY

- **23K** DIRECT CONTACTS
- **57%** SENIOR, DIRECTOR AND ABOVE
- **66%** REGIONAL REACH

66K TOTAL SUBSCRIBERS

2 ANNUAL SOLAR REPORTS YEARLY

MESIA PROMOTES, ATTENDS OR ORGANISES

>90 EVENTS & WEBINARS ANNUALLY

Denisa Fainis
Secretary General
MESIA

2021 was a “year of extremes” -as aptly described in the ABC News Live climate change special – so extreme that the world leaders who met for COP 26 in Glasgow ratcheted up the pressure on countries and companies to address the severe impacts of climate change and reduce carbon emissions. The event concluded with the signing of landmark agreements to reduce the use of coal in the power sector.

In the past 12 months, it could be said that we’ve gone from ecstasy to agony. As technology evolves and BOMs (bill of materials) are optimised every year, we’re witnessing rapid advancement in technologies to accelerate the transition to a low carbon economy with the implementation of artificial intelligence (AI) applications. Real time data, advanced analytics and automation are essential for the digitalisation of decentralised power systems and increasingly complex grids.

But global reality kicked in, and most of 2022’s solar PV projects risk delay or cancellation due to an increase in the raw material and logistics cost. The cost of PV modules surged from below $0.20 per Wp in 2020 to between $0.26 to $0.28 per Wp in the second half of 2021 – an increase of almost 50%. Costs continued to rise, closing the year at $0.30 Developers and offtakers will need to face a decision on whether to reduce their margins, delay projects or increase offtake prices. Another burden is the surge in shipping costs, which have increased by almost 500%. The levelised cost of electricity (LCOE) has increased between 10% to 15% for most of the solar projects planned for 2022.

The COP 26 event held in Glasgow highlighted UAE’s climate change efforts, and the country’s remarkable contributions to addressing the matter. The UAE’s Ministry of Energy and Infrastructure were highly commended, resulting in the UAE being appointed as the host of the 28th session of the Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change in Abu Dhabi in 2023. The great recognition is a statement of the pioneering role the country is taking in reducing the carbon footprint, with a commitment of net-zero by 2050. Having the two largest solar plants on the globe, and home to the HQ of IRENA, the UAE’s journey to a sustainable future started many years ago and will continue for the future generations.

Egypt is another Arab country making commendable progress with its renewable energy efforts, having set a target for 42 per cent of its energy to come from renewable resources by 2035 and having recently commissioned one of the largest solar parks in the world at Benban. In recognition of this, Egypt has been selected to host COP27 in 2021.

Saudi Arabia is also making notable progress with its plans to develop clean energy and reduce emissions. In 2021, the kingdom announced its target to reach net zero emissions by 2060. Megaprojects such as the city of NEOM, incorporating green energy plans including a $5 billion hydrogen plant, and the Red Sea Project, which includes a 400MW of solar PV and the world’s largest off-grid energy storage project to date, are part of the kingdom’s development plans. Although controversial, the climate measures will go hand in hand with tending to the continued high demand for

fossil fuels. As the world’s largest oil exporter, more than half of Saudi Arabia’s revenues come from its fossil fuel sector.

Lebanon, which suffered greatly in 2021 as a result of increasing black outs and shortages of diesel for back-up generators, is turning to solar energy. Businesses and residential owners bought more than 200MW of solar equipment online in 2021, with the number of solar companies increasing to 400.The demand is surging, but it is vital that regulations keep up.

Oman is also making commendable progress with its ambitious clean energy programme. Following the commissioning of the 500MW Ibri 2 solar project in 2021, the Oman Power & Water Procurement Company (OPWP) is due to receive final bids for the Manah Solar I and II parks, which will have a combined capacity of 1GW, in early 2022.

Iraq signed a number of agreements for its first utility-scale solar projects in 2021, including a deal with a UAE developer to build five solar power plants with a combined capacity of 1GW. With the country continuing to grapple with major supply shortages of electricity, renewable energy will play a key part in meeting energy demand moving forward.

In addition to developing record breaking domestic solar projects, the UAE is also driving the development of renewables across the Middle East. Towards the end of 2021, UAE investors signed a contract to develop a 300MW solar park in Syria. The park is expected to be built within two years and play a key part in meeting the country’s goal of generating at least 5 per cent of its electricity from renewables by 2030.

Solar energy is also being adopted across the region to provide essential services for populations. In Sudan, solar-powered water pumps are playing a key part in meeting water needs following the damage to vital irrigation infrastructure during the conflict.

While more than 300MW of capacity has been installed under Dubai’s Shams net metering scheme, rooftop solar is yet to take off in much of the region. Progress with developing incentives and robust regulations will be vital for enabling the development of significant residential solar capacity across the region.

Go ahead and dive into the Solar Outlook Report 2022 to discover the emerging trends and technologies driving forward the development of solar across the Middle East and North Africa. Some of the region’s forefront clean energy experts and some of the world’s leading solar companies provide insight and analysis into the technologies, challenges and opportunities that are expected in 2022 and beyond.

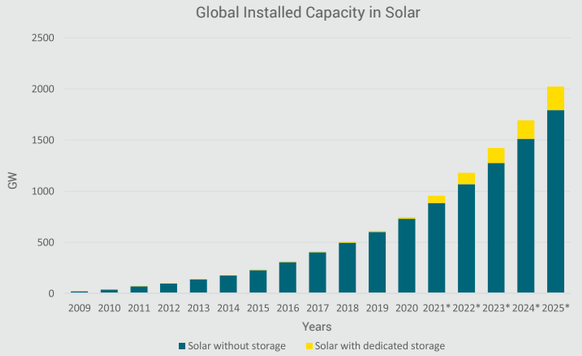
Special thanks to all our members and non-members for their contributions over the years, the ongoing support of the MESIA board and a warm welcome to our new members. All of your efforts and collective support is playing a vital role in driving forward the development of clean energy across the Middle East.

> “The 9th edition of the annual Solar Outlook Report was supported by more than 30 experts that I’d like to thank for their efforts. Partners, members and non-members, we’re always honoured to work with you specially in making this report reflect the solar market reality in the region. I hope our readers benefit from this report that is dedicated to highlight the main solar trends, hot topics and project updates.”

Dania Musallam - Author
Research and Content Manager- **MESIA**

01. Introduction

After a year of lockdown and unpredictability due to Covid-19 pandemic, 2021 pushed the limits to go back on track deploying renewable energy projects. Although the year witnessed fluctuations in solar pricing, material costs and supply chain issues, the market is expecting an improvement by 2022. According to Figure 1, on a global level, the solar installed capacity is expected to increase by almost 1000GW by 2025. Furthermore, projects combining solar and storage will also grow by 30% on average by the next five years.



Sources: International Renewable Energy Association, DNV GL ET) *Estimates and forecasts are based on DNV GL experts and external sources

Figure 1: Global Installed Capacity in Solar

In the MENA region, according the to the Middle East Energy Transition reports, in the first half of 2021, no contracts were awarded for oil-powered or gas-fuelled power stations. However, during the same period, renewable energy projects worth about $2.8bn were awarded in the region. As a result, an exponential progress in renewables is expected and the execution of solar projects shall rise accordingly in the next coming years. Similarly, storage projects are picking up. Also, green hydrogen projects are gradually increasing, and pilot projects are already being implemented. Strategies are also being put in place to engage in the next phase of the energy revolution.

In the Middle East and North Africa (MENA) region, countries have advanced in reaching their renewable energy targets and new projects have come online. Major highlights from 2021 include:

- Saudi Arabias first utility-scale renewable energy project, Sakaka PV Project was inaugurated
- In Q4 , the largest solar panel production plant in MENA was inaugurated in Tabuk, Saudi Arabia
- In Dubai, the first 300MW of phase 5 of the Mohammad Bin Rashid Solar Park was inaugurated in August
- The first green hydrogen pilot project in MBR solar park was in inaugurated
- Algeria tendered 1GW of solar projects in December 2021.
- Two solar tenders for projects with a total capacity of 7.5MW were issued by SEA in Bahrain
- Egypt announced it was planning to increase green bond issuance rate to achieve their sustainable goals
- The 26 MW Kom Ombo Solar Park was constructed in Aswan and is fully operational
- Iraq announced it is planning to develop two 2GW renewable energy projects
- Al Husainiyah Solar Project in Jordan achieved commercial operation
- Morocco received bid proposals for the Noor II PV project
- In Oman, it was revealed that contracts for the Sahim II scheme torooftop solar PV systems on 514 residential premises are expected to be awarded in Q1 2022
- A number of major green hydrogen projects were launched in the MENA region, including a 25GW green hydrogen project in Oman
- Construction works were initiated on the Al Kharsaah PV Project in Qatar

**For a concise overview about the solar market in each MENA country, refer to section 10 of the report.*

1.1 EXCLUSIVE OVERVIEW ABOUT AL DHAFRA PROJECT

The largest PV plant in the Middle East with a capacity of 2GW was awarded to EDF and Jinko Power in 2021, to be located in the emirate of Abu Dhabi in UAE. TAQA and Masdar shall own 60% of the project and 40% will be allocated to the awarded consortium. The record-breaking size project is expected to commercially operate in 2022, as construction already started. The plant will be the largest of its kind and can supply enough electricity to power 160,000 local families while offsetting emissions by more than 2.4 million metric tons of CO2 per year.

Al Dhafrah will serve the community by bringing a whole set of employment opportunities in the UAE through the different phases the project will be going through, from construction to operations and maintenance. In addition, the project creates the need for a whole new set of specializations as this technology is growing massively in the country, according to Farid Al Awlaqi, TAQA's executive Director of Generation. The plant takes a major step forward in the clean energy transition of the country's vision towards net zero.

Solar energy is changing the world energy generation landscape. The latest innovations are being pushed in the market. At Al Dhafrah, crystalline bifacial solar technology will be implemented utilizing both sides of the solar panel to increase energy as well as cell tracking systems.

Zooming into the project's site, the plant's location is abundant in sunlight; however, its inclement natural conditions of high temperature, raging sandstorms and highly corrosive environment propose harsh requirements for the reliability of tracking systems. As a result, the first IEC-certificated multi-point parallel drive tracking system, SkySmart II by Arctech was selected to be installed in the plant. The trackers can cope with the harsh natural environment and reduce the cost per KWh of the project significantly. Furthermore, the system capitalizes upon artificial intelligence technology to learn from and optimize natural environment and device operational data. The backtracking algorithm adopted by SkySmart II calculates the optimal tilt at all times, increasing power generation capacity by up to seven percent in comparison to traditional back tracking algorithms without active feedback systems.

Jordan Hospital - Madaba, Jordan
Courtesy: Yellow Door Energy

2.1 GLOBAL OVERVIEW

Karim Megherbi - *EPDA Executive Director*

In 2021, global investments in the electricity sector reached an all-time high, in the amount of USD 820bn. Renewable energy accounts for the majority of the total, with 70 per cent invested in renewable energy plants. Simultaneously, parts of the world continued investing in the exploration and usage of fossil fuels. On the bright side, to keep up with the increasing energy demand in emerging markets, more investments will be required in green fuel (such as biofuel) or modern biomass amongst others. Furthermore, the level of investment in green energy is way below what is necessary to be on track for a 1.5oC scenario. These investments should double for a +2oC target, and more than triple to hold the line to 1.5ºC.

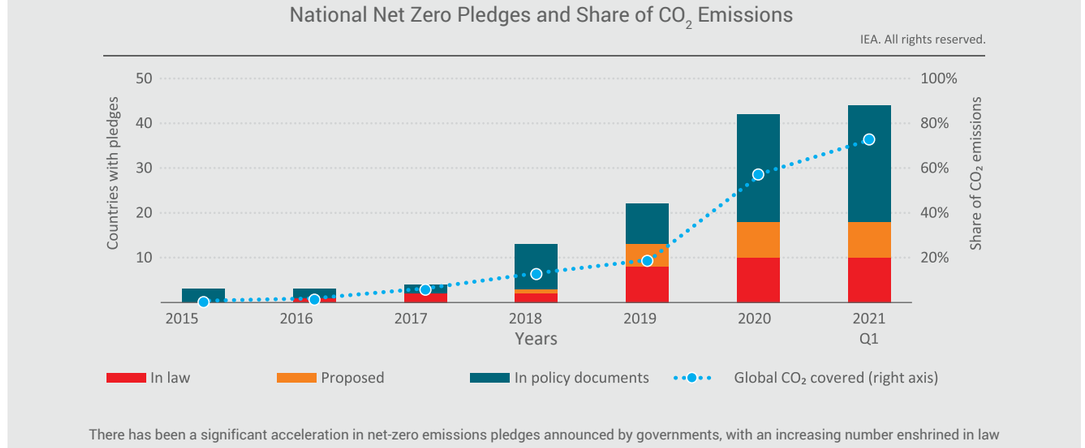


Figure 2: Net Zero Pledges and Global CO2 Emissions

The current situation is expected to improve rapidly in the next few years. To reach the 1.5oC target, many countries have already proposed or injected laws and regulations pledging for net zero emissions. According to Figure 2, initiatives started from 2015 and grew by 40 times, exponentially increasing the number of country commitments. Day by day, more countries are announcing their intentions to reach net-zero by between 2050 and 2060, such as Saudi Arabia and UAE. It is anticipated that green investments in solar, wind, batteries, EVs and hydrogen will grow accordingly.

▸ RENEWABLE ENERGY

Globally, investments in renewable energy were expected to reach a total amount USD 530bn in 2021. Given the tremendous decrease in CAPEX costs as well as the technological improvement in efficiency in the past decade, one dollar invested today in renewable energy generates four times more electricity than in 2010.

According to the Global Market Outlook 2021-2025 by Solar Power Europe, in the first half of 2021 solar witnessed an increase in costs for modules and solar systems. Silicon prices more than doubled, while aluminum appreciated by nearly one-third. Encapsulation material costs grew in the low double digits. Silver - the most expensive consumable of a solar cell besides the wafer – costs went up by 1.5 times. On the system side, steel and copper prices – used in mounting systems or cables – have also

increased. However, the main cost driver has been silicon, where a severe supply shortage has caused its price to nearly double, adding about 20% in production costs. Therefore, module prices went up significantly for the first time in nearly a decade. Although the end of 2020 and beginning of 2021 reflected a drop in costs, estimations are expected to reshuffle in 2022.

The MENA region has been strongly impacted by the Covid-19 pandemic and the increase in PV module prices. All the awarded projects were based on very aggressive business models, which resulted in some companies deciding to delay the implementation of projects in 2021, in anticipation of an improvement to the current situation by 2022.

Despite all these developments, the world is still far from being on track to keep a 1.5°C trajectory. According to IEA, by 2030, net zero trajectory needs to reach 630GW/y of global solar installations, which means a 20% increase average. The gap between what is required to be on track and reality is even wider in emerging markets. It is particularly due to lack of clear regulatory frameworks to attract private funds as well as international companies and lenders. Furthermore, numerous lockdown periods during COVID crisis and the slow economic recovery led to fewer investments and low energy demands, with few exceptions.

▸ GRID AND STORAGE

Although investments in grids have been declining during the past 4 years, they are now set to increase dramatically as part of all investment packages for 2030. This is the case in France, Europe as a whole, as well as the US and China. Even India also has set a target to largely develop its grid, as the penetration of renewables is increasing in all states, many of them having reached more than 30% of the energy mix on a yearly average basis.

Investment in energy storage solutions increased by 40% in 2020 compared to 2019, reaching an amount of USD 5.5 bn. Investment in grid scale batteries rose by 60% and costs reduced by 20% compared to the previous year, 2019. At the same time, market experts believe that there is a need for regulatory frameworks to inject battery storage solutions into the market. They are crucial in order to implement demand-side management strategies to supply flexibility to the grid, a key element allowing a smooth integration of renewables to the grid. Furthermore, batteries were also hard to ship and stock as there aren't enough conditions to properly store storage solutions.

▸ HYDROGEN

Different segments are necessary to develop the 1.5oC scenario. Those include electricity storage applications providing flexibility to power systems, the production of hydrogen-based synthetic fuels, which could be used to the aviation, marine and long-haul trucks as well as industry applications.

In 2020 more than USD 70m has been invested in electrolysers, and capacity of electolyser projects have reached 65MW, which falls below the 140MW target set by the developers. Most of the projects in the MENA region are mainly focused on the power sector, as some countries consider both hydrogen and ammonia. Countries in the MENA region, such as Oman, Saudi Arabia and Morocco, benefit from significant vacant land, high solar radiation and good wind resources. Additionally, the region provides access to ports with all necessary logistic facilities and aligns with the country's strategy to partner.

The following segments are expected to drive the future H2 demand:

- Industrial application (in particular iron and steel)
- Chemical production
- Ammonia production
- Transport – such as ammonia for shipping, or e-kerosene and e-methanol for aviation
- Power Sector – to provide flexibility to the grid (to store)

The MENA region has started to take strategic steps toward the production of hydrogen with a goal to become an international hub. The strategy has been so far to sign MoU with different countries in order to study the possibility of creating a hydrogen supply chain for potential large consumers, such as Japan and Germany.

Example of some initiatives announced between 2020 and 2021 in MENA:

- In September 2021, Saudi Aramco, the Institute of Energy Economics, Japan and JBIC successfully carried out the 1st shipment of ammonia (40 Tonnes) produced from fossil fuels with carbon capture, utilisation and storage (CCUS)
- In May 2021, an international consortium announced the start of the development of the Green Fuel Mega Project in Oman, a 14 GW electrolysis project powered by 25 GW of wind and solar, with construction planned in 2028 to end in 2038
- DEWA and Siemens have inaugurated for Expo 2020 the first renewable energy powered electrolysis
- In 2020, DEME announced the first initiative to develop 200-250MW of electrolyzers in Oman. Another project has been announced, by ACME and the Oman Company for the Development of Special Economic Zone, with the target to produce 2,400 t/day
- In Saudi Arabia, Air Products, Acwa Power and Neom signed an agreement in 2020 to develop a USD 5bn electrolysis project powered by 4GW of PV and wind, with the objective to produce ammonia which could be exported globally

Audi - UAE
Courtesy: Yellow Door Energy

In the MENA region, the total installed solar power capacity is increasing as initiatives to implement sustainability goals are approaching. By 2025, almost 40GW of solar is expected to be added. On the other hand, as Figure 3 shows, solar-plus-storage projects will also increase almost tenfold. The future of solar relies on several factors, but one of the most important is technology and its advancement. TOPCon technology is anticipated to revolutionise the solar market as cell efficiencies are expected to increase over the next year in the market.

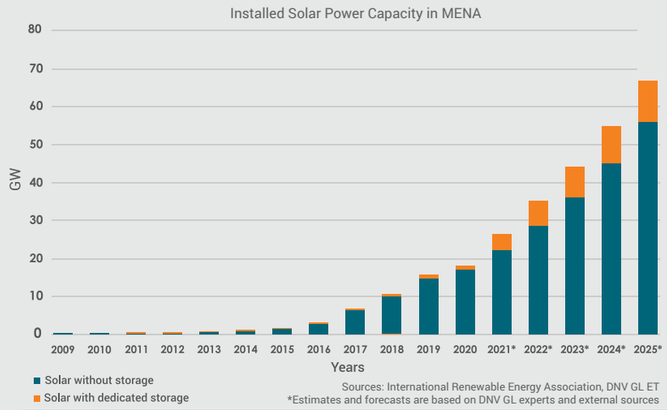


Figure 3: Installed Solar Power Capacity in MENA Region

3.1 SOLAR PV TECHNOLOGY OVERVIEW

The global solar PV market installation capacity was expected to reach beyond 150 GW in 2021 according to many market studies. Compared to the cumulative installed solar PV capacity up to 2012, 100 GW, today, the solar market is growing to become the new king of energy markets. This development was caused by the variety of technologies offered by Tier1 suppliers in the market.

Technologies such as Passivated Emitter Rear Contact (PERC), Half Cut (Cut), Multi Busbar (MBB) and bifacial cells have proven themselves to be mature and reliable. They have become mainstream technologies globally and in the MENA region.

To be specific, the development of PERC technology was a milestone in the solar PV market. PERC is today´s mainstream technology (p-type gallium doped) with a 90% share of the PV market. The technology shifted the market approach from low efficiency low power modules into high efficiency high power modules and paved the way for bifacial modules to become mainstream. It also led the market to even the price between poly and mono, and production of preponderantly poly modules to decrease. Yet, what is the next technology that shall revolutionise the solar industry as PREC?

The PV market is now dominated by the P-type modules where it makes up most of the production capacity of Tier1 suppliers along with limited capacities of N-type for specific markets and applications. However, since the industry is currently reaching the theoretical limits of PERC technology (around 24.5%), it's clear that switching from P-type to N-type modules will be the next step in the market.

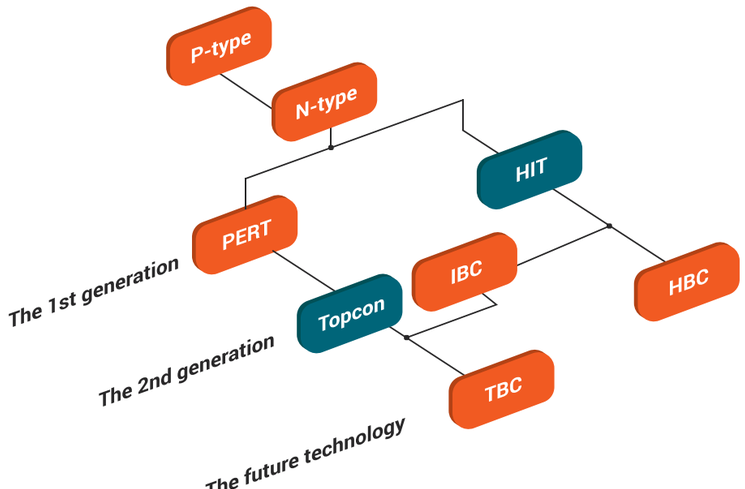
3.2 N-TYPE TECHNOLOGIES

N-type modules have been available in the market for a quite a while, but, until recently, they were considered premium products. However, the current developments of mature technologies such as Tunnel Oxide Passivated Contacts (TOPCon), solar cell technology n-type phosphorus doped with a thin oxide between emitter and Si wafer (base), and Heterojunction Technology (HIT), n-type phosphorus doped with amorphous layers on c-Si wafers, along with the improvements in N-type production machines are allowing these technologies

to become more competitive, with P-type modules. As a result, many Tier1 suppliers consider increasing the production capacity of N-type modules starting from 2022.

On one hand, Heterojunction Oxide Tunneling (HOT), known commercially as Tunnel Oxide Passivated Contact (TOPCon), is considered to be the second generation PV technology after PERC. To manufacture it, few additional steps should be included in production lines converting PERC to TOPCon. As a result, minimum capital investment is needed. Ultimately, this affects price differences between the P-type PERC and N-type TOPCon technologies, which can be less than 10% compared to other N-technologies.

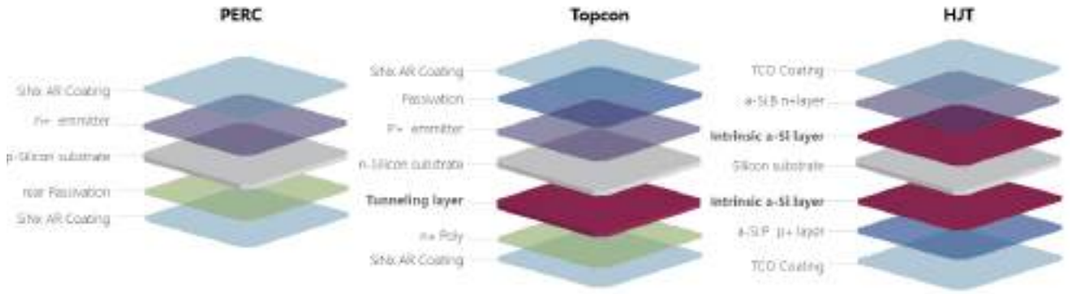
On the other hand, HIT would need a few more production steps to manufacture, compared to TOPCon. However, the current PERC line cannot be optimised for HIT production. Thus, HIT would require new production lines to be procured, which consequently requires larger investments.



Source: Jinko Solar

United Foods - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

3.3 TOPCON VS HIT TECHNOLOGY



Source: Jinko Solar

The simple concept of a TOPCon technology is adding a tunneling oxide layer. This layer will allow the majority carrier to pass though it while restraining the minority carrier pass. Accordingly, it will reduce the recombination process happening in the bandgap and will result in lower resistance losses and carrier recombination, opening a circuit voltage (Voc) increment.

TOPCon has signific advantages over standard PERC technology, some of which are shown in below table:

Table 1: TOPCon vs PERC Technology

	P-type PERC	N-type TOPCon
Module efficiency	21%	22%
Temp coefficient	0.35%/C°	0.30%/C°
First year degradation	2%	<1%
Annual degradation	0.55%	0.40%
Bifacial factor	70%	85%

Because of listed advantages in Table 1, it is estimated that the N-type TOPCon will improve energy generation by at least 3% and will reduce the Levelised Cost of Electricity (LCOE) by at least 5%.

On the contrary, the Heterojunction technology (HJT or HIT) concept is the addition of two layers of amorphous silicon surrounding the crystalline silicon cell. These layers have different energy bandgaps than crystalline silicon. Ultimately, this structure will provide a selective barrier for electrons and holes to cross to the other side, which will also lead to reduce their recombination.

Although the current structure of TOPCon is considered to be a new technology, it witnessed rapid developments in cell conversion efficiency during the last few years. TOPCon showed huge improvements in its cell conversion efficiencies and even surpassed the well-established HIT technology. Particularly, TOPCon has a theoretical limit of 28.7% which is higher than HIT's limit of 27.5%.

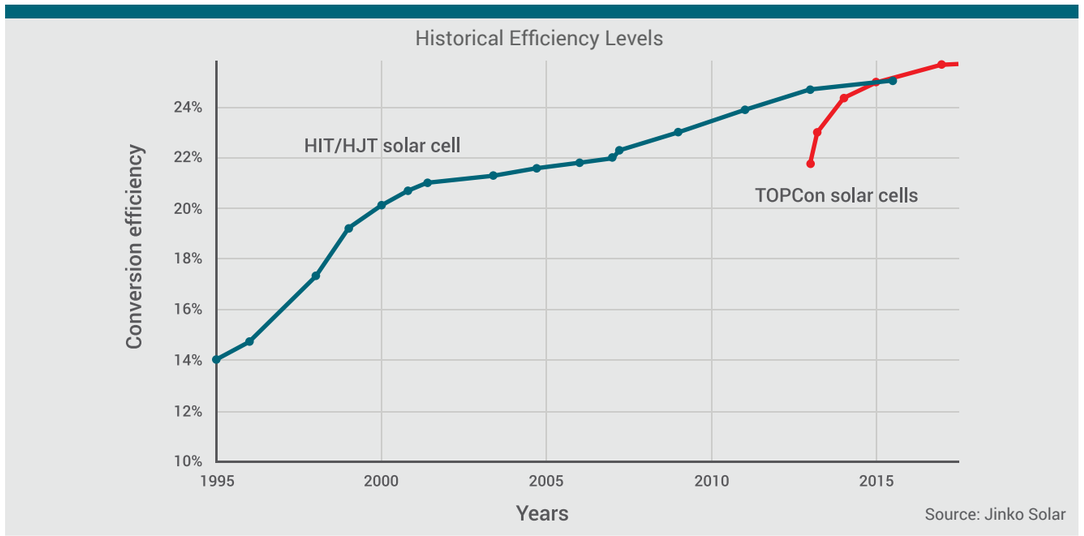


Figure 4: Historical Efficiency Levels

A wide adoption of TOPCon is expected on a global scale, Figure 4. In 2021, the world has witnessed a rapid development of the technology. Suppliers and research canters broke many world records in TOPCon technology including cell and module efficiencies in the past two to three years. Most recently, Jinko Solar broke a world record in cell efficiency reaching 25.40%. Furthermore, many suppliers have already announced increasing TOPCon capacities starting in 2022.

3.4 BIFACIALS IN ACTION

Radovan Kopecek - *CTO & Co-founder - ISC Konstanz*

The king of PV is bifacial PERC in combination with HSAT (Horizontal Single Axis Tracking) reaching LCOEs (Levelised Cost of Electricity) down to 1 USct/kWh. Bifaciality is therefore becoming mainstream, as can be seen in Figure 5 on the left as summarised by International Technology Roadmap for Photovoltaics (ITRPV). In 2021, it already penetrated half of the PV market, from 2028 on reaching a market share of 70%. Assuming a 1 TWp/year market from that time, this then means 700 GWp/year bifacial technology production, which is more than double of today's overall cell and module production capacity.

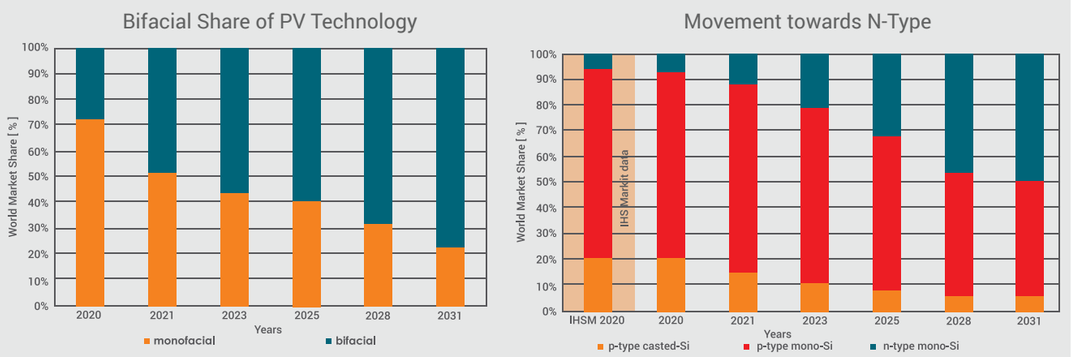


Figure 5: Graphs from ITRPV 2021 showing (left) bifacial share of PV technology and (right) the movement towards n-type technology.

With about 21% module efficiency, PERC is coming to its limits, whereas n-type with TOPCon, HJT and Interdigitated Back Contact technology (IBC), solar cell technology with both contacts (emitter and base) on the rear side, can reach stable module efficiencies well above 22% already today and above 23% in future. That is why IRTPV is proposing a fast grow of n-type technologies in the future with a market share of 50% from 2031 on - all products then naturally being bifacial.

» Bifacial PV Systems and Bifacial Gains

In which configuration bifaciality can be used and how the bifacial gain affects the total energy yield can be seen in Figure 6 and Table 2, respectively. Figure 6, in a to c, depicts three fixed tilt geometries and, in d, a HSAT configuration with one module on each side of the tracking axis. The broadest and highest power generation curve, shown in e, is produced by a bifacial HSAT system (black solid line), which results up to 45% yield gain compared with a monofacial fixed tilt system (blue dotted line) which is shown in Table 2. This was first shown by Enel in La Silla PV system in Chile.

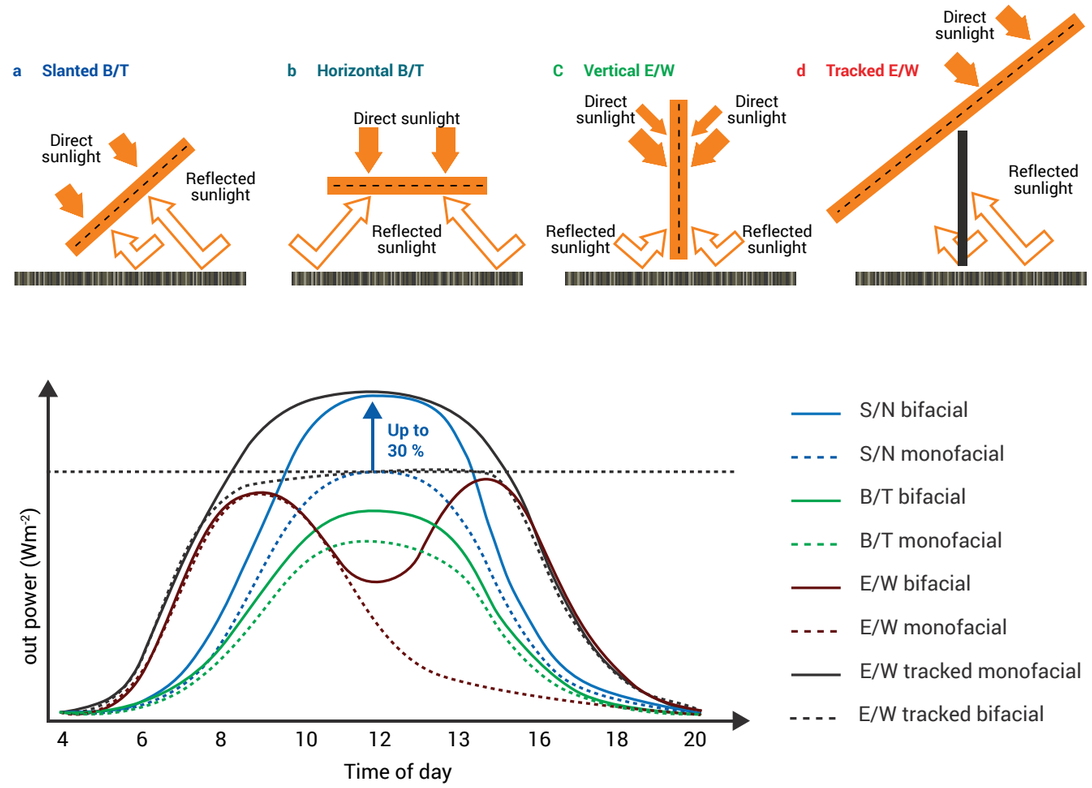


Figure 6: Geometries for bifacial systems and schematic power curves as a function of time of the day for each arrangement comparing monofacial with bifacial systems.

The energy yield ranges can be seen in Table 2, which is reworked from a white paper from pi Berlin. Fixed tilt monofacial installation is taken as reference (100%) and the yearly energy yields are summarised for different installation geometries. The range of gains are influenced mostly by the bifacialitaly of the module, installation geometry, albedo and the installation site.

Table 2: Energy yield increase from bifacial systems in comparison with monofacial counterparts

Installation geometry	Monofacial [%]	Bifacial [%]
Fixed tilt (flat roof)	100	105 - 115
Fixed tilt (utility scale)	100	107 - 130
Vertical (utility scale)	-	95 - 112*
HSAT (utility scale)	110 - 122*	117 - 145

**comparison with monofacial fixed tilt*

» The Future of Bifacial PV Systems in Desert Areas

From Table 2 it can be seen that the highest gains, that means also the highest energy harvest, can be generated with a HSAT bifacial PV system. Furthermore, Table 3 looks deeper into the numbers and compares different module technologies with different properties at a site with 30% albedo and a tracking gain of 20%. The modules compared are PERC, TOPCon and IBC- which have different properties and costs. Due to a lack of reliable numbers for HJT, it has been left out.

Table 3: Bifacial module properties and resulting LCOEs in high albedo regions.

Technology	PERC	TOPCon	IBC (ZEBRA)
Module characteristics			
Module efficiency	21%	21.5%	22%
Module bifaciality	75%	85%	80%
Temperature coefficient of Pmpp	- 0.35%/K	- 0.30%/K	- 0.30%/K
Initial degradation Due to LID/LeTID	2%	0%	0%
Module costs	20ct/Wp	21.5ct/Wp	28ct/Wp
LCOE for bifacial HSAT: assumptions and results			
WACC (weighted average cost of capital)	5%		
Yearly GHI	1700 kWh/m2		
Ground albedo	30%		
Tracking x bifacial gain	20% x 15%	20% x 17%	20% x 16%
Energy yield (after 1st year degradation)	2294 kWh/kWp	2387 kWh/kWp	2382 kWh/kWp
LCOE	2 USct/kWh	1.9 USct/kWh	2.1 USct/kWh

Assuming a site with 1700 kWh/m2 and a 30% albedo it can be seen that, even if the module costs are higher for TOPCon, the LCOE is the lowest. nPV technologies, which are nowadays used mostly for roof-top applications, are becoming more and more visible even on special utility scale markets (with high albedo and high temperature), as the costs/Wp are getting closer to PERC. The major challenge for nPV is to reduce the Ag-content in the device and finally to replace the metallisation fully by Cu or Al.

OUTLOOK

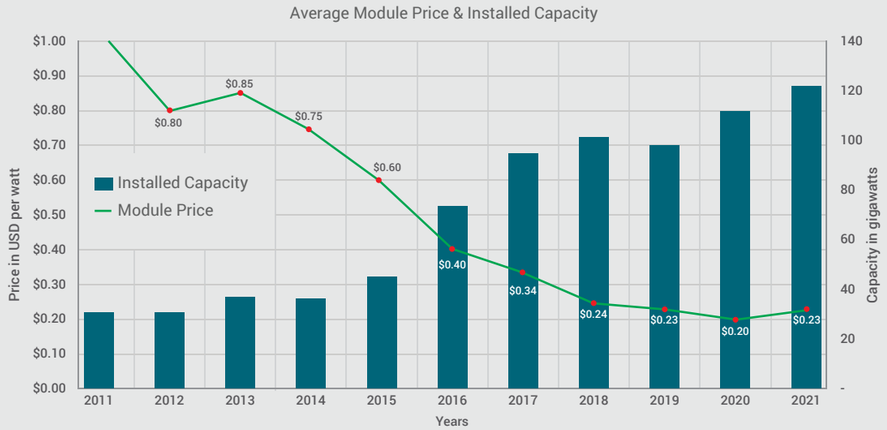
The annual improvement of PV modules is still going strong. In 2020 the industry witnessed impartments in wafer size, the number of busbars and more reliable BOM. However, in 2021, major improvements in cell technologies were observed. It is anticipated that the second generation of N-type PV technologies will lead the solar industry in the coming few years.

PV already is, with bifacial PERC in HSAT systems, the king on energy markets reaching electricity costs down to 1USct/kWh. With nPV, PV will become the new emperor reaching electricity costs well below 1USct/kWh in future. First of all large “nPV utility scale systems” will be set up in hot desert regions in MENA, Chile and US. TOPCon will be “the next big thing” for such applications first and in the future have the highest market share in the entire PV arena.

Although TOPCon and HIT are the favoured technologies today, other technologies such as Interdigitated Back Contact (IBC) are also coming to light. We may also see a combination of TOPCon and HIT with IBC in the near future, which will be the third generation of N-type technologies.N-type technologies.

4.1 SOLAR PRICES

David Dixon - *Senior Analyst - Rystad Energy*



Source: Rystad Energy Research and Analysis, ITRPV

Figure 7: Average Module Price & Installed Capacity

A domino effect impacting solar supply chain was vividly witnessed in 2021. Multiple fluctuations in prices were observed throughout the year mainly because of the strong demand due to the postponement of projects from 2020. Consequently, many utility scale projects were delayed, postponed, and may face cancellations. To take a closer look on the major changes in 2021:

Module Prices - Modules are considered one of the major components affecting the price of projects. The steep increase of module prices in 2021 were mainly due to the rise in polysilicon costs. Compared to January 2020, the price increased by 300%. In addition, other raw materials such as silver, copper, aluminum, and glass were also impacted by price inflation. Therefore, module prices increased from "below $0.20 per watt peak (Wp) in 2020 to $0.23 per Wp in the first half of this year and then to between $0.26 and $0.28 per Wp in the second half of 2021 – a near 50% increase in a year" according to Rystad Energy.

Shipping Costs - Due to Covid-19, the current global shipping situation is unique, and the challenges were not predicted. Shipping prices from China to the Middle East have almost tripled from pre-covid to date. Container rates are sharply increasing, and shipping schedule reliability and availability are unpredictable, as many factors are impacting the situation. Furthermore, experts believe that the surge in shipping costs will continue until Q3/Q4 of 2022.

PPAs - Many studies and contracts were made on prices from 2019 and 2020, however, many contracts are being re-negotiated to cope with the changes in the market. With modules and shipping costs reserving almost a third of a project's cost, LCOEs will be impacted. As a result, it is predicted that projects might be cancelled, delayed or adjusted. Offtake prices could also increase to adapt to the new market conditions and get projects to financial close.

OUTLOOK

The journey to inject more than 1,000 GW of solar globally by early 2030 achieving the 1.5 Celsius target might be rough. Solar prices have significantly increased in 2021 and the future is not predictable. Prices have reached unexpected levels witnessed in 2011 but solar experts are hoping for an improvement by the early quarters of 2022.

4.2 FLOATING SOLAR – CHALLENGES AND EXPERIENCE

TÜVRheinland® Precisely Right.

Floating Photovoltaics (FPV), sometimes also called floatovoltaics, are solar panels on a floating body on water, mostly reservoirs or lakes, but sometimes also offshore on salt water. The technology opened new opportunities for developing solar, particularly in densely populated countries with high cost of land. The market for this technology has grown rapidly in the last 5+ years. Most experience has been collected in Asia, but in recent years many systems are starting to get deployed also in Europe. Some countries have started to give special funding for FPV projects or product development (e.g. Germany Federal Network Agency definition from 01 October 2021).

As with any new technology, there is some uncertainty regarding reliability and code compliance which may impact the bankability for some projects. As holistic standards for FPV have not been developed yet and field experience is limited, compared to ground mounted PV, it is essential to look at the potential additional technical risks and take measures to mitigate those.

The various environmental factors influencing FPV reliability are partly additional stresses compared to ground mounted systems. Wind and wave caused stresses are of major concern. However, the reflection of sunlight from the water surface that increases the energy yield of a FPV system increases the potential of UV related degradation mechanisms. Furthermore, potential snow and ice loads need to also be taken into account when dimensioning floats. As some systems have experienced snow accumulation, floating bodies could not carry the extra weight and modules were sinking or below water level. Finally, vegetation and fauna cannot be neglected. Sea birds may see a good place to rest and leave plenty of dirt behind on their departure. Also, barnacles and fern can create a new home on FPV systems.

The system components of FPV are different or include additional parts than conventional PV systems. Two main design concepts have come to dominate to date: floats made from high-density polyethylene (HDPE) or of reinforced hydro-elastic membranes. Both variants can offer advantages depending on specific project conditions and design. However, given the challenge of both coping with and protecting the surrounding environments, correct dimensioning and design is crucial.

Figure 8: Influencing Factors for FPV Systems

Since there is a critical need for an international standard for floating bodies, companies such as TÜV Rheinland have put together a test specification to address the various stresses FPV bodies need to withstand. TÜV Rheinland has established a list of test methods in its in-house standard 2 PfG 2731/02.20 to allow the assessment of various designs that includes a number of mechanical tests looking at the load baring capacity, tensile strength and elongation under heat. Furthermore, environmental tests like UV resistivity, temperature resistivity, water tightness and buoyancy tests are part of the assessment. Finally, demo systems are taken to a wave laboratory to assess reaction to wind and wave exposure. First floating systems have undergone this extended testing procedure, and more are currently under test.

Since some bodies are smaller than the modules that get installed on them, the mounting situation needs to be carefully checked. The typical spread of mounting clamps at a 2/3 position of the module length may not be applicable to all designs. Should the mounting instruction of the module maker not be applicable, it is imminent to test the mechanical strength of the modules under a real installation situation. As dynamic loads through wave and wind are expected, it is recommended to request for a Dynamic Mechanical Load Test in accordance with IEC 62782. Should the system be for sea water, a Salt Mist Corrosion Test following IEC 61701 is applicable to all critical components.

Many insulation resistance issues were reported at FVP systems. Furthermore, FPV projects were also facing the risk of long-term exposure of electrical components to water. As a result, companies such as TÜV Rheinland recommended certain requirements for cables to be used to improve water resistance for installation. Generally, cables qualified against IEC 62930 respectively EN 50618 have not been qualified for long-term submersion and may hence have issues in such harsh and moist environments. The new industry standard by TÜV Rheinland 2PfG 2750/09.20 shall allow PV cables to be qualified for improved water resistance. Similar standards are under development for other floating system components like connectors and wiring compartments.

The issue of safe and cost-effective anchoring and mooring concepts were also garnering increased attention. Strong wind events or high wave activity as well as long-term fatigue and corrosion are real threats to the anchoring and mooring systems, and hence, right choice of components and dimensioning is essential.

Besides components, O&M practices and preventive actions against flora and fauna influencing FPV system performances need to be adjusted to onsite conditions. Until today, the investigation of the bio compatibility of some materials used in FPV systems is still on going. It is important for the industry to work together and share the learnings from real installations to make full use of this additional potential for solar energy use.

Solar Diesel Hybrid for Fakieh Hatchery- Lith
Courtesy: Haala Energy
Photo Courtesy: Khalid Al Sudairy

4.3 SOLAR CSP FOR C&I APPLICATIONS

N P Vincent - *CEO - Energylink*

Concentrated Solar Power (CSP) has reached some key milestones in recent years. The oldest CSP facility is now being retired, Chile was able to see an opportunity for the lowest utility scale CSP tariff so far, and in the MENA region, DEWA is set to break records with the 700MW MBR Park completing the largest CSP development in the world. All the indications are that CSP has reached a pivotal point in its development. CSP remains the only solar solution for 24 hours dispatchable electricity similar to conventional sources of electricity generation. CSP is versatile and can easily be combined with conventional Combined Cycle Gas Turbines and Geo-Thermal solutions, to name a few, thus improving efficiency, reducing emissions and improving response to the electricity demand. However, CSP technology for applications between domestic hot water and utility scale CSP, a sector we shall call “CSP Commercial”, the uncertainty and hurdles remain.

The United States and Spain lead the way in CSP for utility scale projects and therefore a majority of the developers originate from the US and EU regions. However, local market players have also established immense credibility in the MENA region by developing utility scale CSP projects. For example, as a result of the MBR Solar Park in UAE, significant regional competency and capability has been developed. Supported by governments and financial institutions, projects such as the Enhanced Oil Recovery project in Oman and the 400kWe CSP blocks in Morocco have also been explored for relatively smaller scale CSP projects. These projects cannot be strictly classified as CSP commercial projects, but they offer a glimpse of the possibilities for CSP at the commercial scale.

CSP can be used for heat and power (electricity generation) applications. The efficiency of a CSP in converting sunlight to electricity has a direct correlation with the temperature of the working fluid. Achieving higher temperature in the working fluid requires larger fields and more concentration of sun, thus, making utility scale an ideal size. Heat as a primary application is relatively more energy efficient because there are fewer conversion losses between forms of energy, as opposed to electricity generation. This requires compatibility with other heat generating solutions in order to explore possibilities for cogeneration. The applications for heat directly is suitable for numerous commercial applications such as:

- Food & Beverage Processing
- Pharmaceutical, Chemicals & Plastics
- Heating for Hotels, Resorts, Apartment Buildings & Communities and
- District Cooling (Absorption Refrigeration Cycle)

The combination of heat and power as outputs present the opportunity for wider applications. In the applications listed above addition of CSP will serve to improve the efficiency of operation and will be supplemental to existing sources of heat and power. Thereby creating a smoother transition from one source of energy to another in a phased manner. The scale of the CSP solution is, perhaps, still larger than most individual commercial applications, requiring a district level solution that is integrated into multiple industrial requirements.

One of the hurdles for wider adoption of CSP in the MENA region has been the need for high volume of water not only as a working fluid (in some applications) but also for cleaning. With the growth in alternative working fluids and solutions that use air as a working fluid this hurdle can now be crossed. Across the MENA region several power generating and heat applications utilise natural gas as fuel, this ties in well with upcoming solutions. For applications such as low-pressure steam, hot water and district cooling (absorption cooling) roof space can be explored as an installation location for fresnel collectors which are light and aren’t encumbered by complex tracking requirement.

The solutions that are available for CSP commercial are similar to those of the utility scale and the solution design requires similar level of detailed engineering. The hurdles are also similar to those faced by solar PV at the nascent stage. The solution engineering, equipment manufacturing, and construction are not streamlined; this results in uncertainties streamlined; this results in uncertainties in the project meeting its technical and commercial goals. This phase of the market development is expected and will be overcome through development of better solutions. The confidence of early adopters will improve as empirical proof from successful implementations become available.

The growth will also be dependent on exploring and discovering reliably successful use cases. CSP technology continues to develop with various innovations such as the adoption of the Brayton Cycle based solution that uses air as the working fluid, using pressurised storage tanks as thermal storage and steam piston engines to convert lower temperature steam to mechanical work. The solutions also explore standardised modular blocks for deployability and scalability.

Solar PV is the vanguard for CSP, the versatility of solar PV has proven that solar as an energy source can be applied to numerous requirements. Breakthrough will occur when solution providers can demonstrate clear advantages as opposed to conventional technologies. Complexity of the CSP solutions will be more addressable as expertise and experience increases. The rate of growth of solar PV indicates that as CSP technologies improve, and the threshold of complexity in comparison to other solutions is resolved, there will be greater adoption. As the adoption rate improves, manufacturers and solution providers will have a reliable track record of successful projects. This will lead to investors and banking institutions being able to model the technical, financial & operational risk more accurately, which will improve the bankability of CSP. The addressable market is indeterminable at the moment; however, this will improve as solutions and adopters increase. Regulatory facilitation in identifying and capitalising on opportunities for CSP solutions will be vital to growth.

In the case of the MENA region, with limited potential for hydro, geo-thermal and wind, CSP offers flexibility to apply the power of the sun to more of our requirements. The MENA region has been one of the leaders in adoption of CSP, the various projects across the region is testament to this act. As the need for alternative sources of energy for diversification away from fossil fuel burning solutions increases, the need to adopt CSP also increases. CSP requires the adopters to think beyond electricity and fossil fuels as energy sources for heat. Ubiquitous adoption of CSP for applications at the commercial scale will improve the diversification goals of countries in the MENA region.

Audi - UAE
Courtesy: Yellow Door Energy

4.4 DISTRIBUTED SOLAR

SirajPower

There has been an increase in investments towards the solar rooftop market in the MENA region, as policies or visions are being put into place. Today, the main countries that have embraced investments in distributed solar include the UAE, Jordan, and Egypt. However, distributed solar initiatives have also been launched recently in Saudi Arabia, Bahrain, Oman, and other countries.

In the MENA region, the UAE, particularly Dubai, is taking the lead in the growth of solar rooftop investments, with over 300 MW of cumulative distributed solar connected to the grid. Its market has well-established solar regulations, relatively high utility tariffs, creditworthy customers, and openness for the private sector to enable the distributed solar market through unique financed solutions. Consumers in Dubai today are well educated on the economic and sustainability benefits that solar rooftop solutions offered by the private sector. DEWA launched its Shams Dubai program back in 2015, which gave the distributed solar market players sufficient time to go through that initial steep learning curve, improve their competitiveness, and establish a mature market. Furthermore, it is anticipated that similar regulations will also come through in the other Emirates of the UAE to meet overall decarbonisation objectives. The Northern Emirates offers excellent potential for solar investments, given that the grid electricity prices are comparable to Dubai.

As regulations for distributed solar come to fruition, many organisations are considering expanding in countries like Saudi Arabia, Bahrain, Oman, Jordan, and Egypt. Tremendous opportunities for growth in solar investments are foreseen in the coming years as solar becomes more competitive and subsidies electricity tariffs are slowly lifted in selected countries in the MENA.

An increasing growth rate is witnessed in the solar rooftop market. The UAE and Saudi Arabia take the lead in the market for distributed energy, whilst Oman emerges as the fastest-growing market within the region. When it comes to the UAE, the country has been at the forefront of clean energy transition within the Gulf region. Its vision is to produce 75% of its energy from clean sources by 2050. Moreover, solar rooftop usage is increasing with a significant demand for solar PV projects which is in line with the targets set by the region for renewable energy. Yet, challenges need to be overcome to achieve similar success in other regions.

The main challenge observed in the distributed solar space in many parts of the MENA region is either restrictive regulations or lack of regulations entirely for on-grid systems, which is the primary driver for kickstarting solar markets. Regulations in some countries make it very restrictive with stringent criteria that shrink the market size. Moreover, the tough challenge is for regulators to be open for private developers to enable this market through financed solar solutions. Today, many customers understand the benefit of outsourcing solar to a private developer, where interests are aligned, rather than self-investing in a system outside their core business. The above-

DEWA Solar Park - UAE
Courtesy ACWA Power

mentioned regulatory and restrictive challenges are perceived risks for private sector investments, limiting market growth potential. Nevertheless, the market has witnessed the success of net metering regulations adopting this scheme.

The cost of solar energy has reduced to a level that storing excess output behind the meter is feasible in the C&I market. As seen in other parts of the world, energy storage systems create additional value, such as peak shaving and providing backup and ancillary services. When all these values are stacked, energy storage becomes attractive at the current mainstream lithium-ion battery system cost, which is the case for Dubai. Furthermore, utility companies would need to adapt their regulations to take advantage of distributed solar and storage systems. The adaptation could be quite fast, as an increasing number of electric vehicles is observed on the road, boosting the demand for the existing grid infrastructure. The utility companies would benefit the most from the distributed solar rooftop & storage systems to tackle the increasing demand.

OUTLOOK

Decreasing solar energy costs combined with evolving regulations should unlock premature rooftop markets and facilitate rapid growth. Adaption of electric vehicles would commercially incentivise both utility companies and end-users to install solar rooftop systems combined with energy storage. Utility companies would embrace solar rooftop systems without compromising their revenue stream, thanks to the adaptation of electric vehicles.

"Hybridisation", such as combining solar and wind with storage, will become more prevalent and other disruptive technologies such as high-efficiency solar and solar integration into buildings are also being considered.

The UAE recently announced that it wants to reach net-zero a carbon emissions by 2050. Having the net-zero concept embraced by an increasing number of countries worldwide, with incentivised stakeholders, will lead to exponential growth in solar rooftop investment in the next 5 – 10 years.

4.5 RESIDENTIAL SOLAR

N P Vincent - *CEO - Energylink*

Electric consumption of the residential sector accounts for nearly 30-40% of total consumption in most MENA countries, making the residential sector a major contributor to emissions from electricity generation. Therefore, residential solar is an important component for the transition to renewable energy sources and the reduction of carbon emissions.

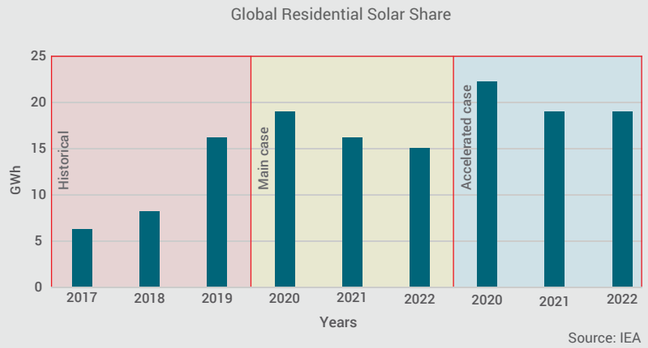


Figure 9: Residential Solar PV Capacity Additions and Forecasts

The residential sector is unlike commercial & industrial (C&I) and utility scale solar segments, with individuals and families having different expectations from their solar installations. This requires a differentiated business development approach for the residential solar sector. Unless a solar installation is for a community developer, proposing integrated solar for houses, the approach from residential owners to solar adoption is very similar to their decision-making process for other purchases of similar value.

The primary reason to install solar for residential customers is cost, in other words, the potential for reduction in cost of electricity. Residential customers expect that generating their own electricity, and thereby being self-sufficient, provides a predictability to their electricity supply. Other important influences in the purchase of solar for their homes include aesthetics, environmental responsibility and societal status. This mélange of customer expectations need to be met by solar equipment manufacturers, developers, financiers and regulating authorities. To successfully grow the residential solar market, the various service providers and stake holders need to work together to create the right balance of customer service and regulatory environment, providing impetus for individuals to take action.

DEWA's Shams Dubai program has been the leading and most effective program for solar net metering for the residential sector in the GCC. Programmes in Saudi Arabia and Oman have been launched more recently and are yet to gain traction. Effective energy efficiency programs such as those implemented by Abu Dhabi, Dubai and Ras Al Khaimah have shown progress in achieving energy conservation goals without the need for rapid growth in residential solar.

The net metering policies in the GCC market are favourable to the residential customer but they are of marginal benefit in comparison to the status quo. Given that the electricity prices in the region are stable and unlikely to be impacted by inflation, the motivation for customers to adopt solar for better prices is unlikely. However, given that it is hard to predict what the prognosis will be by looking at the current scenario in terms of solar prices deploying solar is still feasible but with an increased return on investment period if the hit is taken by solar developers. Moreover, stable electricity supply and reliable transmission infrastructure counterintuitively works against the growth in solar. A majority expatriate population, which are predominantly renters rather than owners of their residential properties, also contributes to the lack of motivation to change and embrace rooftop solar.

The launch of residential net metering programmes in Dubai, Oman and Saudi Arabia led to several businesses being launched to address the residential solar segment. However, the subsequent lack of significant growth led these businesses to either exit the market or pivot to more promising segments such as the C&I sector. This resulted in insufficient development of an operational method that is specific to the residential sector. In addition, unlike other counterparts in the US & Australia, developers in the GCC have limited financing options to offer residential solar customers. The lack of finance providers catering to the residential solar sector is a consequence of insufficient market demand.

The regulations and compliance requirements for interconnection of solar to the electricity grid are stringent because of the political and economic sensitivity regarding transmission and distribution systems. Additionally, municipal and development authorities also require the solar structural integration and construction to comply with their codes. These requirements create a procedural requirement that is often difficult to overcome in a short time and requires customers to exercise patience during the compliance process. Residential solar developers in the US and Australian market have the same constraints but, due to the steady growth and high demand, solution providers have stepped in to facilitate the solar permitting process for developers.

Worldwide:

The European and US electricity markets are evolving to accommodate distributed energy resources (DER), consisting of battery storage and smart devices in addition to solar, where demand side management is implemented to match the intermittent nature of renewable energy generation of electricity. A collection of such DERs are, in some cases, integrated through IoT control mechanisms to act as virtual power plants (VPP). In addition to these developments, the growth in electric vehicles, demand for a renewable source of electricity for charging. Also, vehicle to grid (V2G) requirements is a new factor to be considered.

The electricity transmission and distribution system that has traditionally been unidirectional from the point of generation to point of demand is fast evolving into a bi-directional system where customers now generate, store and consume their own energy. Meanwhile, solar photovoltaic efficiency for electricity generation continues to improve in tandem with the improving energy efficiency of household electrical equipment.

In response to these new trends, regional utility providers and regulators are seeking to carefully transition their existing infrastructural investments in order to accommodate these expectations. Existing generation and transmission infrastructure is an investment in assets that needs to be protected and evolved, to accommodate the changing nature of the electricity consumption.

From the perspective of residential customers, early adopters of solar and energy efficient electrical equipment for their homes will benefit from immediate savings in expenditure on electricity. Individuals purchasing electric vehicles will find a residential solar solution capable of meeting the total electricity required for typical electrical vehicle usage. It is highly recommended that all new home buyers insist on integrated solar as a minimum standard.

These developments present an important opportunity for developers and installers to reexamine their business and operational model to improve customer experience. Developers would also be well served by adopting an integrated approach for residential customers; providing them energy efficiency devices, smart technology, battery storage and electric vehicle charging solutions in addition to their solar offering. These developers need to be supported by ancillary services, finance providers and continuation of favorable regulatory policies. This will result in the residential sector developing energy self-sufficiency through renewable sources, at which point 30% of the electricity consumption in the GCC will be supplied entirely by renewable energy resources.

4.6 SOLAR SOFTWARE

N P Vincent - *CEO - Energylink*

The evolving scenario, transformed by the effects of the pandemic, has brought new opportunities for operational optimisation in the solar industry. The costs of customer acquisition and customer support are beginning to have a greater impact on operational costs for developers in the MENA region. Developing an optimised operational methodology and a cohesive suite of software will serve as the fundamental framework needed to achieve the dual goals of reducing cost and increasing performance. Solar software solutions are no longer limited to solar photovoltaic design and simulation, the software also provides opportunities for flexible remote operations and shifting resources to lower cost jurisdictions.

The customer journey begins at the website, social media or email and continues with the support of a knowledgebase that provides in-depth information on the technical, financial, operational, and societal benefits of solar. Reducing the cost of customer acquisition requires improving sales conversion from the high volume of leads to qualified customers and signed contracts. In this high-volume zone of the sales funnel, software and automation are the primary methods to reduce costs. Software and automation allows the solar developer to provide the necessary information to a prospective customer without the need to dedicate resources to non-billable operational requirements.

The customer experience throughout the sales process; the speed, efficacy and quality of information, will have a direct impact on the closure rate. The sales operation requires a dedicated pre-sales technical team that is available for numerous revisions based on customer requirements and feedback. The assessment of roof space and optimisation of solar photovoltaic design with the support of satellite or aerial imagery, LIDAR, Geographic Information Systems (GIS) and Typical Meteorological Year (TMY) data has become increasingly reliable; thereby removing the need for a site survey prior to sales closure. The improved accuracy of the solar design and simulation tools reduce the time required for customised site-specific engineering.

Solar design software allows for pre-configuration, standardisation in solar components and pricing; which results in greater confidence in the information provided in the sales proposal. Simultaneously, for loan, lease & power purchase agreement (PPA) options, support is required from finance providers. Some solar software enables direct integration of finance providers' tools in the solar software. This shortens the time required for approval in the event that customers would like to explore their financing options. Integration of video conferencing and appointment scheduling tools has created a digital sales experience, such that the entire consultation prior to sales closure can take place remotely. The customer can view the sales proposal, complete the consultation on their solar system's performance, apply for financing and receive approval and sign the contract through a single portal.

Cost of customer support is the cost of delivering the related operational and compliance requirements. It encompasses all costs, including goods sold of the solar photovoltaic system. The cost of customer support may be billed to customer as a part of the price of the solution. Therefore, it directly impacts the resultant price per kWp that is offered. The installation process requires highly detailed engineering drawings

Figure 10: Solar Software Features

and compliance documentation. Procurement, stock management and logistics are equally important parts of this operation and derive their inputs from the engineering design and drawings. An integrated solar software allows the engineering, compliance and procurement functions to receive tasks and inputs from a single source, with a timeline of deliverables.

Customer relationship and support throughout the installation and commissioning phase is important, the sales and customer support executives have the benefit of the single source of information to improve their response to customer queries. Certain solar software provides a dashboard for customers to independently track the progress of the solar installation, much like tracking of shipping packages. Completion of installation, commissioning, operation and maintenance are the next steps, before the customer handover is completed with all relevant documentation delivered to customers. Monitoring of performance, scheduled maintenance and emergency response can also be incorporated in the software in order to complete the full lifecycle support to customers.

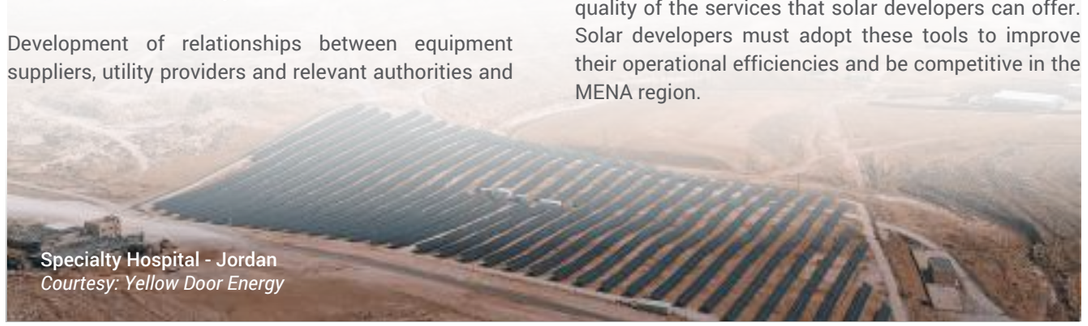
Most solar software providers are focused on, North American, Australian & European markets. MENA solar developers will need to restructure operations around software, and some software will require work arounds. Solar software providers do not have well-functioning tool sets that cater to the MENA market, such as integrated financing options from finance providers. MENA Financial institutions interested in investing in solar projects will need to take a close look at the developments in solar software. If the MENA region seeks to emulate the financial institutions of the US & Australian markets, they would also need to invest in the development of plug-ins for solar sales software.

Development of relationships between equipment suppliers, utility providers and relevant authorities and solar software providers will be important in order to create service integrations or Application Programming Interfaces (API) with the solar software to simplify the exchange of vital information. Regulatory authorities in the MENA region have put laudable effort into developing standards and compliance procedures and have ensured stability and continuity. Now, they will have to further develop tools that allow solar developers and financiers to access, with the customer's permission, their annual electricity usage data to improve the accuracy of the generation, consumption and financial estimations in the solar sales proposals.

The following important criterion need to be considered in order to choose the right software suite for operations:

- **Bankable -** The solar photovoltaic system generating the annual electricity as designed by the solar design software and the simulated solar photovoltaic system components meeting the warrantied performance detailed in the specifications
- **Cost Effective -** The software suite adding value through reduction in cost of customer acquisition, reduction in cost of customer support and improvement in operational efficiency; vis-a-vis cost of the software
- **Platform Agnostic -** The solar software should be usable across multiple OS and devices for onsite & offsite requirements. The flexibility across several devices will also contribute to being able to shift these functionalities to remote and low-cost jurisdictions

Even at this stage, there is clear evidence of the benefits of restructuring operations around solar software developed adopting best practices. A well-structured solar software suite will improve the quality of the services that solar developers can offer. Solar developers must adopt these tools to improve their operational efficiencies and be competitive in the MENA region.



Specialty Hospital - Jordan
Courtesy: Yellow Door Energy

5.1 MERGING SOLAR WITH AI AND IoT

N P Vincent - *CEO - Energylink*

The increased use of variable renewable energy (VRE) sources, integrated with the existing electrical infrastructure, introduces many new challenges. The inherently intermittent nature of VREs causes a shift towards the need for demand side management, to improve capacity utilisation. Today, the exponential growth in deploying solar, due to cost competitiveness, often neglects the fact that sunlight is not available at night and daily interruptions to efficiencies exist, such as passing clouds, dust and birds. Thus, while the levelised cost of electricity (LCOE) is competitive, all solar power plants are limited by their capacity factor. Globally, the capacity factor of utility scale solar has been in the range of 18% - 20% over the past few years. The laws of nature force these constraints on stand-alone solar PV plants. However, in the case of solar thermal plants with molten salt storage and solar PV with battery storage, fortunately, opportunities to improve the capacity factor exist. The combination of solar and storage also offers a dispatchable source of electricity.

The growth of distributed solar PV is another factor that influences the electricity grid. Excess electricity generation at certain times in the day or year without a corresponding demand of electricity is becoming common. Such excess electricity events have the potential to disrupt and destabilise the electricity supply. Such cases are likely to increase in frequency because the drive towards carbon neutrality and zero emission electricity sources requires a growth in renewable energy electricity generation sources. Furthermore, distributed solar PV has resulted in a change from the unidirectional flow of electricity from electricity generation source to electricity consumption, to a bidirectional flow of electricity in the distribution network. Households and commercial entities now can generate, store, consume and supply surplus electricity to the distribution network. The growth in electric vehicles, electric vehicle charging infrastructure and vehicle to grid (V2G) adds yet another dimension to the evolution of electrical infrastructure.

Managing a complex and dynamic electrical infrastructure capable of accommodating VREs requires the adoption of Internet of Things (IoT) and Artificial Intelligence (AI) technologies. These technologies together with renewable energy sources have the potential to not just maximise electricity generation, but also reduce the cost of the electricity to consumers, by managing electricity demand.

Chalhoub Group Rooftop - UAE
Courtesy: SirajPower

IoT describes various networked devices connected to the internet, which have the ability to sense, process, collect & transmit data as well as control the functioning of equipment.

Artificial Intelligence (AI) uses computers' processing power to analyse large volumes of data, consider responses based on complex or uncorrelated data points and take necessary actions to achieve required goals. Artificial Intelligence is developed through Machine Learning; wherein data is fed to the processors to instruct the AI on the condition and the required goals.

Humans are exceptional at evaluating limited amounts of data and identifying trend and forecasting predictions based on the patterns seen. However, what makes the combination of IOT and AI state-of-art, is the ability of AI enabled computers to detect complex or hidden patterns by analysing amounts of data that are far beyond human ability to evaluate. The AI based analytics can be used as a pre-processing step to channel human attention, to focus effectively on problem areas (plant component faults, generation anomalies etc), as well as making sophisticated forecasting predictions.

Globally, IoT and AI together have been applied for various applications such as:

- Solar PV Design, electricity generation and shading analysis
- Increasing the electricity generation by controlling trackers with AI, that are provided with data in addition to the sun's position in the sky (as well as additional data such as cloud cover, the scattering of light by suspended dust particles and solar panel surface temperature)
- Measuring soiling rate of solar panels and recommending corresponding cleaning intervals
- Forecasting electricity generation based on data in addition to solar irradiance Typical Meteorolgical Year (TMY)[1] data by factoring in historical analysis of electricity generation from the current and similar solar PV power plants operating in similar conditions
- Predicting and responding to Arc faults[2]
- Inverter IV-Curve[3] analysis for fault detection, reduced production, or mismatch at the string level, PV panel wiring, for utility scale solar PV installations
- Optimisation of solar PV power plant's electricity grid connection with voltage and frequency control

In the broader context of renewable energy and the electricity grid, IoT and AI, together, offer the means to coordinate all the distributed energy resources (DER) connected to the electricity grid, in order to maximise electricity generation and to synchronise the electricity demand accordingly.

5.1 AI INTEGRATION IN PV PLANTS

Moving gradually towards the Fourth Industrial Revolution, AI is finding increasing acceptance among grid operators, plant owners and operators, and electricity system regulators. Stakeholders are preparing for a significant portion of the electricity supply to be reliably provided from green energy sources. Major challenges include managing grid stability, increasing energy generation efficiency to make energy more widely and equitably accessible, and managing the more variable generation and storage aspects of solar and wind generated electricity.

Fortunately, the combination of Artificial Intelligence (AI) and Internet of Things (IOT) provide emerging solutions in all three areas.

As the world entered the decade from 2010 to 2020, the sensors behind IOT have become both more capable and highly accurate, while costs have steadily reduced. As a result, the quantity of data available has begun to exceed the levels analysable without machine assistance. Fortunately, while AI has been under serious development since the 1970s (some would

[1] *In this case, solar irradiance that will occur for a particular location considering all weather patterns and influences for a given year.*

[2] *An Arc flash occurs in an electric circuit when the potential difference is very high that the electricity crosses the air between 2 conductors of opposing polarity and causes a flash. In such cases, the arc will be a high temperature hot flash and has the potential to damage equipment and cause fires if not immediately corrected.*

[3] *Current-Voltage IV curve is the inverter matching the load characteristics to maximize electricity production. The monitoring of an IV curve is useful to detect deviations from expected IV curve or past performance.*

argue earlier), the widespread availability of Graphics Processing Units (GPUs) and Cloud Computing has allowed AI to evolve in parallel.

Traditionally, solar operators have been using data collection (e.g. through SCADA systems), and analytics (e.g. using spreadsheets) to draw conclusions about plant operations. With the introduction of AI-based analytics, sharp improvements are witnessed in the ability to detect emerging events and faults in real time, provide accurate future generation prediction and emerging fault forecasts in minutes that enhance the operator's ability to control plants, and most importantly the ability to analyse economic impacts of the detected changes and faults that allow the operator to optimally deploy valuable human engineering and maintenance teams.

To achieve a net-zero future, the grid must evolve to become smarter, scaling and adapting to a massive, interconnected network of power-generating and consuming devices. This is precisely where AI is poised to help renewables thrive.

» AI Accelerating Solar Deployment

PV Solar has achieved the goal of becoming the lowest LCOE by a combination of technological advancement, massive increases in scale and geographic distribution, and a trend towards just-in-time maintenance activities.

AI powered advanced data analytics plays a critical role in accelerating the uptake of solar. For optimal asset performance, advanced data analytics can be utilised to troubleshoot a wide array of persistent issues in solar portfolios.

1. Technological advancement causes highly complex systems, implying an increased number of possible failures. Data analytics can recognise intricate patterns, both identifying the nature of a fault, and in some cases predicting in advance that the fault is developing or is about to occur.

2. Increase in scale of asset management activities renders any human effort of error detection inefficient, defeating the economies of scale advantage. Advanced data analysis is able to direct human attention purposefully and specifically, filtering out noise and freeing up managers' time to focus only on those components which are failing or have already failed.

3. Geographic distribution strategies that deploy solar plants in the best locations to generate power generate a monitoring challenge - requiring deployment of multiple local operations and maintenance teams, or frequent, expensive travel from the centralised location to the plants. The solution is the use of sensor systems and data analytics and real time remote monitoring. Human intervention is dictated by AI based systems to prioritise where it is most required.

4. Finally, significant cost can be incurred through rigidly scheduled maintenance activities (e.g. biweekly panel cleaning), but using data analysis to identify the optimal time for each set of activity results in substantial reduction in human labor costs and use of scarce resources like water.

Through a combination of low solar panels and plant infrastructure components costs, optimal operations and maintenance costs and increase in plant efficiency enabled by AI-based analytics, larger solar plants are getting developed to generate cheaper electricity. In this sense, AI-based analytics is one of the key technologies required to keep solar LCOE below the rapidly reducing MW-hr prices set in PPA agreements.

Honolulu Covanta H-Power Plant - USA
Courtesy: S-5

» IoT & AI Implementation Stages

IOT and AI-based Energy Management Systems, are effective at three stages (1) the design phase, (2) the plant stabilisation phase (first couple of years) and (3) the mature operation phases. While the second and third stage models can be combined, the changing nature of a PV Solar plant's operation requires a highly adaptive (essentially an AI-based) model. Critically for the owner/operator, the degradation of weakly monitored solar plants is cumulative, so implementing an Energy Management System as soon as possible reduces losses substantially.

Some key factors are:

1. AI-based digital modelling techniques are useful at the design phase for accurate energy generation forecasts, by incorporating historical irradiance level and variability, local weather impacts, and terrain adjustments

2. AI allows the creation of an adaptive plant monitoring model. Specifically, as the plant goes through its infancy (first two years), early operating years (three to five years), then the intermediate and longer-term operation phase, the nature of the dominant errors changes considerably. Additionally, as the plant ages new types of generation degrading faults (like Light Induced Degradation) can emerge.

3. Several types of advanced AI-based Digital Twin models allow both

a. Generation of extremely accurate plant generation predictions

b. Generation of plant operation characteristics under various conditions (e.g., dirty panel versus clean panel operation). This enables the models to better advise the human operators when to optimally schedule interventions.

» MENA Region

Algeria, Egypt, Iran, Iraq, Jordan, UAE, Oman, Qatar and Saudi Arabia have already installed IoT and AI systems in the renewables sector. An indicative example is the Saudi smart grid market, predicted to reach a value of $3.6 billion before 2030. For the $500bn Neom project, the objective is to power the megacity entirely through AI-guided solutions using 100 percent renewable energy. Broadly, the MENA region has an ideal combination of large usable land areas for PV solar plants and high solar irradiation levels to maximise energy generation from solar energy.

OUTLOOK

A mix of fossil-based, renewable, and other clean-energy sources will drive the future of power generation. Co-existence and compatibility of these technologies will substantially increase grid complexity, creating demand for smart, AI-based solutions. Globally, investment in AI within sustainable energy is expected to be over $7.78 billion by the year 2024.

A major, immediate issue arises due to the intermittency of renewable energy, coupled with the difficulty to plan in real time. But, machine learning, application of metering, data collection and advanced analytics within smart, connected power networks, will significantly help in resolving the crucial gaps – as AI represents an effective solution for some of the problems facing energy companies. This is particularly true for solar and wind, which are burdened by weather patterns that are difficult to predict and have many variables to consider.

As the more variable solar and wind plant outputs reach above 10% of the electricity generating capacity of electricity grids, the introduction of load balancing mechanisms like pumped hydro and battery storage become critical components of energy systems. Measurements can be supported by IOI sensors and AI will provide quick response algorithms. This will allow energy producers, project developers and managers to optimise power systems through increased reliability, resilience, and stability. When generating capabilities are at peak and performing optimally, AI-driven robotics will auto-divert excess power into charging storage or into energy markets. On the other hand, the machines will mobilise supplementary techniques to bridge the energy supply when there is insufficient sun or wind.

5.2 SOLAR IOT IN CYBER SECURITY

It is a well-known fact that the cyber resilience of Operational Technology (OT) environments including power plants of all technologies, and Solar PV plants as part of them, has been lagging behind IT environment for decades. Millions are lost in damages and ransom pay-outs, not to mention the life-threatening disasters that could occur when industrial equipment malfunctions or critical infrastructure goes offline, especially in the energy sector.

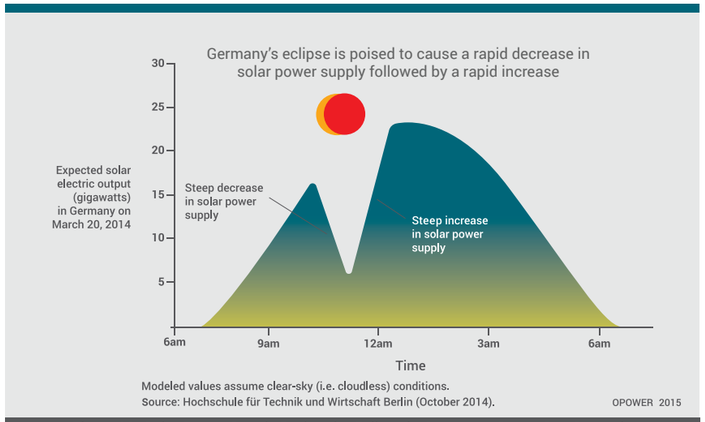


Figure 11: Solar Power Supply During the Eclipse in Germany - Sunny Day Scenario

» The Horus Scenario

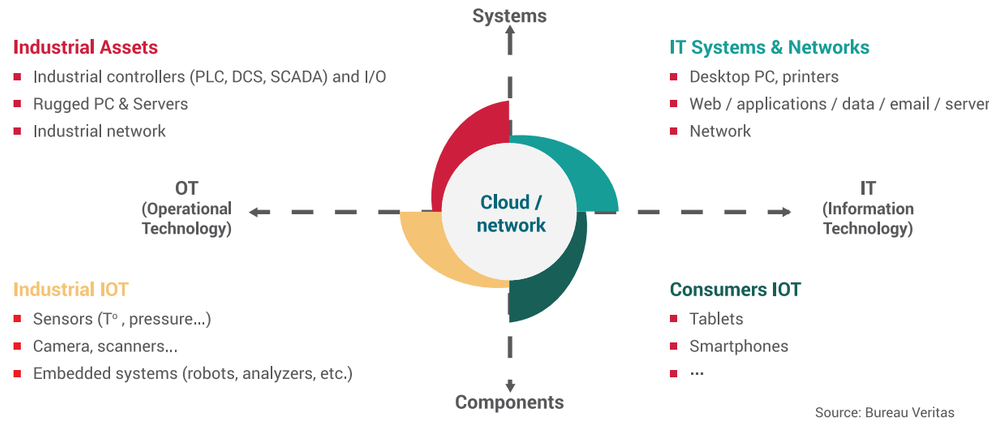
Figure 11 describes a large-scale cyber-attack scenario targeting the vital energy infrastructure and was both theoretically and practically proven to exist. A malicious hacker targets the electrical grid by focusing on PV-installations, so he can control the flow of power from PV panels. With a large scale attack the impact of shutting down many PV systems in a very short period could even transcend the impact of a solar eclipse. This will have an influence on the power grid that needs to maintain a constant balance between supply and demand of power. Where power grids are interconnected, an event like this could create a cascading effect on other power grids resulting in a large-scale power outage.

» Situation

Of course, the scenario described above is only possible when a large-scale attack could be performed. At the same time the impact of solar energy is increasing rapidly from small consumer installations to very large PV power plants and anything in between.

While it can be considered that solar, and renewables in general, are a recent development and this operational technology (OT) sector should have less "technical debt" and less legacy systems, all these installations have the same cyber security challenges as any "regular" OT system. For PV plants such systems mainly exist of Supervisory Control and Data Acquisition (SCADA) systems, Programmable Logic Controllers (PLC), industrial or embedded PC's/servers & network components and specific, solar inverters or solar trackers.

Most of these industrial assets and protocols are still "insecure by design" as they are intended to only be deployed within trusted networks and a corresponding mind-set made itself master among vendors, system integrators and asset owners. However, due to various reasons, ranging from obtaining business intelligence and production optimisation to predictive maintenance and geographical distribution of production processes, these PV systems have become increasingly connected to other IT and OT systems. A trend only increasing with the rise of Industrial IoT/industry 4.0 that pushes connectivity to central cloud services.



Source: Bureau Veritas

At the same time, all the regular constraints within OT environments are also applicable for PV installations. Long system lifespans, interoperability and backward compatibility issues, high uptime demands, lack of cyber security awareness to name a few. It's a recipe that even a well-designed system will degrade over time due to the lack of cyber-care.

What to do when components within a PV plant have not been designed to be secure from the ground up? You take them offline and put-up big walls around them.

Segmentation became prevalent, illustrated by its formalisation in the IEC62443 Purdue Model. Although a valid strategy, many PV plants today have not ventured far beyond this step. This is often referred to as the coconut model: hard on the outside but soft on the inside. Many asset owners don't even realise when they have been compromised, as security monitoring is all but absent in most of their solar portfolio. This relates to PV power plants requiring a different mindset than IT.

A popular belief is to implement security according to the inverse of the well-known CIA triangle, where availability is the most important. However, in practice, other aspects like physical safety, reliability and performance are most important. Whereas in an IT environment the tendency is typically to seek mitigations for every technical risk, PV plant environments require a more careful consideration and a balanced, context-sensitive translation of technical risk to business impact. Making this translation requires a cyber security expert with a deep understanding of the primary processes and system components within a PV plant.

IEC 62443,
is an international series of cyber security standards specifically for industrial (OT) networks. One of the key concepts is to divide all equipment that form the OT network in different zones that share the same risk characteristics and to define the security requirements for those zones.

» Threats

In recent years, several factors have aligned to make organisations with OT environments, where PV plants are a subset off, a target of increasing interest to cybercriminals with a financial incentive. First, the rise and success of ransomware has produced increasingly professional criminal business models, including Ransomware-as-a-Service or RaaS. This has given cybercriminals a sharp incentive to target organisations whose data or operations they would otherwise have little interest. They individually study and target specific organisations for extortion, a practice sometimes referred to as "big game hunting". Secondly, due to the increased use of "commercial-off-the-shelf" components, the rise of hyper connectivity and the general trend of IT/OT convergence, the attack surface of OT-oriented organisations has both increased significantly and become more familiar to adversaries operating primarily in IT environments.

At the same time, IT environments in more traditionally targeted sectors, such as the financial world, have become comparatively harder targets due to years of defensive experience. Organisations with OT

BPC Le Chocolat - UAE
Courtesy: Yellow Door Energy

environments are lacking behind in cyber resilience. They are therefore often easier to hack than a bank, have a lot of capital and their primary processes are extremely sensitive to disruption: they are likely to pay. As long as organisations pay, the business model for ransomware stays viable.

Of course, criminals with a financial incentive are not the only threat actors - the world has witnessed incidents perpetrated by actors from disgruntled employees to geopolitically motivated parties. Many incidents with geopolitical motives have been attributed to state-sponsored actors engaged in espionage and sabotage for reasons of foreign influence or strategic signaling and preparation.

» Solutions

Is it all bad? Absolutely not. With the implementation of an OT cybersecurity management program the cyber risk within a PV asset has become far more manageable.

Starting with product security certification to ensure all industrial assets, ranging from PV inverters to PLC's and SCADA systems, are designed with security in mind using a Secure Development Lifecyle (SDLC). Especially in the procurement phase, it would be wise to use this as one of the selection criteria.

In the design phase, risk assessments and threat modelling can already be used to verify all technical solutions. Protocol-aware firewalls (Modbus TCP, IEC 60870-5-104, etc.), data diodes, segmentation of different data streams (like supervision and control traffic) within a PV plant has become more manageable by giving more granular control, enabling a defense-in-depth approach. Finally, after installation, make use of security testing during the factory and site

IEC 60870-5-104,
or IEC104 in short, is a standardised communication protocol that is widely used by industrial equipment for remote control of substations or powerplants.

acceptance tests (FAT/SAT). Examples of this include vulnerability scans and penetration tests.

At last, the operating and maintenance phase starts. Security of all devices, applications and systems needs to be maintained. For large enterprises IEC 62443-2-1 could be used to implement a cyber security management system. Depending on the maturity of the organisation, proper monitoring is in place and regular gap-analysis, penetration tests and red-team exercises are conducted in the OT environment during the entire lifecycle. The goal is to regularly test the segmentation and security controls and to both find and mitigate new or unknown vulnerabilities as the security threats are always changing.

IEC 62443-2-1,
Is part of the complete IEC 62443 set of standards and defines the need of a cyber security management system to manage the risk for the OT network.

Outlook

When looking to the future, the Solar industry space will face many challenges in the area of cyber security, as their environments are becoming an increasingly more popular target for digital threat actors and the security is often lagging behind. Where segmentation protected these environments before, the rise of IoT and industry 4.0 is pushing integration with IT, greatly increasing the attack surface. Awareness remains an issue, although demonstrations and costly cyber incidents are putting ICS security on the map in recent years. Some organisations invest heavily in their operational cyber resilience and new techniques and methods for securing these environments are emerging. Combined with products developed through SDLC, periodic technical assessments and red-team exercises, operators of Solar PV plants will be able to reliably deliver renewable energy for years to come.

6.1 UNCERTAINTIES IN YIELD ASSESSMENTS AND PV LCOE

PV projects in any market segment require a dedicated technical risk framework where the requirements may vary depending on the complexity of the project. In general terms, initial risks need to be identified and quantified, with all the stakeholders operating in various phases along the value chain required to be involved to vastly reduce and minimise the residual risks. This can be done primarily by preventing the occurrence of failures. Technical risks which cannot be transferred to other stakeholders will ultimately stay in the hands of the PV project owner. A clear technical risk framework is important as it can de-risk the investment by "quantifying" the quality of a PV project and thus demonstrate the advantages in terms of business model (more reliable generation for a longer lifetime) compared to other projects of lower quality.

In the past, the term "solar bankability" was defined as an active quality management process where all stakeholders in the approval process of a PV project attempt to identify potential legal, technical, and economic risks through the entire project lifecycle. These risks need to be quantitatively and qualitatively assessed, managed and controlled. Despite a wide overlap in this quality management process, the focus and the assessment criteria will vary depending on the stakeholder.

Quality in PV projects starts from the planning phase where a fundamental role is played by the accuracy and uncertainties related with the yield assessments. A yield assessment with reduced uncertainties can lead to a much more favorable business model. This is, for example, achievable thanks to improved models and access to better site dependent data such as irradiance.

Yield assessments (YA) and long-term yield predictions (LTYP) are used by investors in order to take business decisions on long-term investments. Yield assessment is an essential step in a PV project, as together with cost data (CAPEX, OPEX and discount rate), provides the financial investors the parameters needed for the calculation of the levelised cost of electricity (LCOE) and to assess the cash flow model of an investment with relative internal rate of return (IRR) and net present value (NPV).

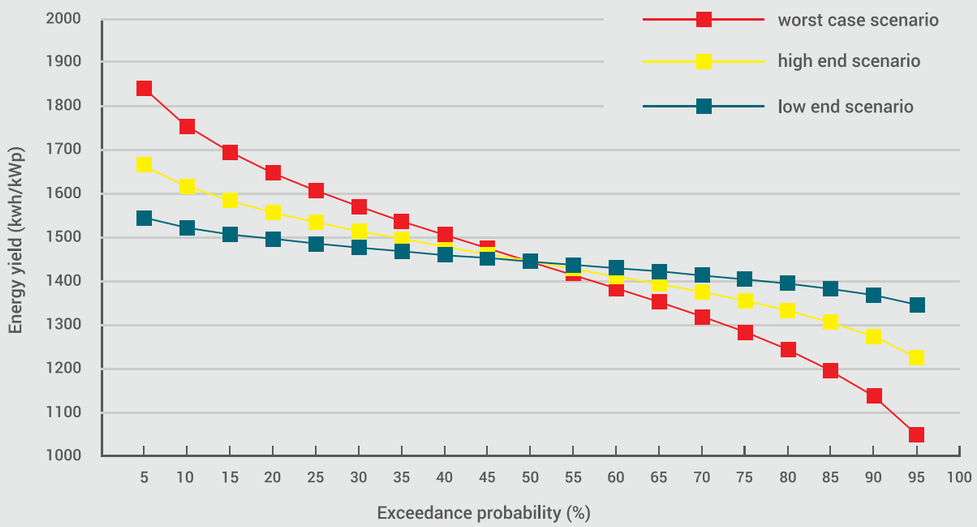


Figure 12: Impact of increasing uncertainties in yield assessments (from low end to worst case scenario) (from H2020 project solar bankability).

However, the YA is not only about the models and the used software, it is mainly about the user. YAs may not be as reliable as expected, and in the IEA PVPS Task 13 Report "Uncertainties in Yield Assessments and PV LCOE", the authors demonstrated how seven highly skilled specialists did not arrive at the same result, despite having been provided with the same detailed inputs.

YA and LTYP outputs should always be provided with a related exceedance probability. This gives the right tool to stakeholders involved in PV projects to take the best decision in terms of risk-aversion. A reduction in the uncertainty of the energy yield can lead to higher values for a given exceedance probability (e.g. P90) and hence a stronger business case.
The main challenge in YA and LTYP relates to the trustworthiness of site-specific information. In a global market it is not uncommon to be assigned the task of assessing the yield of a PV plant in areas which are not familiar for the yield assessor. Therefore, access to local knowledge is of extreme importance.

The most important parameter influencing the energy yield assessment is in fact the site-specific insolation (i.e. kWh/m2/year). Several aspects need to be considered: reliability of the database, interannual variability, and long-term trends. Availability of validated satellite data or availability of ground measurements is thus an essential first step. To this extent, site adaptation techniques can increase the reliability of the selected site-specific insolation as they combine short periods of measured data with satellite-derived data and they can thus be used to reduce any bias.

Other parameters directly affecting the estimation of the incident radiation are linked to

- the calculation of the irradiation on the module plane and thus the model used for the decomposition and transposition of the global horizontal irradiance to global tilted irradiance,
- shading losses (near and far)*,
- soiling losses*,
- reflection losses.

**Shading and soiling losses are also site-specific and knowledge on the local conditions can ensure that the losses are properly assessed.*

Finally, all of the conversion steps from irradiance to electricity must be considered. While the modeller can input or translate datasheet values as provided by the manufacturer, no guarantee is given by most manufacturers as to the accuracy of these key inputs. This can be translated into inaccurate module or inverter files, which can negatively affect the yield, and with it, the financial viability of PV plants. Therefore, PV modules or inverters are increasingly subjected to additional characterisation by independent third-party laboratories upon instruction by investors.

Investing resources during the design phase is thus of extreme importance as mitigation measures which prevent future failures in the field and allow optimal system design are the most effective from the perspective of a cost-benefit analysis.

To this extent, the main risks related to yield assessments which need to be mitigated are:

- The choice of database for the horizontal irradiation. Irradiation data derived from satellite images are increasingly used as input for long-term yield estimations and as the basis for reference yield calculations for monitoring and business reporting.
- Inexperienced yield assessor, or one that is not familiar with a specific location.
- Input parameters not validated for a specific location.
- Assumed degradation rates higher/ lower than expected with an impact on the long-term yield assessment.
- Specification of components do not correspond to their datasheet and guaranteed values.

Typically, investors require one YA. In some cases, more YAs might be requested if results are unclear. The various YAs can be averaged to assign a purchase value to a given project and this could be a source of error. YAs should contain all information needed to assess their reliability.

6.2 MOTIVATION, BENEFITS, AND CHALLENGES FOR NEW PHOTOVOLTAIC MATERIAL AND MODULE DEVELOPMENTS

Over the past decade there has been an enormous growth in the production capacity of photovoltaic (PV) modules worldwide: in 2019 an estimated 120GW to 140GW of PV was produced. With significantly increasing production capacity, PV module prices have fallen dramatically over the course of 2019 to mid-2020. However, the increase in the price of raw materials starting June 2020, together with the power crisis in China, have affected the price of PV modules. Currently, the PV market shows an extremely high-cost pressure, which is also the driving factor for the development and implementation of new module designs and the use of new materials and components. New technologies, which promise either higher efficiency for the same cost or cost reduction at same efficiency, are very often quickly introduced to the market.

With current production capacities, many gigawatts of modules with new technologies and materials can be produced and installed without having sufficient experience about long term reliability. Such circumstances can lead - in the worst case - to unexpected degradation mechanisms only several years after field deployment. Within the last decade failures as Potential Induced Degradation (PID), Light and elevated Temperature Induced Degradation (LeTID) or backsheet cracking appeared after a few years of operation in the field although they were not detected in any laboratory accelerated testing.

The main objective of the IEA-PVPS Task 13 Report on "Designing New Materials for Photovoltaics: Opportunities for Lowering Cost and Increasing Performance through Advanced Material Innovations" is to provide a global survey of technical efforts aimed at lowering cost and increasing performance and reliability of PV modules by employing new designs, materials and concepts. Furthermore, the report aims to:

- increase the exchange of information about promising materials and design concepts
- provide the means for increasing the value of PV modules
- provide recommendations on characterisation methods for new technologies and
- give input regarding new requirements for standardisation

The paper focuses on describing the motivation, benefits, and challenges for new photovoltaic material and module developments

Equestrian Estate Barn - Canada
Courtesy: S-5!

There are several motivations for investigating new materials for PV modules. Reducing or replacing expensive materials is important for the overall economics of module production. For example, reducing the use of or replacing silver with copper or aluminium leads to a significant cost reduction for manufacturers.

Another example is using thinner glass for top sheets or converting from more expensive PVF to less expensive PVDF materials for backsheets. Accelerating the manufacturing process is another way to decrease production costs. Lamination is typically the slowest step in a module production line and manufacturers are very interested in materials that can speed up this process step. For example, fast or ultra-fast cure EVA encapsulants have reduced the time needed for cross-linking from 25 minutes to 10 minutes. Converting to thermoplastic encapsulants, which do not crosslink, may help reduce these times even further.

Increasing performance is an obvious motivation for material innovations. This can be achieved with increasing the number of busbars, increasing the active area by using shingling, increasing light absorption using anti-reflective coatings, or increasing internal reflections with highly reflective backsheets or white templates between cells. The trend towards larger wafer size also leads to performance gains. Making modules more sustainable is another strong motivating factor. Life Cycle Assessment (LCA) is a methodology to quantify the environmental impact of a product. Some manufacturers seek recognition of ecologically responsible material choices by using various labelling standards to identify good sustainability practices.

The process of material innovation for PV is further complicated by the complex interactions within a PV module. The advantage of one material may be outweighed by its interaction with another component. For example, EVA is inexpensive and highly effective for encapsulation; however, it degrades to form acetic acid which can cause corrosion of the metallisation if it is not allowed to escape the module package due to use of an impermeable backsheet.

New materials must work within the whole module package and in concert with the other materials present. Consumers and manufacturers rely on international standards, such as those from Technical Committee "Solar Photovoltaic Energy Systems" TC 82 to ensure that new materials do not result in unexpected performance or reliability problems. However, testing procedures and standards often have to be adapted to suit new module designs or reflect new degradation modes. Another issue is that module manufacturers do not typically advertise their bill of materials (BOM) and the BOM for a particular module model can vary depending on when and where it was made.[4]

6.3 THE SIGNIFICANCE OF TESTED AND CERTIFIED SYSTEMS

Numerous solar mounting system vendors have appeared in the market providing attachment of roof-mounted solar PV to standing seam rooftops - each claiming to be the first, best, ultimate or strongest. In many regions of the world, including MENA, there are no industry standards or mandates for design, manufacture, use or testing of these products; this market space is *completely unregulated!*

The result is that many of these applications are not specifically engineered or proven for design-load conditions, nor can they be due to insufficient testing or a lack of quality assurances in production to enable the necessary testing and engineering. Sub-standard equipment can lead A lack of recognised standards can lead to failure and cause death, injury, and property or roof damage. This creates a life-safety issue and potential liability. Modules are typically warranted for 25 years and have expected service life of 35 years, but mounting systems are typically warranted for only two or five years—or not at all.

Until the industry develops standards or mandates, system designers and contractors need to know what steps they can take in the interim to discern prudent product selection from sales hype and how to best vet these devices by seeking proof of certified materials, certified testing and manufacturing.

[4] *G. Oreski, J. Stein, G. Eder, K. Berger, L. Bruckman, J. Vedde, K.A. Weiss, T. Tanahashi, R. French, S. Ranta, "Designing New Materials for Photovoltaics: Opportunities for Lowering Cost and Increasing Performance through Advanced Material Innovations"*
https://iea-pvps.org/key-topics/designing-new-materials-for-photovoltaics/

Even if the market space is unregulated, the best practices to qualify a solar mounting system and its manufacturer are simple. Look for mounting assemblies and hardware that are engineered, load tested and proven with verifiable evidence to ensure all aspects of the product are designed to outlast the life of the PV system. A reputable manufacturer offers meaningful ***product defect and performance*** warranties. Look for evidence of warranty on the vendor's website—preferably for the entire service life of the solar system or roof but 25 years at a minimum. A qualified manufacturer should gladly provide proof of all claims.

Equally important is the mounting system provider's track record. How long the vendor has been in business is somewhat irrelevant. The question is, "How long and on how many projects has the system been in use?" and "will the manufacturer be in business for the long-term to honor its warranties?"

Important Certifications to Consider in a Solar Mounting Structure to Ensure Safety and Performance

- UL 2703 – a standard for safety pertaining to mounting systems/devices and earthing lugs for use with PV modules
- Certified load testing on specific roof panel profiles by an ISO 17025 laboratory
- ICC – International Code Council approvals
- ISO 9001:2015 audited compliance in manufacturing, packaging, shipping and other QA/QC assurances

» Lower-Quality Solution Consequences

A lower-quality mounting product simply does not comply with the extensive testing, certifications and track record of success as described previously. Without proof of quality requisites in design, production and use, it is impossible to competently engineer the roof attachment against the forces of nature working against it. In a windstorm, the entire system could become airborne from localised or total failure. Disconnected modules can pose life safety issues, ruin the roof and/or invalidate warranties. So, choosing a lower-quality PV mounting solution is a gamble with extremely high risks.

Specific to commercial-sized PV system applications on metal roofs, choosing a superior mounting product does not add significant cost, yet the overall assurances are substantial. Mounting hardware is typically less than 4% of the total system cost but is often compromised for the sake of one or two pence per watt. This is not value engineering, but a lack thereof. Small upfront costs are inconsequential for a reliable, high-quality, long-term solution that lasts the lifetime of the roof, eliminates the need to replace failed parts and prevents future liability.

» The MENA Region

Without industry standards and mandates, developers are subject to the same vulnerabilities and potential liability. In the interim, understanding how to vet these devices and their manufacture is a step in the right direction.

United Foods - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

6.4 LONG-TERM ROI OF SECURING SOLAR PV FOR THE LIFE OF THE SYSTEM & THE LIFE OF THE ROOF

Metal roofing is known for its durability, sustainability and versatility. Featuring a service life that actually exceeds that of a solar PV system, it is the perfect platform for mounting solar.

» Service Life

In the commercial and industrial market sector, the field/lab study published by the Metal Construction Association indicates the service life of 55% AlZn coated steel, premium standing seam metal roofing (SSMR) is in the range of 70 years in non-coastal environments (less on the seacoast, depending on salt spray severity). Metal roofing is the most sustainable roofing type, at recycle rates above 70% and conducive to lower solar installation costs.

Many non-metal, or aged metal, roofing systems will expire long before the life of the PV system. This leads to costly disassembly of the PV array, re-roofing and re-assembly.

The service life of solar PV is between 28 and 37 years, with an average of 32.5 years (and rising), according to a Berkeley study. Aside from premium SSMR, few other roof types measure up without requiring replacement during the life of the PV. Given the value of the roof is considerably less than the cost of fitting solar to it, wouldn't it be prudent to evaluate the roof's remaining service life before proceeding?

Most EPC solar contractors understand PV components and electrical design quite well, but often do not have the skillsets to evaluate the roof's condition. This is something the building owner, solar developer or design professional should know and carefully consider.

According to the study, "expectations for the useful life of utility-scale PV projects vary by respondent but have consistently increased over time – from an average value of ~21.5 years in 2007 to ~32.5 years in 2019 (Figure 13). Directionally, this tracks the increase over the typical duration of module warranties."

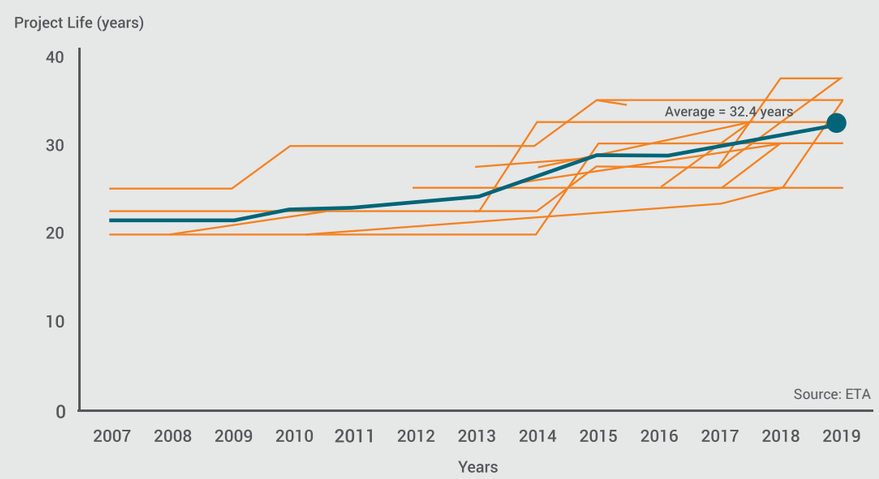


Figure 13: Project Life Expectations for Utility Scale PV, Over Time

» Ease of Installation

Solar PV can be mounted penetration-free on the standing seams of the roof, which serve as the rails for reliable mechanical attachment of modules.

SSMR solar mounting can offer fewer components, light-weight materials, better load distribution and provide zero-penetration, preserving roof warranties. These factors are driving roof selection to SSRM globally when solar PV is a design element.

» Lifetime Return on Investment (ROI)

Once the decision is made to retrofit solar, often a new roof is worthy of consideration. Many building owners are replacing their roofs with SSMR for reasons attributed to improvements in the real lifetime ROI of the complete system—roof and PV. In this regard, the PV array and the roof should always be viewed as a *single asset.*

When computing PV cash flow and ROI, inverter replacement is usually factored in at about year 15 – but what about the cost of roof replacement mid-life of the PV? The solar array has to be totally dismantled and then re-installed on the replacement roof. Factor in the following costs and the economic landscape changes dramatically:

- Remove modules
- Remove mounting & racking system
- De-commission system during reroof
- Re-roof
- Re-install PV system
- Re-commission system
- Replace damaged components
- Replace wiring
- System downtime

Carrefour Majid Al Futtaim - Jordan
Courtesy: Yellow Door Energy

» The Rise of Metal Roofing & Solar

With the cost of solar decreasing significantly over the last decade, the breakeven and ROI improves every year – so it makes greater financial sense.

SSMR is the most solar-friendly roof available, and the developer should understand its benefits. It is attractive, durable and requires almost no maintenance. Moreover, it is the chassis for an expensive and long-lasting PV array. The “buy-it-cheap and fix-it-later” mentality has steadily diminished over the last few decades, and more building owners are choosing SSMR than ever.

» IMP Roofs

Insulated metal panels (IMPs) are growing sharply in popularity in the MENA region and other hot climates globally. Sometimes called “sandwich panels,” they are two metal skins with an insulating foam core between them. IMPs offer some significant advantages in thermal efficiency and a finished underside aesthetic. IMPs have been in use in the U.S. for many decades and are quite available in SSMR profiling from numerous supply sources. Unfortunately, SSMR profiles seem much less available in the MENA region, unless by import. Exposed-fix IMPs, while regionally quite available, are a bit challenging as a solar platform. Hopefully, a regional IMP manufacturer will see the light and soon emerge with a SSMR offering.

» Next Steps

Solar contractors should know about roofing alternatives and service lives in order to bring added value to their customers. The roof and the solar PV array should be evaluated as a single system. Advising the mounting of a solar array with a 30-yearplus-life on a less than premium roof is a bit like mounting a Ferrari engine on a Mini-Cooper chassis. Who would do that?

» Market Solution

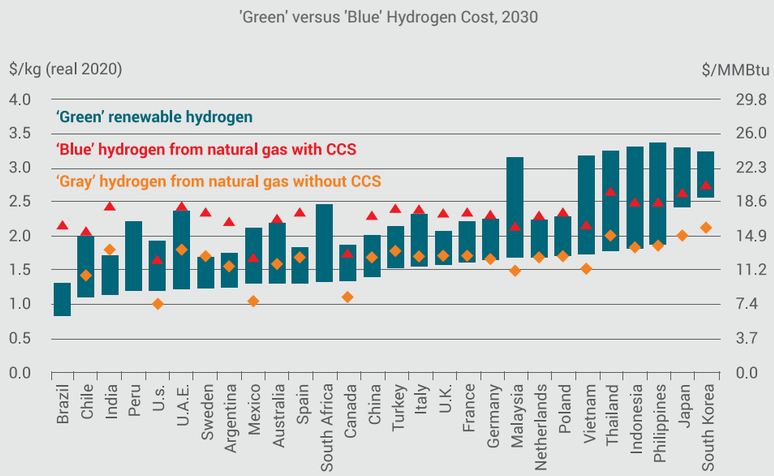
Tested and engineered attachments for metal roof types exist. Clients should focus on investigating the best products available in the market to assemble their PV modules. Without compromising on cost, PV mounting solutions that provide better load distributions and eliminate risks including holes and damage can be avoided. Such solutions are strong enough to withstand wind complying with local regulations. Sometimes, there are no available solutions in the market, no stock, and suppliers only deliver based on a specific minimum order. As a result, suppliers always study and analyse popular and available products in the market, based on local rooftops, and keep good stock levels via distributors or local agents. Furthermore, reliable manufacturers providing warranties should always be taken into consideration over the full life of a rooftop system. Nevertheless, testing their products and solutions with local inspection bodies to ensure reliability is also crucial.

Hira-WalRaven - UAE
Courtesy: Yellow Door Energy

7.1 OVERVIEW

In the last quarter of 2021, the world observed a tremendous amount of green hydrogen announcements such as MOUs signed, projects planned, initiatives launched and more, almost every week in the MENA region. This ramp up is no surprise knowing that green hydrogen offers the MENA region a significant opportunity to decarbonise and maintain a leading energy export global role for decades to come. Ultimately, integrating green hydrogen will also coincide with the region’s zero carbon goals set.

Green hydrogen is still expensive compared to blue or brown hydrogen, but the cost gap is relatively smaller in the Middle East due to low cost of renewable energy generation. In a recent study by BloombergNEF, a forecast shows that green hydrogen will outcompete blue[5] hydrogen worldwide by 2030 as shown in Figure 14. Such cost reduction shall be driven by lower renewable energy prices and economies of scale for green hydrogen generation and transportation.



Note : Assumes optimistic electrolyzer cost scenario, Renewable H2 cost range reflects a diversity of electrolyzer types, from chinese alkaline (low) to PEM (high). Assumes equal CCS costs in all countries.

Source: BloombergNEF

Figure 14: Green vs Blue Hydrogen Costs, 2030

Decreasing the renewable energy generation costs has not been historically a problem in the Middle East, with Saudi Arabia, UAE and Qatar achieving some of the lowest LCOE costs for PV in the world. Additionally, the presence of major local oil and gas companies with the ambition to grow further beyond the fossil fuel era generated a massive pipeline for green hydrogen projects in the MENA region. Announcements for collaborations between local Middle Eastern energy companies and global energy giants have been promising GWs of installations with a mixture of technologies. Global alliances including companies and governmental entities in Saudi Arabia, UAE, Oman, Qatar, Egypt, Algeria and Jordan have been formed with clear agendas to capitalise on green hydrogen, achieving local energy transition targets and exporting clean energy to the world.

[5] *This term relates to hydrogen produced from natural gas using the SMR or ATR processes.*

7.2 MENA GREEN HYDROGEN MARKET OVERVIEW

Pinsent Masons

All over the world, countries such as Germany, Australia, and Scotland have begun developing and investing in green hydrogen projects with the intention of reducing fossil fuel consumption and to decarbonise. In the MENA region, green hydrogen offers a significant opportunity to achieve the ambitious net zero targets that have been announced by some governments in the region, such as UAE and Saudi Arabia. Traditionally, blue hydrogen has played a significant role in this region with oil and gas companies taking a lead in this area. However, today, renewable energy combined with electrolysis to produce green hydrogen is attracting countries to push for their decarbonisation agendas. Most recently, the UAE's first green hydrogen project was inaugurated at the MBR Solar Park, with pilot projects also emerging in Oman and Egypt.

The MENA region has a lot to offer in developing and promoting green hydrogen projects. Following climate change and a period of lower oil prices, the region's oil and gas industry has had to reinvent itself. The opportunity lies in repurposing the knowledge and skills of the energy sector to the emerging hydrogen industry. This, in addition to the quality of the solar and wind resources and geographic location in MENA, makes the region well placed to be a leading world exporter of green hydrogen. Recently, several companies in the MENA region formed alliances with other players in the green hydrogen industry and pledged to begin its development. Some of those initiatives include, but are not limited to, MOUs signed with several government and private entities such as Abu Dhabi's Mubadala Investment Company and the Egyptian Electricity Holding Company to develop

Green Hydrogen facilities in the region. Similarly, hydrogen alliances were also observed in the UAE and Oman aiming to establish a green hydrogen market.

Several green hydrogen projects were also launched across the MENA region in 2021. In March, Dubai Electricity and Water Authority (DEWA) and Siemens Energy inaugurated the Middle East's first industrial-scale, solar-powered green hydrogen project which is powered by the Mohammed bin Rashid (MBR) Al Maktoum Solar Park. The MBR park currently has a solar capacity of 1,013MW, which is expected to reach 5GW when fully operational in 2030.

Scatec, Fertiglobe, the Sovereign Fund of Egypt, and Orascom plan to construct a 100MW Green Hydrogen Plant in Ain Sokhna, Egypt. The construction of this plant is expected to follow an accelerated schedule to showcase it during COP27 in November 2022.

Similarly, in Saudi Arabia, Acwa Power and Neom are planning to build a Green Hydrogen-based ammonia production facility, which is expected to become operational in 2025.

**Refer to section 10 for further updates on green hydrogen on a country level.*

According to MEED, current hydrogen pipeline in MENA includes the following:

Country	Project	Energy Source	Client	Status
Egypt	Egypt Green Hydrogen Pilot	Solar	Ministry of Electricity and Renewable Energy, Siemens	Study
Egypt	Deme Green Hydrogen Plant	Solar	Ministry of Electricity and Renewable Energy, Ministry of Oil and Minerals Resources, Egyptian Navy	Study
Oman	PDO Block 6 Green Hydrogen Project	Solar	PDO	Study
Oman	Sezad Green Hydrogen Plant Phase 1	Solar	Deme Concessions and OQ Alternative Energy	Design
Oman	Sezad Green Hydrogen Plant Phase 2	Solar	Deme Concessions and OQ Alternative Energy	Study
Oman	Sohar Port Green Hydrogen Hub	Solar	Sohar Port and Freezone, Port of Rotterdam	Study
Oman	Acme Sezad Green Ammonia Plant	Solar	Acme Group	Study
Saudi Arabia	Neom Green Helios Fuels Project	Solar, Wind, and Battery	Acwa Power, Neom, Air Products	Design
UAE	Dubai Clean Hydrogen Plant at MBR Solar Park	Solar	Dubai Expo, DEWA, Siemens	Execution
UAE	Mubadala/Snam Green Hydrogen Projects	Solar	Mubadala/Snam	Solar

7.3 CHALLENGES AND OUTLOOK

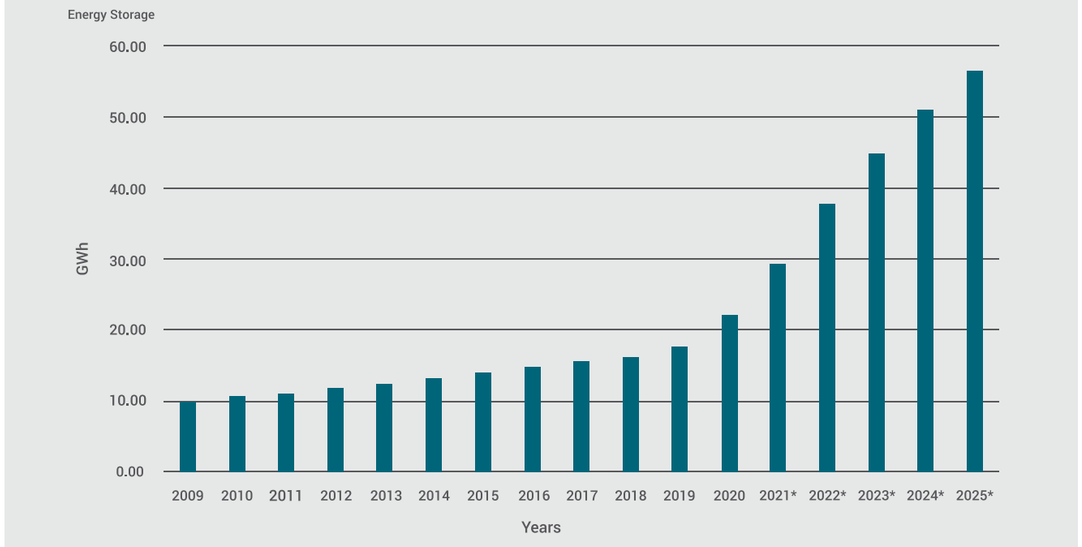
As an emerging industry, the green hydrogen market faces several challenges. However, these challenges are expected to decrease as the regulatory, insurance, finance and contracting environments mature, and offtake opportunities grow. Such challenges include:

- **Costs:** Green Hydrogen is currently not cost competitive with blue hydrogen or brown hydrogen (which is produced from coal) even when these are combined with CCS to reduce their carbon footprint. However, it is anticipated that Green Hydrogen production will become competitive with fossil fuel-based hydrogen by 2030.
- **Securing Offtake:** There is not currently a significant hydrogen market in the Middle East and therefore initial projects in the region are targeting export markets. The challenge is that they will need to be cost competitive to succeed in the international export market. They will also be competing with existing conventional producers of hydrogen and ammonia in the region.

  The costs of electrolysis are forecasted to reduce significantly as production is scaled up. A regional developer recently formed a consortium with other developers with the aim of getting green hydrogen to below $2 a kilogram by 2026. Additionally, over the next few years, opportunities for hydrogen offtakes are expected to emerge in various industries, including the transportation and grid industries.
- **Storage and Transport:** Before a truly global green hydrogen market is possible, an appropriate means for storing and transporting hydrogen in a cost effective and safe way must be developed. Although technology has been launched to store and transport brown hydrogen, green hydrogen technologies remain a work in progress. Projects including Neom are looking to use ammonia as a transport medium as this is easier and safer to store.
- **Regulatory Environment:** The regulatory environment around green hydrogen has not yet been developed. Currently, Abu Dhabi is launching advisory tenders to help develop a regulatory framework for hydrogen. A mature, certain and consistent regulatory regime would help develop the market and it remains to be seen if any incentives will be offered. The regulatory environment can be subject to regular change, which raises the risk of such projects, and therefore the contracts will need to deal with appropriate changes in law regimes.
- **Contracting Models:** EPC contracting is the global norm for hydrogen projects. However, given the specialist nature of the individual components which make up a hydrogen project, split contracting could be a more economic way of project delivery on early projects. However, this approach is often not supported by financiers (which push for full risk transfer through EPC contracting).
- **Finance:** As this is a relatively new market, financiers tend to apply more onerous lending principles when undertaking its financial assessment of a project. While debt finance remains relatively plentiful for standard renewable energy assets like solar and wind, the limited offtake opportunities in respect of green hydrogen is troublesome for conventional debt financiers. However, the emergence of private equity investors and pension funds in this market are quickly filling the liquidity shortfall.

Although there are a number of challenges being faced by the green hydrogen market, these challenges are all surmountable, and the MENA should capitalise on its abundant natural resources and geographic location to position itself as a key player in the growing demand for green hydrogen.

It is obvious that the expected multi-billion hydrogen market in the Middle East is set to grow significantly even though there are no published regulatory frameworks yet. Nevertheless, the market expects the issuance of the first regulations in the upcoming months and the first projects to proceed to the construction phase, which will be a further boost for the renewable energy sectors in the region.



Sources: International Renewable Energy Association, DNV GL ET) *Estimates and forecasts are based on DNV GL experts and external sources

Figure 15: Installed Storage Capacity in MENA Region

The installed storage capacity is set to gradually rise in the MENA region. The region is blessed with high solar irradiance levels encouraging the addition of storage solutions to reserve excess electricity to dispatch at night. Projects are already implemented and many more shall be deployed in the next few years. While prospects for energy storage vary between different countries, there is expected to be a general increase in installed storage capacity across the region in the next five years.

8.1 BATTERY ENERGY STORAGE SYSTEMS – MENA MARKET

The deployment of renewable energy assets has grown substantially worldwide in recent years, with the MENA region playing a key part in driving down the global cost of solar and wind production.

Significant solar, including some of the world's largest single solar sites, and wind projects have been developed across the MENA region. These include the 200MW Baynounah PV project, the 1.8GW Benban solar development in Egypt and the MBR solar park in Dubai, UAE, which will have an installed capacity of 5GW by 2030.

Supply chain challenges, intensified by the pandemic, have led to shortages of key solar materials and subsequently rising costs of PV modules since mid-2020. This has led to a slowdown in the development of projects across the region. However, the deferment of projects will only be temporary, with the long-term economic case for developing solar energy unquestionable.

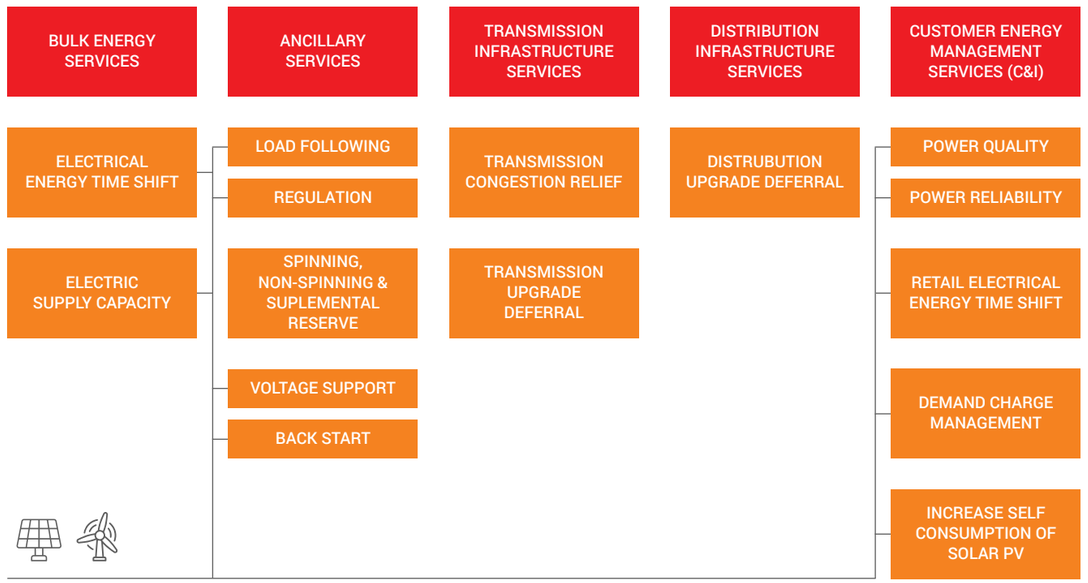
While almost all countries in the MENA region have now set renewable energy targets, progress with developing projects varies significantly from country to country. Countries such as Morocco and Jordan have already achieved high renewable penetration rates, while others such as Kuwait and Tunisia have struggled to get projects off the ground.

The rapid fall in the cost of developing renewable energy in tandem with the push from governments across the region to reduce carbon emissions and diversify their energy sectors has led to countries in the region launching some of the most ambitious clean energy targets in the world. Saudi Arabia provides a potent example of the this, with the kingdom having set a target to develop 58.7GW of clean energy by 2030.

The already installed and planned renewable energy generating capacities are leading to an entirely new energy landscape, where the growing share of renewables requires more flexible energy systems to manage the intrinsic variability of renewable resources. This is where energy storage can play a key role providing the required flexibility to the electrical grids, ensuring renewable generation is dispatched in an efficient and reliable manner. For example, energy storage can either smooth the output of renewable generating plants or store energy at times of high generation with low demand for later use when demand is high. Depending on the specific market or application segment, energy storage provides different advantages and opportunities in combination with renewables.

At commercial, industrial and residential level, renewable integration and energy storage is focused on self-consumption to decrease electricity bills and to provide power supply resilience on weaker grids. The market launch of hybrid inverters, able to connect both Solar and batteries at their input, reduce both, the integration costs and efforts, being a good lever to increase the deployment of battery energy storage systems in combination with PV power plants. In recent years, countries like Oman with the Sahim initiatives are encouraging the deployment of solar, which also support the deployment of energy storage at this level. However, in general the lack of clear or remaining restrictive regulations across the MENA region do not allow sufficiently interesting revenue models to really foster such hybrid installations.

In the case of off-grid installations, solar plus energy storage is becoming more frequent, where energy storage is minimising and even replacing diesel generation. The hybrid systems result in savings in fuel costs and also reduce operational costs due to reducing the logistical challenges of supplying fuel to off-grid sites



RENEWABLE ENERGY INTEGRATION *Figure 17:BESS Applications* *Source: Bureau Veritas*

MENA TARGET RENEWABLE ENERGY SHARE BY 2030

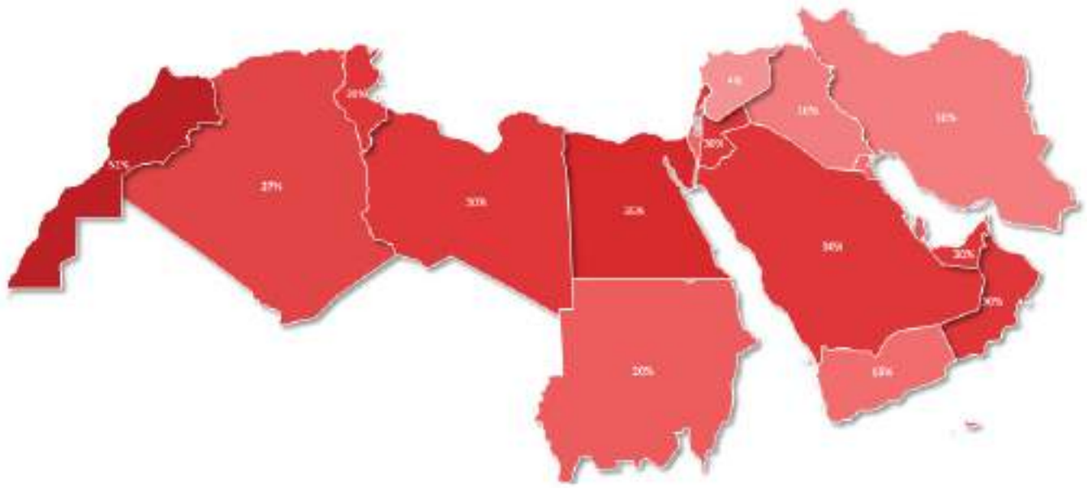


Figure 16: MENA Target Renewable Energy Share by 2030 *Source : Bureau Veritas*

» Energy Storage Technology Landscape

The range of energy storage technologies includes electrochemical energy storage (also known as battery storage) and thermal storage systems in combination with CSP solar plants, as being developed in Morocco and the UAE. There is also numerous studies and pilot projects being undertaken to determine the feasibility of hydrogen technology too.

In the MENA region's energy storage landscape, lithium-ion battery technologies are the most widely used across all segments, and it is expected that they will continue to maintain the largest market share also in the near to mid future. Their high efficiency, energy density and cycle life, in combination with the continuous decrease in prices (> 90% over the last 10 years) makes them a good choice for creating effective business cases.

There are several lithium-ion technologies based on cathode material, among the most commonly used ones are NCA (Lithium Nickel Cobalt Aluminum Oxide), NMC (Lithium Nickel Manganese Cobalt Oxide) and LFP (Lithium Iron Phosphate). NCA are more focused on the large-scale segment, while NMC and LFP technologies are represented at all segments and are hence the most widely used ones. LFP continues to increase its market share, and although environmental conditions in the MENA region can be considered a challenge to keep lithium-ion batteries operating within their normal operational temperature range, LFP technologies have proven to provide a very good thermal stability, enhanced safety and tolerance in high temperature environments.

BESS

Room Temperature Batteries
- Lead Acid (flooded, VRLA)
- Copper-Zinc
- Nickel-Cadmium
- Nickel-Metal Hydride
- Lithium-ion (Li-ion)

High Temperature Batteries
- Sodium-Sulphur (NaS)
- Sodium-Nickel Chloride

Redox Flow Batteries
- Zinc-Bromide
- Vanadium
- Polysulfide-Bromide

Other battery technology deployments represented in the MENA region include Sodium Sulfur (NaS) batteries, which offer long discharge times (~6 hours) and high energy density as well as their high normal operational temperature (300ºC ~350ºC), making this technology ideal to withstand the particular environmental conditions in the region. Compared to lithium-ion however, they have a lower cycle life and it is a proprietary technology, which can limit the supply chain and create captive markets. Lead acid batteries are also present in the region.

While lead acid batteries enjoy a high market share in the in the commercial, industrial and residential segment, they are not deployed at utility-scale due to their low energy density, efficiency and cycle life. Other technologies like flow batteries are being explored because of the unique decoupling between energy and power, but they are still in an early development stage.

8.2 FUTURE OF ENERGY STORAGE

Although the necessity and benefits from energy storage are clear, energy storage deployment in MENA region is still in an early stage with the following challenges yet to be overcome:

- There is a gap in the regulatory frameworks for renewables and energy storage in some countries of MENA region. A lack of clarity regarding their role and market participation has led to uncertainties and slowed down the development of strategies and business models for hybrid installations, while many countries have or are in the process of developing national strategies.
- Financial viability of solar plus energy storage projects needs to be guaranteed; as long as energy storage continues its price decrease and revenues can be quantified, effective business cases will arrive and will further encourage energy storage deployment.
- Lack of knowledge and experience in technology and application impact the modelling of business cases as well undertaking and execution of projects, from design to full operation.

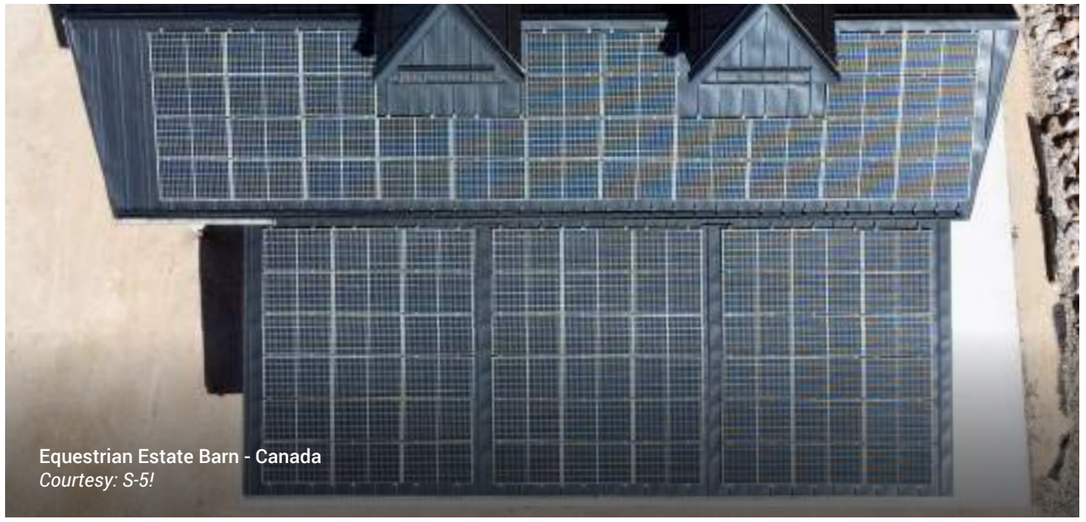
With the continuous growth of renewables in the energy mix, enabling technologies such as energy storage are imperative. As regulatory frameworks advance, pilot projects are completed and developers gain experience in delivering storage projects, energy storage will become much more prevalent in the MENA region's solar sector and will play a key role in driving the development of further renewables capacity and stable sustainable energy systems.

KD Industries Solar Rooftop
Courtesy: SirajPower

Projects Currently Under Construction 2021				
Project Name	**Country**	**Technology Used**	**Capacity**	**Status**
Al Kharsaah PV Project	Qatar	PV IPP	800 MW	Construction
REPDO Round 2	KSA	PV IPP	2,970 MW	Construction
Al-Dheieen Solar Project	Sudan	PV IPP	5 MW	Construction
Al Dhafra	UAE	PV IPP	2 GW	Construction
MBR Solar Park Phase 4	UAE	CSP	950 MW	Construction
MBR Solar Park Phase 5	UAE	PV IPP	900 MW	Construction

Upcoming Projects				
Project Name	**Country**	**Technology Used**	**Capacity**	**Status**
CREG - Biskra	Algeria	PV IPP	50 MW	Awarded
1 GW Solar Plants	Algeria	PV IPP	1000 MW	Tender Phase
Formula 1	Bahrain	PV IPP	3 MW	Bid Evaluation
West Nile	Egypt	PV IPP	600 MW	Development Phase
Kom Ombo 200 MW	Egypt	PV IPP	200 MW	Awarded
Kom Ombo 500 MW	Egypt	PV IPP	200 MW	Bid Evaluation
Sawa 1	Iraq	PV IPP	30 MW	Pre-qualifications
Sawa 2	Iraq	PV IPP	50 MW	Pre-qualifications
Khidhir	Iraq	PV IPP	50 MW	Pre-qualifications
Babel	Iraq	PV IPP	225 MW	Awarded
Jissan	Iraq	PV IPP	50 MW	Pre-qualifications
Karbala	Iraq	PV IPP	300 MW	Awarded
Al Diwania	Iraq	PV IPP	50 MW	Pre-qualifications
2 GW PV Plants	Iraq	PV IPP	1 GW	Planned
Dhi Qar governorate	Iraq	PV IPP	450 MW	Planned
Ramadi	Iraq	PV IPP	100 MW & 200 MW	Planned
Mosul	Iraq	PV IPP	100 MW	Planned
Amarah	Iraq	PV IPP	100 MW	Planned
1 GW Phase II	Iraq	PV IPP	NA	Planned
1 GW Solar Project	Iraq	PV IPP	1000 MW	Planned
Shagaya Phase 3	Kuwait	PV IPP	2500 MW	Planned
		CSP	500 MW	Planned
Abdaliyah	Kuwait	PV IPP	150 MW	Planned
12 PV Farms	Lebanon	PV IPP	15 MW each	Bid Evaluation
3 Solar & Storage Farms	Lebanon	PV IPP	70 - 100 MW	Tender Phase
		Storage	70 MWh	
Noor PV II	Morocco	PV IPP	400 MW	Bid Evaluation

Upcoming Projects				
Project Name	**Country**	**Technology Used**	**Capacity**	**Status**
Noor Midelt 1	Morocco	CSP - PV	800 MW	Awarded
Noor Midelt 2	Morocco	Hybrid	NA	On Hold
Manah Solar I	Oman	PV IPP	500 MW	Bidding Stage
Manah Solar II	Oman	PV IPP	600 MW	Bidding Stage
Tanweer	Oman	Hybrid	146 MW	On Hold
North Oman Plant	Oman	PV IPP	100 MW	Pre-construction
		Storage	30 MW	
Suhar Industrial City Plant	Oman	PV IPP	100 MW	Planned
Two 400 MW Plants	Qatar	PV IPP	800 MW	Planned
Qatar Petroleum Solar Scheme	Qatar	PV IPP	800 MW	Planned
REPDO Round 3	Saudi Arabia	PV IPP	1,200 MW	Bid Evaluation
REPDO Round 4 & 5	Saudi Arabia	PV IPP	NA	Limited Notice to Proceed
Sudair (PIF Programme)	Saudi Arabia	PV IPP	2 GW	Awarded
NEOM - RE Plants	Saudi Arabia	NA	4000 MW	Planned
Red Sea Project	Saudi Arabia	BESS	1,300MWh	Awarded
Solar Scheme - Third Round	Tunisia	PV IPP	500 MW	On Hold
Solar Scheme - Fourth Round	Tunisia	PV IPP	70 MW	Bid Evaluation
Abu Dhbai - Solar Scheme	UAE	PV IPP	2000 MW	Planned
Abu Dhbai - Solar Scheme	UAE	PV IPP	1000 - 1500 MW	Planned
RAK Solar Project	UAE	PV IPP	15 MW	Tender Phase



Equestrian Estate Barn - Canada
Courtesy: S-5!

A. ALGERIA

Moneef Barakat - *Managing Director - Solarabic UG*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030 & 2035
24,764 MW	**686 MW**	**30% of the installed capacity on 2030** **15,000 MW by 2035**

Source : IRENA

I. CURRENT SITUATION

The total installed renewable energy capacity in Algeria is more than 650MW. The country has high irradiation levels and has the potential to install renewable energy sources. With Covid-19 impacting the country on several levels, progress with planned renewables projects has been slower than anticipated. Algeria's National Renewable Energy and Efficiency Development Plan, announced in 2015, aimed to increase the domestic renewable generation capacity to 22GW by 2030. Yet, some of the planned projects to reach the countries target, worth $42.1bn, are still under study or may not happen. However, Algeria could witness a progress in its renewable energy strategy as the country's plan to launch a 1GW solar tender in early 2021 was executed in December of the same year.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

In February 2021, a presidential decree announced that Mohamed Arkab, the former mining minister, would replace Abdelmadjid Attar as Energy Minister. Attar had been appointed as minister in mid-2020. In June 2021, the previous plan set to develop 4GW of solar, between 2020 and 2024, was abandoned, deemed as unrealistic. The country is currently facing an economic crisis due to COVID19 since hydrocarbon revenues have significantly declined.

III. PROJECT UPDATES IN 2021

» 1 GW Solar Tender

Eleven sites in southern Algeria were included in a tender to develop a total of 1GW of solar in the country, as announced in March 2021. Each site shall construct a project ranging from 50MW - 300MW. It will also embed a local content requirement for the project. The country expects the project to generate between $3.2bn and $3.6bn in investment. The tender was released in December and developers were invited to submit proposals by April 2022.

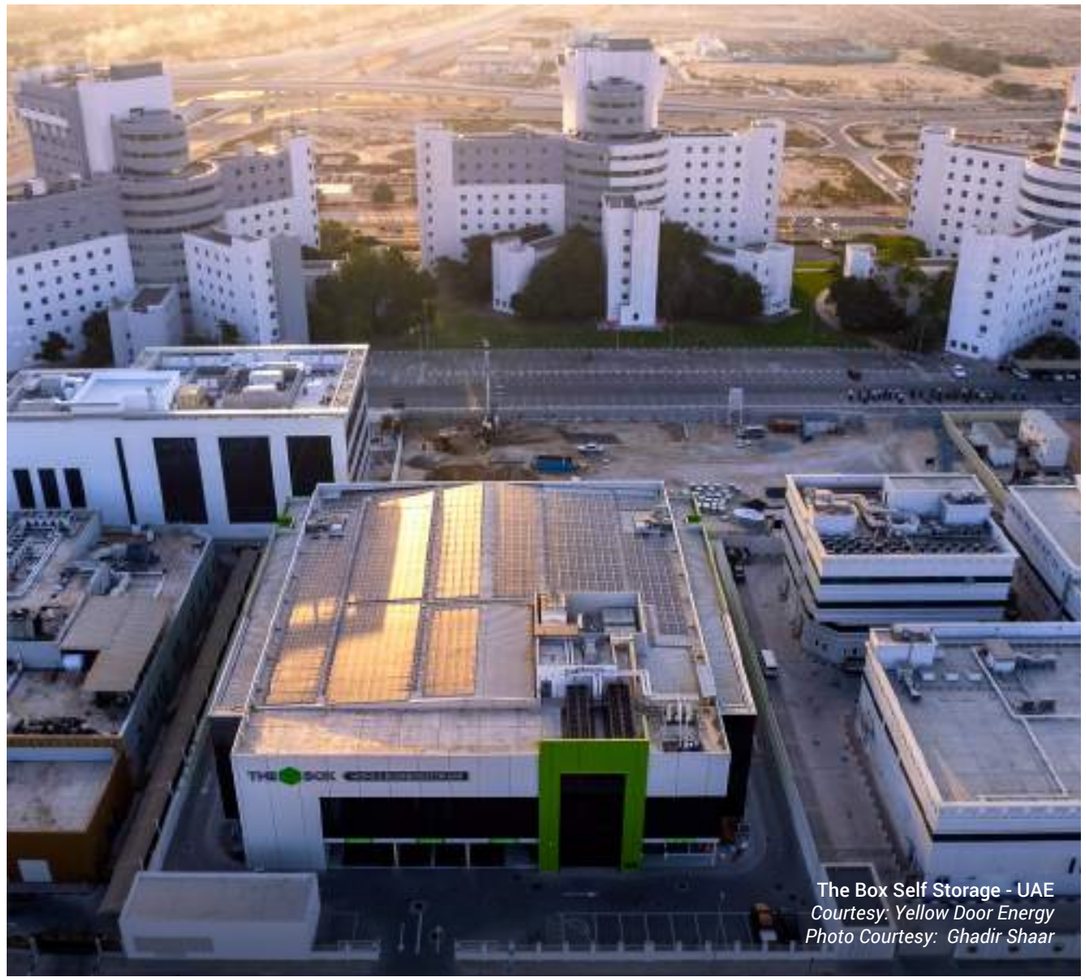
» 50 MW Project

Algerian Electricity & Gas Regulation Commission (CREG) tendered a solar PV IPP scheme for several projects of 10 MW each with a total capacity of 150 MW in 2018, but only successfully procured a 50 MW project in Biskra. Tendering the remaining 100 MW was not very successful to date. Construction of the 50 MW has not started.

IV. CHALLENGES AND OUTLOOK

On July 12th, 2021, the maximum electricity demand reached a record high, exceeding 16GW, doubling the average annual maximum demand, which made it clear that new generation capacity is needed and energy efficiency initiatives have to be extended. The expected 1GW tender is being planned with local content requirements to empower manufacturing strategic components of the PV system, which is difficult considering the current limited PV panels manufacturing capabilities in Algeria.

There is no doubt that there will be a lot of opportunities for renewable energy development in Algeria over the coming 10 years and PV will play a key role in it. Based on the announced strategic plans to develop the PV industry, Algeria will localise production and transfer knowledge to local workforce. With regards to green hydrogen, it has been formerly announced that it is possible to replace natural gas with hydrogen in the energy mix. The idea is relevant, insofar as the network of gas pipelines could be modified to deliver hydrogen to Europe. However, there are currently no concrete plans.



The Box Self Storage - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

B. BAHRAIN

Total Power Capacity by 2020	RE installed capacity	RE target by 2025	RE target by 2030
8,781 MW	**10 MW**	**255 MW**	**710 MW**

Source : IRENA

I. CURRENT SITUATION

Bahrain has only installed 10 MW of renewable capacity; however, the country is aiming for a greener future. Bahrain announced, in October 2021, its plans for a net zero carbon emission target by 2060. This comes after the country has already put in place goals to reach a renewable energy target of 5% by 2025 and 10% by 2035. The current plans in place include solar, wind and waste-to-energy technologies as well as floating solar. Bahrain's Sustainable Energy Authority (SEA) adopted two plans to foster sustainable energy: the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP), both of which are currently working towards Bahrain's decarbonisation goals.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» National Economic Growth and Fiscal Balance

The government of the kingdom of Bahrain has announced a new national economic growth and fiscal balance plan in 2021. Supporting the country's post Covid-19 recovery and its goals to enhance Bahrain's economic competitiveness, the country has set 5 pillars to achieve its net-zero initiative by 2060. The pillars include a new labour market reform plan, regulatory reform package, strategic projects plan, six priority sectors plan (including oil and gas; tourism; logistics; financial services; telecommunications, IT and digital economy), and a fiscal balance program update. Each pillar has a set of desired goals to achieve and implement in the years to come.

» VAT Increase

The Council of Ministers decided to double the value of added tax to 10% starting January 2022, to restabilise the country's economic position following the impact of the pandemic. However, the country did not announce details on applicable and exempted categories under the new regulation.

» Grid Solutions

The Electricity and Water Authority (EWA) announced that Hitachi Energy will provide a power quality solution improving voltage stability and increasing power capacity of the country's transmission grid. In addition, EWA has plans to embed grid software solutions with GE Digital optimizing efficiency and operations.

» NBB Initiative

The National Bank of Bahrain decided in September 2021 to introduce exclusive financing plans for individuals looking into installing solar. This initiative focuses on increasing environmental awareness and encouraging sustainability practices in the Kingdom.

III. PROJECT UPDATES IN 2021

» 7.5MW Solar Tenders

SEA issued two tenders in 2021 to install solar for the Ministry of Education and the Ministry of Labor & Social Development under a BOOM scheme. The first tender has a capacity of 5MW. The project includes installing solar on the rooftop and carport of the Ministry of Education. In January 2022, four bidders submitted proposals and the lowest price announced was BHD 0.021. The second tender with a capacity of 2.5MW received three bid proposals to deploy solar at the Ministry of Labor & Social Development.

» Formula 1 Solar Project

Bahrain International Circuit (BIC) partnered with SEA to tender a 3MW solar project under a build, own, operate and maintain (BOOM) structure. Five bid proposals were submitted in June 2021. The project aims to power the entire Formula 1 race weekend through the installation panels on car park shades at the F1 circuit.

» Bahrain Mall

To construct the largest private solar plant for Bahrain Mall with 6MW, real estate firm Majid Al Futtaim signed a power purchase agreement (PPA) with Yellow Door Energy. The project will be completed in 2022 and shall power 50% of the shopping mall's energy needs. Bahrain Mall will be powered by more than 11,600 solar panels to generate 10 million kWh of clean energy during the first year of operations.

» Sustainable Initiatives

The number of solar rooftop projects in Bahrain are increasing due to the limited amount of space in the country. The country recently achieved energy efficiency ratings for commercial and residential buildings. Several rooftop installations were deployed on homes, hospitals (King Hamad American Mission Hospital), schools, governmental entities, and carports. On the other hand, Bahrain has replaced 70,000 streetlights and 400,000 bulbs with LED bulb systems in the country.

IV. CHALLENGES AND OUTLOOK

2021 marked an important year for Bahrain. The country set goals to achieve its net zero targets by 2060 with five pillars introduced and clear steps to deploy sustainable initiatives. Bahrain is currently encouraging solar, focusing on installing rooftop projects due to the limited amount of space in the country. During the 26th United Nations Climate Change Conference of the Parties (COP26), the country was praised for its green initiatives promoting renewable energy. Progress with plans for district cooling and the introduction of electric vehicles will further boost Bahrain's energy efficiency progress.

Landmark Group - UAE
Courtesy: Yellow Door Energy & Amana
Photo Courtesy: Ghadir Shaar

C. EGYPT

Ehab Ismail Ameen - *Vice Chairman For Technical Affairs - NREA*

Total Power Capacity by 2020	RE installed capacity	RE target by 2035
59,420 MW	**5,971 MW**	**42% by 2035**

Source : IRENA

I. CURRENT SITUATION

By 2020, the total renewable energy installed in Egypt was 5,971 MW. However, the country still wants to increase its renewable energy mix percentage to reach 20 per cent of total power production by 2022. The Electricity & Renewable Energy Minister Mohamed Shaker announced in 2021 that Egypt allocated 7,600 Km2 to produce renewables, that could allow an additional 90 GW to be installed. Ultimately, the country aims to improve itself and allocate 42% of its energy mix by 2035 from renewable energy. Furthermore, green hydrogen studies and pilot project initiatives are increasing which is also in line with Egypt's clean energy strategy.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» Green Bonds

In Egypt and many MENA countries, green bonds are increasingly being adopted to help finance sustainable projects. During 2021, deputy finance minister Ahmed Kouchouk indicated that Egypt is planning to increase the green bond issuance rate. With $750 million green bonds issued in 2020 to attract investors, Egypt foresees a bright future towards achieving their ambitious decarbonisation targets and meeting the UN goals for sustainable development.

III. PROJECT UPDATES IN 2021

There was not significant progress with new renewable energy projects in Egypt in 2021. Moreover, recent updates showed that two major projects in Kom Ombo could experience delays because of global inflation and particularly rising solar and shipping costs affecting project budgets. Major updates include:

» 500 MW Kom Ombo Solar PV Scheme

Proposals were received in mid-2021 from EPC contractors for a 500MW PV solar project in Kom Ombo. The capacity of the project was increased from the originally planned 200MW. The project shall be located in Aswan governorate and will be developed under a 25 years take-or-pay agreement between Abyodos Solar Power Company (ASPC), a fully owned subsidiary of AMEA Power, and EETC under a BOO scheme.

» 200MW Kom Ombo Solar Project

The power purchase agreement (PPA), network connection and usufruct agreements for the 200MW Kom Ombo PV IPP were signed in April 2021, with ACWA Power signing a 25-year PPA with EETC. Also in April, the developer signed agreements for a $115m financing package with the European Bank for Reconstruction and Development (EBRD), the OPEC Fund for International Development, the African Development Bank (AfDB), the Green Climate Fund (GCF) and Arab Bank. ACWA Power is aiming to reach financial close for the project in mid-2022.

» Installed and Operational

26 MW Kom Ombo Solar Park - In Kom Ombo, Aswan, a 26MW solar park owned by NERA was constructed by TSK Grupo and is currently under operation. The plant is producing 53,000 MW annually and shall prevent emissions of about 300,0000 tons of carbon dioxide.

Benban Solar Energy Complex - In December 2021, President Abdel Fattah Al-Sisi inaugurated several energy projects in Benban Solar Energy Complex. The new projects include the converted West Assiut Energy Station into a combined-cycle system and the Samalut Regional Control Center. The president announced that energy investments exceeded EGP 1trn since 2014 in upper Egypt.

» Hydrogen

100MW Green Hydrogen Plant - A consortium between Scatec, Fertiglobe, Sovereign Fund of Egypt and Orascom will build one of the largest planned green hydrogen plants in Egypt in 2022. The plant is expected to be completed before November and shall produce 90,000 tonnes of green ammonia per year.

Pilot Project - In early 2021, Siemens and the Egyptian Government have jointly explored the development of a green hydrogen pilot project. Consequently, an MOU between Siemens Energy and Egyptian Electricity Holding Company (EEHC) was signed to develop the project with export capabilities at the hydrogen facility, later in the year. It is anticipated that the pilot project will have an electrolyser capacity of between 100MW and 200MW. In addition to reducing the carbon footprint of its industrial sector, Egypt is seeking to become a key exporter in the global green hydrogen market.

Hydrogen Study - In March 2021, the Egyptian Ministry of Electricity and Renewable Energy, Ministry of Petroleum and the Egyptian Navy signed an agreement with Dredging, Environmental and Marine Engineering Group (Deme) to study and explore green hydrogen production as well as low carbon fuel production in Egypt. According to MEED, "the Belgian firm aims to explore the production of green hydrogen on land and on the Egyptian coasts."

IV. CHALLENGES AND OUTLOOK

Egypt has managed to transform the situation of its electricity sector over the last 7 years, with winter black-outs in 2014 now replaced by a significant surplus of generation capacity. While this is a positive for the government, it does mean that planned projects have been deferred due to the current supply surplus – resulting in less opportunities for investors and developers.

However, Egypt is keen to position itself as key exporter of green electricity within the MENA region, east Africa and even Europe. In 2021, Egypt finalised contracts for a 3,000MW interconnection with Saudi Arabia, signed contracts to double its electricity exports to Jordan and also signed MoUs for interconnection projects with Cyprus and Greece. Egypt's goal of emerging as a key export market for electricity will ensure that progress is made with developing further renewable capacity in the coming years.

Egypt's aim of becoming a global hub for the production and export of green hydrogen will also drive the development of additional renewable energy capacity.

Audi - UAE
Courtesy: Yellow Door Energy

D. IRAQ

Ziad Muneer - *CEO - Thager Al Rafedain*

Total power capacity (2020)	RE installed capacity	RE target by 2030
31,278 MW	**2,490 MW**	**33% of total power generation**

Source : IRENA

I. CURRENT SITUATION

Iraq is still suffering from a major shortfall of supply to meet electricity demand, with the current generation capacity of 20GW far short of the 30GW peak demand. Significant progress was made in 2021 in advancing renewable energy in the country, particularly solar. Iraq has set a new target for renewables to account for 33 per cent of its total power generation by 2030. The plans in place could boost the total solar power deployment to 12,000MW. With a number of major deals inked with international developers in 2021, optimism has increased that Iraq will be able to harness its high irradiation levels to increase solar capacity and improve the provision of electricity across the country.

II. PROJECT UPDATES IN 2021

» First Solar Tender - 755MW

In October 2021, a consortium led by Scatec signed an agreement to develop 525MW of the tendered 755MW solar IPP programme. The projects are in the provinces of Babel and Karbala with capacities of 225MW and 300MW, respectively. The projects shall be developed under a build, own, operate (BOO) model. Other members of the Scatec consortium include Egypt's Orascom Construction and Iraq's Bilal.

The other 5 planned projects within the 755MW IPP program are not assigned to any developer yet.

Project (IPP)	Capacity	Province
Sawa 1	30	Muthana
Sawa 2	50	Muthana
Khidhir	50	Muthana
Jissan	50	Wassit
Al-Diwania	50	Diwania

» 2GW Renewable Project

An agreement was signed in June 2021 between Iraq's Ministry of Electricity & National Investment Commission and UAE-based Masdar to develop a 2GW renewable energy project. It will be implemented in two phases, the first includes five solar PV projects in different locations: : Dhi Qar governorate (450 MW), Ramadi (100MW & 200MW), Mosul (100MW) and Amarah (100MW). A second phase will deliver another 1GW in the future.

» 2 GW Solar Project

In mid-2021, the Ministry of Electricity signed an agreement with Chinese state-owned group Power Construction Corporation of China (Power China) to install 2GW of solar in several locations across Iraq. The project will be implemented in phases, with the first phase to have a capacity of 750MW.

» 1 GW Solar Project

In the third quarter of 2021, France's TotalEnergies signed a contract to develop $27bn worth of energy projects in Iraq, the largest Western investment in Iraq. Under the contract, TotalEnergies will develop a 1GW solar project.

III. CHALLENGES AND OUTLOOK

Iraq's energy sector has historically faced challenges over the last few decades due to previous government's' plans only focusing on the import of electricity. Up to now, the energy transmission and distribution networks are still unreliable. Therefore, the country requires special studies including ways to stabilize energy production fluctuations, as Iraq has an outdated grid. Such initiatives from external organizations will enable solar power stations and other renewable sources to operate consistently and in a stable manner.

The 2021 boost of plans in the energy sector paved the way for Iraq towards a sustainable future, which combined with a vision for 2030, should enable Iraq to gradually reach its goals. Emissions and pollution should significantly reduce over the next 5 years after integrating the current planned projects in the country.

E. JORDAN

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
6,145 MW	**1,903 MW**	**3,200 MW**

Source : IRENA

I. CURRENT SITUATION

Jordan's power sector has historically been fuelled by imports of gas and oil, with the country having very limited hydrocarbon resources of its own. As a result, Jordan has emerged as one of the region's most successful states in procuring and developing clean energy to reduce its exposure to the volatility of hydrocarbon prices.

Jordan currently has a total installed renewables capacity of 2GW, with solar accounting for 1.6GW. The country is aiming for its renewable energy capacity to reach 3,200MW by 2030, increasing the contribution of renewables in Jordan's total power generation to 31%.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

In early 2019, Jordan decided to put a hold on net metering and net wheeling projects with capacities above 1 MW to manage the grid due to the influx of renewables capacity putting stresses on its grid. While the restrictions remain, several exemptions were granted for C&I projects due to an economic need to decrease their operational costs. To be able to inject more renewable projects, as the grid is currently overstressed, a new national grid "Green Corridor" needs to be implemented to increase grid capacity.

III. PROJECT UPDATES IN 2021

» Baynouna Solar Farm

The largest single solar energy project with a capacity of 200MW achieved commercial operations in end 2020. The project is estimated to produce enough electricity to power approximately 160,000 homes while displacing 360,000 tons of CO2 annually.

» Al Husainiyah Solar Project

The 50MW solar project achieved commercial operations in September 2021, after facing some delays due to Covid-19 pandemic. The project developed by AMEA installed over 200,000 locally manufactured PV panels in the plant. Al Husainiyah solar plant will supply almost 50,000 households with electricity and reduce more than 3 million tonnes of CO2 emissions.

» Wheeling – Eight Solar Plants

In Q1, under the Jordanian wheeling regulation, the largest private to private renewable project was signed. Eight solar plants producing 48MW will provide power to five entities. The project received support of more than $30 million from several lenders including the European Bank for Reconstruction and Development (EBRD), Deutsche Investitions und Entwicklungsgesellschaft (DEG) and Global Environment Facility. An additional $1.8 million in result-based payments was provided from Spain and the European Union.

Yellow Door Energy have already constructed four sites for Umniah telecom provider, Classic Fashion and Carrefour retailers in 2021. The remaining two projects for Safeway supermarkets and Taj Mall are almost at the end of the construction and are expected to be commissioned shortly.

IV. CHALLENGES AND OUTLOOK

Although Jordan is trying to inject more renewable projects in the country, certain challenges are facing the national grid. To handle generation expansion, the "Green Corridor" initiative must be pushed by the government to be able to grow its renewable energy mix. At the same time, planning for long term initiatives to meet the increasing annual demand, improve energy efficiency, develop alternative energy supplies, and attract investors through financial incentives and tax exemption could change the future of Jordan's energy production. Therefore, the next few years will reveal the country's next steps to paving the way ahead for a green future.

F. KUWAIT

Dr. Hassan Qasem - *CEO - Alternative Energy Project Co.*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
19,372 MW	**106 MW**	**15% by 2030**

Source : IRENA

I. CURRENT SITUATION

The total installed renewable energy capacity in Kuwait is 106MW. Despite such limited renewables capacity to date, Kuwait has set an ambitious target of supplying 15% of peak electricity demand from renewable energy sources by 2030. Moreover, the New Kuwait Vision for 2030 has announced multiple packs of mega size projects to achieve its target. Leading these projects is the Kuwait Authority of Public Partnership (KAPP) with with their Shagaya phase 2 and 3 combined projects. The Ministry of electricity and Water (MEW) has also announced multiple packages of (EPC) based solar projects with expectation to be released on Q3 -Q4 in 2022.

Moreover, the Supreme Authority for Higher Planning is planning to integrate green hydrogen into the country's energy transition plan.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

Kuwait is still suffering from the expiration of its public debt law in 2017 allowing access to international financing of its own debt but the government has finally announced a replacement law. With the announcement of the New Kuwait Vision 2030 coupled with the increase in oil prices, the country should be able to recover from its current deficit. Similarly, the government is planning to further expand the IPP law to allow other entities like the Ministry of Electricity and Water and Renewable Energy (MEW) along with KAPP to manage utility projects.

» C&I and Residential Solar

The C&I sector has not witnessed a significant development of solar energy in the country mainly due to the ongoing high energy subsides to all private andcommercial segments users. The exception is government departments and entities, with solar having been installed at a number of government buildings such as MEW's headquarters.

The MEW announced that the government will start exercising the previously announced law in 2017 to reduce energy and water subsidies gradually over the next two years. During this time, the government has also announced a new energy saving initiative called "Hafez" to allow homeowners to reduce their consumption of both energy and water, either by means of utilising solar or energy saving means. Therefore, the programme shall entitle homeowners a bulk discount for annual bills. The announcement included a maximum cap up to 500MW for the total installed PV systems for this program. It was also announced that a new program will be available for the C&I segment as well.

III. PROJECT UPDATES IN 2021

» Shagaya Phase 3

The Shagaya renewable energy park is Kuwait's flagship clean energy project, which will play a key part in achieving the 15 per cent renewables target by 2030. Under the first phase of the Shagaya project, 70MW of renewable energy capacity, 50MW CSP solar and 10MW of both PV solar and wind, has already been installed through a pilot programme.

Following the cancellation of a tender in 2020 for a 1.5GW project at Shagaya, the Kuwait Authority for Partnership Projects (KAPP) is planning to proceed with a 3GW project for the next phase of the park. The project is expected to deploy 3 GW of solar - 2.5 PV and 0.5 CSP with storage - and about 500MW of wind. Recently, the transaction advisor has been selected and the RFQ is expected to be released by Q3 2022 and the RFP in Q4 2022.

» Abdaliyah solar project

The Abdaliyah project was originally tendered as a hybrid integrated solar combined-cycle (ISCC) project. The project was planned to have 60MW of CSP solar capacity and 280MW combined-cycle capacity. However, the project was cancelled and is now being prepared to be retendered as a 150MW PV solar project.

» Subyah Water Storage Tanks + Solar Rooftop Project

A solar rooftop project will be released as part of the Subyah water storage system where the large area on top of the water storage will be used to install 35MW of solar PV. The project will be based on EPC and 5 years operations and maintenance (O&M). The prequalification phase is expected around Q1-Q2 of 2022.

» MEW Desalination Hybrid Projects

MEW has announced that tenders for multiple sets of RO desalination projects powered by solar PV will be released soon. The ministry aims to increase its water capacity generation to cover up for the new developed and under plan urban development in the north and south of Kuwait. The generation capacity is expected to be no less than 1 million imperial gallon per day per plant.

» Government Solar Rooftop Programme

In early 2021, solar rooftop projects were completed for the Public Authority of Housing Welfare and the Kuwait National Petroleum (KNPC). These projects fall under the new mandate for 10 per cent of the load for government buildings are to met by solar energy.

IV. CHALLENGES AND OUTLOOK

Even though the Kuwait solar market did not see any major updates or commissioning of new mega scale projects during the year of 2020, there was a significant progress in the solar sector in 2021. The current electricity tariff segments in Kuwait are subsidized. Yet, the Ministry of Electricity and Water charges all government entities, the highest tariff, 75 cent/kWh. Furthermore, the country is expecting a new market to open because of Hafiz initiative (translate to Sustain/Maintain). Nevertheless, the rooftop solar market has some major challenges to be fully liberalized. Some of those include:

- Highly subsidized energy
- No clear regulations or lack of benefits scheme - other than 'Hafiz' initiative which was recently announced and not implemented yet-
- Outdated pre-approved lists of materials and contractors, from MEW, for system installations since 2017

Overcoming those hurdles will provide Kuwait with new opportunities to tap into the rooftop market once regulated and enabled. The sector could boom because the electricity consumption per household is very high due to the current cheap subsidy leading to bad consumer behaviors. Therefore, removing subsidy or adapting any other mechanism such as FIT, for example, will lead to high demand for alternatives such as solar and energy efficiency measures.

The government is currently trying to balance out the adaptation of renewable energy mandates by releasing different incentives such as discounted bills or FIT (being evaluated) and gradually adjust subsidies reduction. Furthermore, utility scale projects, managed by the IPP Law, are currently facing some delays to be released. This is due to the exclusivity mechanism granted to Kuwait Authority for Public Partnership (KAPP) to sign PPAs, which requires a long process. Therefore, attracting investors and developers could continue to prove challenging for Kuwait.

G. LEBANON

Hadi Abou Moussa - *Energy Engineer - LCEC*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
3,120 MW	**372 MW Hydro and 7 MW Biogas, and 90MWp solar PV**	**30% of electricity consumption in 2030**

Source : IRENA

I. CURRENT SITUATION

The solar market in Lebanon witnessed steady yearly increases from 2010 till end of 2019, whereas 2020 was the first year to record a decrease in the trend of yearly additional installed capacity. In other words, the installed capacity in 2019 was 21.16 MWp, which was the maximum installed capacity per year since 2010, while in 2020 the market had an addition of 13.76 MWp only.

While the severe economic crisis is the main reason behind this growth variation, there are still positive news for solar; the shortage of electricity supply from Electricity of Lebanon (EDL), which increased severely, pushed forward the residential solar market, specifically solar PV systems coupled with storage, in 2021.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» Net Metering

The net metering initiative in Lebanon is currently still functioning, but following the Beirut port blast that damaged EDL's facility in 2020 and the country's economic crisis worsening, the process became much slower to implement projects.

» Decentralised Renewable Energy Legal Framework

In 2019, the Ministry of Energy and Water decided to develop the legal framework and administrative protocols for decentralised renewable energy for self-consumption. European Bank for Reconstruction and Development (EBRD), through a team of experts, is supporting the ministry in developing a distributed renewable energy law.

A steering committee, including representatives from EDL, Ministry of Energy and Water (MEW) and the Lebanese Centre for Energy Conservation (LCEC), was established in May 2019 to guide EBRD efforts.

This law sets a basis for stimulating distributed renewable energy production by founding the main principles for the realisation of projects using net metering in all its forms, and peer-to-peer (distributed) renewable energy (only) trading through direct power purchase agreements (PPA) and/or renewable energy equipment leasing. A first draft of the law has been prepared and it is under review by the steering committee members.

» Decree 6887

On 8 October 2020, Decree 6887 was issued, giving mandatory status to national standards related to solar energy and photovoltaic systems. It lists the concerned standards issued by the Lebanese Standards Institution (LIBNOR) and designates the Industrial Research Institute or any other internationally accredited laboratory for verification.

» Solar Rooftop Procedure

The Ministry of Energy & Water launched a new process in October 2021 to facilitate the installation of rooftop solar PV systems with standards set for quality, safety and performance.

III. PROJECT UPDATES IN 2021

» 180MW Solar PV Farms

A total of 12 PV farms of 15MW each will be implemented in the North, South, Mount Lebanon, and Bekaa regions. Bid proposals were submitted and technical evaluations led to shortlisting firms. Recently, financial offers have been opened, but the negotiations on the final tariffs are still ongoing in light of the macro fiscal situation and the devaluation of the local currency.

» Solar & Storage Project

Three solar PV farms including battery storage will be developed in Lebanon, after the call for EOI in 2018. The minimum power capacity of each solar PV farm will be 70MWp, with a maximum capacity of 100MWp. Additionally, the battery energy storage capacity should reach 70MW of power with a minimum storage of 70 MWh. Consequently, the three farms could produce from 210MWp up to 300MWp of solar power, with a battery storage system of 70 MW power capacity with a minimum of 70 MWh storage.

The structure of the project is now under process with the support of international advisors. Accordingly, the RFP has not been launched yet.

» Solar & Storage Project

Numerous initiatives of installing decentralised rooftop PV systems are currently being led by individuals, municipalities, national institutions, and non-governmental organisations in Lebanon. However, the major challenge remains the cost of imported PV system components, especially the ones equipped with batteries. The high demand for components has resulted in further pricing pressures.

IV. CHALLENGES AND OUTLOOK

Solar rooftop opportunities in the country are unlimited. Knowing that subsidies on diesel are completely lifted, the decentralized PV systems form a reliant and cost-effective alternative solution in the country, mainly for the residential sector. However, at the same time, with the price of diesel being very affordable, incentives to encourage solar growth could be somewhat challenging. Moreover, the installation of rooftop PV systems is currently helping households reduce their electricity bills by benefiting from the available solar energy sufficient to charge their battery banks and supply their daytime load. It is worth noting that all these residential solutions, mostly installed with storage systems, will have to be integrated within a working electricity system in the future, which presents both a challenge and an opportunity.

In terms of utility scale projects, currently, the economic crisis and the devaluation of the national currency can be considered as a major hurdle to implement large scale solar PV. In addition, the unstable situation in the country requires guarantees from investors to ensure bill collection and payment transfers. Therefore, a credit enhancement mechanism is currently taking shape in Lebanon, in collaboration with an international advisor to assure transparency in any power purchase agreement. Furthermore, to speed up the adoption of solar, the restructuring of electricity tariffs is also very important. This will encourage the adoption of large scale renewable energy plants to reduce the electricity production cost thus reducing the electricity bill of the consumers.

On a macro level, the high need for reducing the gap between supply and demand is pushing large scale renewable energy projects to move forward. This could be a chance to provide electricity at lower tariffs and reduce the country's dependence on fossil fuels import. The target is to implement more than 4000 MW of renewable energy projects by 2030, as per the Remap developed in 2020 in collaboration with IRENA, distributed on different renewable energy sources such as solar PV, hydro, wind, and others.

H. MOROCCO

Amine Bouchama - *Head of Business Development - EDF Renouvelables Maroc*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
10,592 MW	**3,452 MW**	**10,500 MW**

Source : IRENA

I. CURRENT SITUATION

By the end of 2020, the total installed renewable capacity in Morocco reached almost 4,000MW, accounting for 37% of the country's total power production – making it the MENA region's largest clean energy capacity to date. Yet, according to the 2009 National Energy Strategy, the installed capacity is 5 percentage points lower than the 2020 targeted goal, 42%.

While the objectives in terms of targeted renewable capacity by 2030 are quite clear (20% solar, 20% wind, 12% hydropower), the government is currently questioning the technology choices the Kingdom adopted over the last decade for solar (CSP Vs PV + eventually BESS). The solar market players are betting on more PV and an ecosystem to be built around it.

Today, the country still imports almost 90% of its energy, but is aiming to reduce that to below 20% by 2050 through its ambitious renewable energy programme. The country is also aiming to become a key player in a global hydrogen market, which would lead to a significant ramp up in renewables projects in the coming years.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» Law 13-09

Under law 13-09 and since 2011, Morocco put in place a wheeling regulation for renewables, which has enabled the development of significant wind capacity over the past decade. However, the current law only allows C&I clients connected to the high voltage (HV) grid to buy energy from IPPs. As a result, the country was awaiting a change in regulation to permit medium voltage (MV) C&I clients to enter this market, which is expected to happen in 2022. The C&I in MV represents a significant market that represents up to five times the HV market.

A drafted law amendment has been approved by the government but is still waiting for parliamentary approval. The amendment is key to allow the development of solar and wind capacity as the HV market is being saturated. Furthermore, the country's offtakers and developers believe that a clear legal framework is essential to address the C&I market, as currently, net metering is not integrated in the country.

» GreenH2 Cluster

In March 2021, Aziz Rabbah, Morocco's Energy Minister announced the launch of the national green hydrogen cluster. It aims to prepare the regulatory framework for the Moroccan hydrogen industry and support the new emerging industry. The GreenH2 cluster will also encourage knowledge transfer national and international partnerships. As the country already signed several agreements to develop green hydrogen, GreenH2 will prepare the industry for a booming green hydrogen future.

III. PROJECT UPDATES IN 2021

Morocco's peak electricity demand was being assessed in 2021 by the Moroccan Agency for Sustainable Energy (Masen) and National Office of Electricity & Water (Onee) post COVID-19 pandemic, as it didn't exceed 2019 level. Consequently, Masen's hybrid solar schemes experienced delays:

» Noor Midelt I

The first hybrid PV/CSP project in Morocco was awarded in Q2 2019 with a record-low tariff at peak hours of $0.07 per kWh. This 800MW solar hybrid project at Midelt will be the first solar project in the world to include thermal (heat) storage of PV as well as CSP. The project PPA has been signed, but, according to MEED, the project has not yet reach financial close.

» Noor II PV

The first phase of Noor II 400MW PV plant bid proposal was scheduled for end January 2021. However, the Moroccan Agency for Sustainable Energy (Masen) announced a second extension to submit bids until the end of September 2021 and received them on September 30, 2021. Currently, bid proposals are being analyzed. The solar scheme includes six plants, Sidi Bennour 48MW, Taroudant 36MW, Bejaad 48MW, El-Hajeb 36MW, Ain Beni Mathar 184MW, Kelaa Shragna 48MW, in six different locations.

» Noor Midelt 2

Masen launched a tender in 2019 for the second hybrid PV/CSP solar phase of the Noor Midelt development. However, the country has since put on hold in order to review the procurement timeline and its capacity in response to the pandemic.

Green Hydrogen

The Moroccan Ministry of Electricity is heavily supporting the development of green hydrogen in the country. It is anticipated that Morocco will produce up to 4% of the world's green hydrogen by 2030.

» Hevo Ammonia Morocco Project

A green hydrogen and ammonia plant, with an estimated budget of $850m, shall be developed by Fusion Fuel and Lebanon's Consolidated Contractors Company (CCC) in Morocco. The developers are planning to sign a ten-year hydrogen purchase agreement with the offtaker, Vitol. Development of plant's first phase is due to start in 2022 and achieve completion in 2026. The project will produce 183,000 tonnes of green ammonia annually when completed.

» Signed Hydrogen Agreements

- In early 2021, an agreement was signed between the Moroccan and Portuguese energy ministries setting out the intention to collaborate on the development of green hydrogen development in the North African country
- After forming a National Hydrogen Commission in 2019, an agreement was signed between the Moroccan Ministry of Energy, Mines, and Environment and the German Ministry of Economic Cooperation and Development to partner to research and investigate the implementation of hydrogen projects, with the first 100MW green hydrogen project arising from the pact expected to start operations by 2025,according to MEED.

Carrefour Majid Al Futtaim - Jordan
Courtesy: Yellow Door Energy

- In June 2021, the Moroccan Ministry of Energy, Mines and Environment and the International Renewable Energy Agency (IRENA) signed a strategic partnership to develop technology and market outlook studies and public-private partnership models in the hydrogen space. This agreement shall focus on exploring "the development of hydrogen value chains" and set the bases for trading green hydrogen on a national and regional level.

Although Morocco introduced the GreenH2 Cluster in 2021, the country must overcome some challenges such as:

- Achieving a price for green hydrogen that can compete with grey hydrogen
- Transforming and transporting green ammonia or methanol for exportation,
- Choosing the right technologies for implementation

IV. CHALLENGES AND OUTLOOK

The country's plans to install more renewable energy projects are still in action. The 2030 target for Morocco aims to produce 52% of renewable energy within its capacity mix. Yet, some challenges are still present within the country's legal framework to enable more opportunities for solar market players.

In the next few years, Moroccan developers are expecting the opening of the MV market as well as state PV (+battery storage (BESS)) tenders to come to life soon. The ambitions for renewable expansion are high and the country is still one of the leading solar producers in the MENA region.

I. OMAN

Hariprasad Gantyala - *Solar Lead - S.A.O.G*

Total Power Capacity by 2020	RE installed capacity	RE target by 2040
12,348 MW	**659 MW**	**13,400 MW by 2040**

Source : IRENA

I. CURRENT SITUATION

During the past five years, the Sultanate has embedded structural reforms and transformative policies to encourage energy transition and carbon emissions. Oman is preparing itself for a 7 per cent decrease in greenhouse gas emissions by 2030, complying with the Paris Agreement. The National Energy Strategy has set a target to derive 30 per cent of electricity from renewables by 2030. Moreover, between 2021-2027, the renewable energy plan aims to secure at least 2,660 MW of clean energy capacity. The plan aims for solar PV to account for 79 per cent, with wind to account for the remaining 21 per cent, according to the Authority for Public Services Regulation (APSR).

II. UPDATES ON REGULATIONS AND FRAMEWORKS

In January 2021, the Ministry of Energy and Minerals, the government body in charge of formulating the country's energy policy, announced that Oman is planning to introduce regulations that would allow for the bilateral trading of electricity between large consumers and generators. This could potentially permit large consumers to enter into arrangements with small scale renewable generators that would generate enough electricity to reduce the consumer's reliance on the grid.

III. PROJECT UPDATES IN 2021

» Ibri II PV

The largest utility-scale renewable energy project in Oman, Ibri II, started commercial operations in H2 2021. The project has a capacity of 500MW and was declared to be the largest TOPCon bifacial solar plant in the world. Located in Oman's Al-Dhahirah governorate, the project shall supply an estimated 33,000 homes with electricity and offset approximately 800,000 tons of CO2 emissions per year.

» Sahim II

As part of the National Energy Strategy, the Regulator of Oman, Authority for Public Services Regulation (ASPR) has launched a competitive tendering process to select a solar PV system developer for the procurement, installation, ownership, and operation of rooftop solar PV systems on 514 residential premises under the Sahim programme. Under the Sahim initiative, the capacity of installations will range from 3KW to 14KW each and cumulatively 2.424 MW. RFP submissions are currently under evaluation, with contracts expected to be awarded by the end of Q1,2022.

» Manah Solar I & II

In 2021, the nine prequalified bidders for the Manah I (500MW) & Manah II (600MW) PV solar IPP projects were granted a bid extension by Oman Power & Water Procurement Company (OPWP). While a new submission date has not yet been set, it is expected to be in the first quarter of 2022. The Manah projects will be awarded to two different bidders and will be located southwest of Oman's capital, Muscat.

» Tanweer Hybrid Project

Rural Areas Electricity Company (Tanweer) is planning to appoint a developer to procure and develop solar-diesel-storage projects in 11 isolated rural areas with a combined capacity of 146 MW. The hybrid plants (70MW of diesel generation and 48 MW of solar PV) will be constructed on a build, own, operate and transfer (BOOT) basis. Selected projects will be granted a 15-year PPA. The project will have a total storage capacity of 28MW to provide up to 14MW hours of storage. Sixteen firms were prequalified, but only one bidder responded and submitted a bid proposal. As a result, the project is currently on hold, as, per the Oman procurement policy, TANWEER must receive at least 3 bids to move ahead with the proposal.

» North Oman Solar IPP

Petroleum Development Oman (PDO) and its parent holding company Energy Development Oman (EDO) are planning to deploy 100MW of solar energy supported by 30MW of battery storage capacity. The project is currently in the engineering design phase and will be located in the north of Oman. The project is expected to reduce up to 300,000 tonnes of CO2 emissions a year.

» 100 MW PV Plant

A 100 MW solar PV plant will be developed in the Suhar Industrial City in Oman. An agreement was signed between Public Establishment for Industrial Estates (Madayn), Oman Investment and Development Holding Company (Mubadrah) and the developer Solar Wadi in Q4 2021.

» Renewable Energy Clusters

Oman National Engineering and Investment Company SAOG (ONEIC), a publicly listed investment and contracting company is developing a strategy for clean energy projects (Solar, Wind & Carbon Capture). As part of their 5 year strategy (2020-2025), ONEIC is planning to develop Renewable Energy Clusters at different locations (5MW-25MW) of Oman cumulatively 250MW on long term PPA basis and these projects under discussions with multiple off takers (mainly O&G, Industrial customers)

» Other C&I Projects

- A 20MW Solar PV project proposed by A'Namaa Poultry for their captive purpose is expected to be awarded soon under PPA Model
- A 4.6MWp Solar PV project proposed by Salalah Sanitary Drainage Company (SSDC), the tender is under evaluation under PPA Model
- A 3.4MWp solar PV IPP project proposed by Nakheel Oman Development Company (SAOC) is in the bid evaluation stage

» Rooftop Solar on Mosques

In November 2020, a pilot "Green Mosque Program" was launched to support the Sultanate's plans towards promoting renewable energy. With an investment more than $1.3bn, the programme increased its ambitions to install solar on 100 mosques under three packages over three years. In the second half of 2021, Hasan bin Tabith Mosque was the first mosque in Seeb to run on solar power, according to a report in Zawya.

» Smart City Pilot Project

A pilot project, scheduled to be rolled out in early 2022, aims to promote IoT in smart water metering; smart street lighting; smart waste bin management; smart urban water management; smart energy metering and smart irrigation is being planned. Based on a Memorandum of Collaboration (MoC) signed between Oman's National Energy Centre (NEC) and Petroleum Development of Oman (PDO), the project will target sustainable smart infrastructure utilities monitoring and management in water and energy management in PDO's Ras Al Hamra residential and leisure community, according to Construction Week.

» Hydrogen

Hy-Fly Alliance - In August 2021, thirteen members joined Oman's Ministry of Energy and Minerals in establishing a national hydrogen alliance from the public and private sector. The Hy-Fly alliance aims to "create a leading national and international industry and Government/public authority alliance to drive the development and deployment of clean hydrogen in line with Oman's Vision 2040 Energy Diversification Plans" according to H.E. Salim Al Aufi - Undersecretary, Ministry of Energy and Minerals.

25GW Green Hydrogen Project - The largest green hydrogen project in the Middle East is planned to be developed by a consortium of Oman's state-owned energy company OQ, Intercontinental Energy and Kuwait's EnerTech. The project will be powered by 25GW of wind and solar energy at the central Al-Wusta governorate, based on a study that began in 2019. In line with Oman's 2040 Vision, million tons of zero carbon green hydrogen will be produced to be used locally or for green ammonia exports.

HYPORT Duqm - A green hydrogen plant is planned to be developed at Oman's Special Economic Zone at Duqm (Sezad). A subsidiary of OQ company, OQ Alternative Energy, and Deme Concessions are joining forces to develop a 1GW green hydrogen project. The first phase, which will develop 500MW, is set to launch in 2026. Furthermore, the project is expected to contribute into Oman's renewable energy target and produce green ammonia to be export to Europe. Its location at the free zone will allow for competitive renewable energy costs and access to large sites to develop solar and wind plants.

SalalaH2 Project - A Joint development Agreement (JDA) was signed to conduct feasibility studies for the development of a green hydrogen and ammonia facility in Salalah Free Zone. Marubeni, Linde and Dutco Group entered this agreement with Oman's state energy company OQ in October 2021. According to Energy & Utilities, the project is expected to produce up to 1,000 tonnes of green ammonia per day, utilizing OQ's existing ammonia plant in Salalah. SalalaH2 electrolysis facility will have a capacity of up to 400MW to produce green hydrogen for ammonia production.

Green Hydrogen-Powered Ammonia Project - A green ammonia plant will be constructed in Duqm industrial zone to be powered by solar and wind. The $2.5bn project is being developed by a consortium led by India's ACME Group at the Special Economic Zone at Duqm (Sezad). Ultimately, the project will export green ammonia to Asia and Europe, the first of its scale. Financial close was scheduled for end of 2021.

IV. CHALLENGES AND OUTLOOK

Oman is facing some challenges to deploy solar. Currently, Discoms, the distribution licensee, is not allowing projects to connect to grid that will produce more than 50% of the applicant connected load, and the country lacks regulations for net metering and wheeling power. Furthermore, various regulatory & authorities are involved in approval process of solar projects, which consumes a long time to receive those approvals in the needed timeframe.

Oman is currently focusing its efforts on deploying several utility-scale solar projects to increase the country's reliance on renewables. The utility-scale targets set for 2027 are ambitious, but Oman has already put in place the regulatory frameworks and policies to make these plans a reality. The country is also planning to be a major player in the global green hydrogen market, with some of the region's most ambitious clean hydrogen and ammonia projects planned. Hy-Fly alliance with public and private companies shall grow the green hydrogen sector significantly. More than three projects are being developed as well as pilots and feasibility studies in place.

J. QATAR

Sumit Shikhar - *Business Development Lead - EDF Renouvelables Middle East*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
10,500 MW	**43 MW**	**20% electricity from solar**

Source : IRENA

I. CURRENT SITUATION

2020 marked the beginning of a highly anticipated new decade for Qatar's renewable energy sector. The country had installed around 5MW of solar capacity by end 2019 and awarded the very first utility scale solar PV project of 800 MW during 2020. Qatar's National Vision (QNV) 2030 is a roadmap guiding the country towards sustainable, economic, social, human and environmental development. The Planning and Statistic Authority is supporting this vision through leading national efforts and producing a series of consecutive national development strategies, that is currently in its second phase (2018- 2022). The Qatar National Development strategy is aiming for an average reduction in electricity consumption by 8% to reduce water consumption per capita by 15%. In addition, a transition to increase renewable energy adoption is expected by end 2022. Most recently, the country announced at COP26 a target to reduce 25% of greenhouse gas emissions by 2030.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

According to the State of Qatar Second Voluntary National Review, 2018, Qatar has established a committee for renewable energy at the Ministry of Energy and Industry to boost solar energy deployment. The country has also allocated funds to encourage the establishment of solar power plants including sustainable energy initiatives and the use of energy saving technologies. Therefore, Qatar is committed to increase the share of renewable energy within the total energy mix. However, the country has not yet embedded a framework enabling net metering, with projects currently being procured through competitive tendering.

Al Nabooda Automobiles - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

» PPP Law

Qatar issued a new PPP Law in 2020 setting out the rules and procedures for undertaking Public-Private Partnership (PPP) projects. The Law provides a legal framework governing the entry of public and private sector entities into PPP agreements for projects of various forms including BOT, BTO, BOOT, OM and others.

The Law sets out a number of procurement methods, with procuring authorities required to consult the PPP committee on the feasibility of any project before proceeding with the tendering process. Bidders in a PPP project are expected to meet a number of financial and technical qualifications determined in accordance with the tender procedures set by the Law and PPP committee.

By structuring and regulating PPP projects, the Qatari government intends to instill transparency, due process and equality in the tendering process for private investments in Qatari projects. It is hoped that the push for transparency, in addition to benefits such as exemptions for nationality requirements set to be granted to partners for PPP schemes, encourage private sector participation in infrastructure investment in Qatar.

III. PROJECT UPDATES IN 2021

» Al Kharsaah PV Project

The Al-Kharsaah PV solar IPP project was the first utility-scale solar project to be tendered and awarded in Qatar.

A consortium of France's Total and Japan's Marubeni was successful in a competitive tender for the project after submitting one of the world's lowest Levelized Cost of Electricity (LCOE) tariffs of 1.745 $cents/kWh. A 25-year PPA was signed, with the project being developed on a Build, Own, Operate, Transfer (BOOT) basis. Total and Marubeni formed a special purpose vehicle (SPV), Siraj 1, to build, operate and maintain the project.

Marubeni holds a 20.4% stake in Siraj1, while Total and Siraj Energy own 19.6% and 60% interests respectively. Siraj Energy is a joint venture of Qatar Electricity & Water Company (60%) and Qatar Petroleum (40%).

In July 2020, the project reached financial close and in August, of the same year, construction works started. Ultimately, the first phase of the project is expected to deliver 400MW in the next few months and the commercial operation date of the 800MW plant is planned for H2 2022. Once completed, the project will meet 10% of peak electricity demand in Qatar.

» 800 MW Projects

Two 400MW projects, aggregating 800MW, are being planned to be tendered on an EPC basis, with Kahramaa expected to be the offtaker. The tender has been delayed on multiple occasions due to dynamic situation of the PV market. The projects are expected to come online in Q3/Q4 2022.

» Qatar Solar Atlas

In May 2021, five-year research about the country's potential in renewable energy was released in the very first Qatar Solar Atlas, by the Hamad Bin Khalifa University (HBKU)'s Qatar Environment and Energy Research Institute (QEERI). The atlas was developed with the intention of aiding the development of national policies to stimulate investment in the country's solar sector.

» Qatar Solar Atlas

The national oil corporation, Qatar Petroleum (QP), launched a 2030 Sustainable Strategy in January 2021. The strategy aims to deploy 4GW of renewable energy by 2030. Most recently, in February 2021, the corporation announced its plans to develop an 800MW solar scheme. However, the procurement process for the project haven't started yet.

IV. CHALLENGES AND OUTLOOK

Qatar is facing some challenges to deploy solar, particularly rooftop solar, due to the lack of incentives provided by the government for homeowners, businesses and industries to adopt solar technology, which is slowing the growth of the solar energy market in Qatar. Therefore, a regulatory framework or support in the form of net-metering or wheeling is needed to encourage the development of solar in the commercial and industrial sector.

Although the country has announced its intention to meet 25% solar generation by 2030, market players are still waiting for a clear roadmap set by the government on how it plans to achieve this goal.

The implementation of the very first utility-scale project and the introduction of the new PPP law are the first steps in enabling the development of renewables in Qatar. Furthermore, energy saving systems and enhanced digital techniques could be embedded to improve grid management, such as IoT that could aid real life remote monitoring. In the meantime, the country's plan to expand its renewable energy footprint requires an acceleration of investments in the clean energy sector.

The Box Self Storage - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

K. SAUDI ARABIA

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
82,135 MW	**413 MW**	**50% by 2030**

Source : IRENA

I. CURRENT SITUATION

Five years after announcing its ambitious Vision 2030 economic reform programme, Saudi Arabia is beginning to make progress with its ambitious renewable energy plans.. Saudi Arabia has set a target to obtain 50% of its electricity from renewables by 2030, which will account for almost 60 GW additional capacity. From a financial perspective, in only five years, state sovereign wealth fund the Saudi Public Investment Fund (PIF) doubled its holdings to approximately SR1.5 trillion. In this time, foreign direct investment has increased from SR5.321bn to SR17.625bn.

In late 2021, Saudi Arabia pledged to reach net zero emissions by 2060, announcing it will invest more than $180bn to reach its goal. The kingdom has assigned the development of 30% of the 2030 58.7GW renewable energy target to REPDO though competitive tendering procedures, with the rest of the capacity be handled by PIF through direct contract negotiation with investors.

In addition to developing significant clean energy capacity, Saudi Arabia is planning to reduce carbon emissions and increase sustainability through a circular carbon economy approach. This includes boosting vegetation, reducing carbon emissions, by more than 4% of global contributions, and combatting pollution and land degradation. Furthermore, in Q4 of 2021, Saudi Arabia's crown prince Mohammed bin Salman launched a Middle East Green Initiative to reduce carbon emissions and protect the environment, allocating funds of $10.4bn. He said, Saudi Arabia "will work to establish an investment fund for carbon circular economy solutions in the region... an initiative to offer clean energy solutions to help feed more than 750 million people worldwide".

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» First Green Bond

Saudi Arabia is planning to issue its first green bond in early 2022, subject to market conditions. This initiative falls under the country's pledge to diversify its investor's base and sources of funding to projects. Issuing green bonds complying with environmental, social or governance ESG are set to be one of the main funding channels in the future.

» Privatisation Law

In mid-2021, Saudi Arabia adopted a new Privatisation Law increasing the private sector's involvement in infrastructure projects. According to Dentons, the law also supports "PPPs; provide public services through private enterprise; privatize public services; reduce government spending; and develop procedures for implementing PPP and privatization projects." Furthermore, it is anticipated that the law will encourage foreign investment and promote transparency and integrity in future tenders. This law comes after the change in regulations of allowing private companies to sell electricity to customers in early 2021.

III. PROJECT UPDATES IN 2021

» Sakaka PV Project

ACWA Power inaugurated Saudi Arabia's first utility-scale renewable energy project, the 300MW Sakaka PV IPP, in the second quarter of 2021. The project attracted SR1.2bn of investment.

» REPDO Projects

Round 2 - Jeddah 300 MW Solar Project - The submitted competitive bid of US$16.24 per MW hour of mega scale project was awarded to a consortium led by Masdar and EDF Renewable, and Nesma Company by REPDO. In April, the project reached financial close and started construction works to operate in 2022.

Seven projects were awarded under the second round of the REPDO program with the total capacity of 2,970 MW. One of the awarded projects, the 600MW Al- Fasiliyah IPP achieved the world's lowest LCOE tariff at $0.0104/kWh. Power purchase agreements (PPAs) were signed for six projects with a total capacity of 1.47GW under the second round of the kingdom's National Renewable Energy Programme (NREP) in 2021, with most of the projects now under construction.

Each project will be developed under a build-own-operate (BOO) model, with the successful bidder holding 100 per cent equity in the special purpose vehicle (SPV) set up to developer and operate the IPP.

SPVs will sign a 25-year power purchase agreement (PPA) with the kingdom's offtaker. Land for the projects will be secured by Repdo and provided to the project company under sub-lease agreements.

Round 3 - In 2020, Repdo began the procurement process for the 1.2GW third round of the NREP. Three bids were received in May 2021 to develop 120MW Wadi ad-Dawasir and the 80MW Layla solar projects under Category A of the third round. This was followed in June by the submission of bids for two larger projects, 700MW Ar-Rass PV and 300MW Saad PV, under category B. Recently, bidders entered negotiation phase with the offtaker and only one project will be awarded to a bidder.

Round 4 & 5 - Following the successful award of projects under round two and the selection of preferred bidders for the third round, Repdo is pushing ahead with plans for the fourth and fifth rounds of the NREP. Recent updates stated that proposals were received for the financial and lead advisory roles in mid-2021.

» Sudair PV Plant (PIF programme)

ACWA Power, in consortium with Badeel and Saudi Aramco, was awarded a contract to develop the 1.5GW Sudair PV IPP under the PIF direct negotiation programme.

In April 2021, the consortium signed the PPA for a tariff of $0.0104/kWh, the second lowest PV solar tariff achieved in the kingdom after the Al-Fasiliyah PV IP. The 1.5GW Sudair PV project will be by far the largest PV solar project awarded in Saudi Arabia to date, and also among the largest single-site PV projects in the world.

The project will provide enough power for 185,000 homes and will offset 2.9 million tonnes of carbon emissions a year. The $906m project reached financial close in mid-2021, with six local and international financial institutions providing financing for $600m.

» 600 MW Renewable Plants

As a part of Saudi Arabia's 2030 vision, the Saudi Ministry of Energy is building two renewable energy plants with a capacity of 600MW in the Third Industrial City in Jeddah and the Industrial City in Rabigh. The projects will cover a total area of 12 million m2 and will implemented through the Saudi Authority for Industrial Cities and Technology Zones (Modon).

» NEOM

The $500bn NEOM megaproject will play a key part in the kingdom's plans to diversify its economy, while being powered exclusively by clean energy. It is estimated that the project will require 20-40GW of solar and wind projects in order to meet the power requirements of the scheme.

One of the early flagship projects is a $5bn green hydrogen and green ammonia project, which will be developed by ACWA Power and US-based Air Products. The consortium signed initial agreements for the project in June 2020.

The project will be powered by more than 4GW of renewable energy, and will be able to produce 1.2 million tonnes per year of ammonia. The plant will produce 650 tonnes of hydrogen daily. The project is due to be operational in 2025. Development work is due to begin in 2022.

» Red Sea Battery Storage Project

The largest 1,300MWh BESS project in the world was awarded to Huawei Digital Power in Q4 of 2021 to be implemented at the Red Sea development. The consortium of Acwa Power and Energy China were awarded the project in 2020. Furthermore, the first phase of the project will be commissioned in 2022 delivering peak service demand of 210MW. Solar, wind and 1.3GWh of battery storage will enable the resort to be powered completely by renewables, both day and night. The second phase, due to be delivered in 2030, will meet a peak demand of 360 MW.

» Solar Factories in KSA

The Saudi Authority for Industrial Cities and Technology Zones (Modon) has revealed that the kingdom will add 23 solar panel factories in the country. The plants will be located in 12 industrial cities covering a total area of 360,000 square metres.

In Q4 2021, the largest solar panel production plant in MENA was inaugurated in Tabuk. The factory covers 27,000 square metres and has a production capacity up to 1.2GW. The development of local manufacturing and technology facilities for solar components is planned to play a key part in Saudi Arabia's economic diversification plans and create jobs for Saudi nationals.

IV. CHALLENGES AND OUTLOOK

Saudi Arabia is one of the booming markets in the renewable energy sector which is bringing more investors and developers to participate in huge projects, than any other. The country focused on solar energy in its REPDO programs and succeeded in the first three rounds to plan the next phase of the NREP program. Furthermore, crown prince Mohammed bin Salman is encouraging the country to step forward and achieve net zero by 2060. Regulations and frameworks are becoming clearer overtime and Saudi is positioning itself to be one of countries at the forefront of a greener future.

Al Nabooda Automobiles - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

L. SUDAN

Dr. Mohamed Alhaj - *Founder & Director - Clean Energy 4 Africa*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
3,608 MW	**2,124 MW**	**2,936 MW by 2030**

Source : Sudan Ministry of Investment & International Cooperation 2021, IRENA, Sudan's updated NDC 2021

I. CURRENT SITUATION

Sudan has already moved ahead with initiatives to develop solar energy, with approximately 19MW having already been installed. The recent boom in the solar sector was due to the observed mismatch between supply and demand, especially given the high demand growth rate in the residential sector, estimated at 11% annually. Furthermore, rising awareness about the benefits of installing solar technologies has also increased demand for solar energy.

The country as set a target of installing 2,936MW of solar and wind capacities to generate electricity by 2030. This is planned to include the development of 2,140MW through utility-scale PV solar plants and 796MW through standalone systems and mini-grids. The Government also has announced a target of 82% electrification by 2035 supported mainly by utility-scale and distributed generation renewable energy projects.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

The regulatory framework for renewable energy in Sudan is still in its development stage. However, the approval of legislation and laws in 2021 to encourage private sector participation, particularly through investment and PPP laws, are expected to boost the development of a solar energy sector in Sudan, especially at the utility-scale generation level.

» Investment Law

The new Investment Law, published in April 2021, provides incentives to foreign investors such as tax and customs duties exemptions for certain types of projects, permanent residence visas for the duration of the investment, and the establishment of a one-stop shop to simplify administrative procedures for investors.

» Public-Private-Partnerships (PPP) Law

The PPP Law, introduced in April 2021, aims to increase the private sector's role in the economy. In the renewables sector, it encourages independent power producers (IPPs) to enter the market. In fact, in June 2021, the Sudan Electricity Holding Company, announced a call for developers to submit expressions of interest (EOI) for developing utility-scale solar and wind power plants under the PPP law as BOOT projects. This first step is a prequalification stage which will be followed by a stage for assessing projects and submitting technical and commercial offers.

» Electricity Law Amendments

In September 2021, the Minister of Energy & Petroleum has announced amendments made to the Electricity Law allowing private companies to work in the power generation business as independent power producers.

» Customs Law and the VAT Law Amendments

In October 2021, the Cabinet has approved amendments of several laws, such as the Customs Law and the VAT Law, to encourage investment in solar energy by exempting all solar energy systems and inverters from customs and VAT duties.

» Net Metering

The Renewable Energy Directorate has announced in October 2021 that it is finalizing the technical specifications for rooftop solar systems in preparation for launching the net metering scheme early 2022.

III. PROJECT UPDATES IN 2021

While *Sudan started installing solar capacity a couple of years ago, MESIA will shed light on all solar projects as Sudan is included in the Solar Outlook Report for the first time.*

» Al-Fashir Solar PV Plant

The first utility-scale solar power plant in Sudan has a capacity of 5MW. The plant comprises of more than 16,000 PV modules and is currently under operation.

» Al-Dheieen Solar Project

The 5MW Al-Dheieen solar project is currently under construction. However, the project is currently facing delays due to PV panel supply chain disruption in Port Sudan. It is expected that the project will be completed in Q2 2022.

» AfDB Solar-Powered Irrigation Pumps Project

To increase adoption of solar-powered irrigation systems the states of Kordofan, the African Development Bank (AfDB) is providing $21.7m to make that happen. In June 2021, calls for expressions of interest started for a solar project to supply 1,170 PV-powered pumps.

» Solar Rooftop

The Renewable Energy Directorate at the Sudan Electricity Holding Company started a rooftop solar pilot project in 2018, which included the installation of 300kW of grid-tie solar installations at selected government buildings. The project targeted exploring the feasibility and challenges of installing and operating rooftop solar projects in Sudan.

Today, most solar companies in Sudan work in rooftop solar, focusing on small residential customers. System sizes are typically in the range 1kW-5kW dc. Larger system sizes are not very common due to limited roof spaces on houses and villas.

» Innovations

There have been several innovative initiatives in the past two years in the Sudan solar energy market, mainly due to increased competitiveness. As the country's economy relies mainly on agriculture, solar-powered irrigation and pumping systems are the most encouraging applications for companies to implement. Recently, a megaproject was implemented in a farm in the Northern State, where a large solar system was commissioned to power a mega center pivot irrigation system for a farming area of 35 feddans. It is probably the largest single solar-powered site irrigation system in Sudan that costed around $80,000. Lately, an increasing number of farmers are showing interest in investing in such mega projects due to the large savings in operational costs and the relatively short investment payback period.

Carrefour Majid Al Futtaim - Jordan
Courtesy: Yellow Door Energy

IV. CHALLENGES AND OUTLOOK

Since the December 2018 revolution, Sudan's political and economic conditions have been relatively unstable, which is a real obstacle for the local solar industry. Furthermore, the underdevelopment of the enabling environment for renewable energy, in particular the absence of a national renewable energy strategy and the delays in approving some key policy instruments, is also a major challenge. However, there has been several important economic reforms such as the recent removal of most fuel subsidies (to achieve more cost reflective tariffs) and the improved stability of the currency exchange rate due to the government's currency devaluation policy.

Other challenges that also impact the solar industry significantly include institutional reform in the electricity sector, local capacity development, data availability, and the need for standardization in the industry.

To speed up the adoption of solar, the Sudanese government needs to expediate the process of finalizing the national renewable energy strategy and approving supporting legislations and regulations such as net metering and the grid code for rooftop solar projects. Furthermore, at the utility-scale level, the government needs to facilitate the process of market entry for new investors via the one-stop-shop concept, publishing all the relevant codes and regulations, and developing clear regulations on the bidding process, PPAs, land allocations, and permits.

Within the private sector, Sudanese consultancy firms need to build their capacity to manage renewable energy technologies and market research and assessment to support international investors who are interested in the market.

The recently approved PPP law is expected to support the development of distributed generation projects and micro-grids which are essential for Sudan's electrification strategy. However, these types of partnership models are new in the market. Furthermore, the residential solar and the solar-for-irrigation markets are expected to grow, due to the emergence of several new companies and supported by the stability of the local currency, the entrance of many Sudanese banks as financers for these projects, and the recent decision by the government to remove all customs and taxes on imported solar equipment.

United Foods - UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

M. TUNISIA

Hatem Azaiez - *Senior Utilities Sales Manager - LONGi Solar*

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
6,272 MW	**401 MW**	**30% by 2030**

Source : IRENA

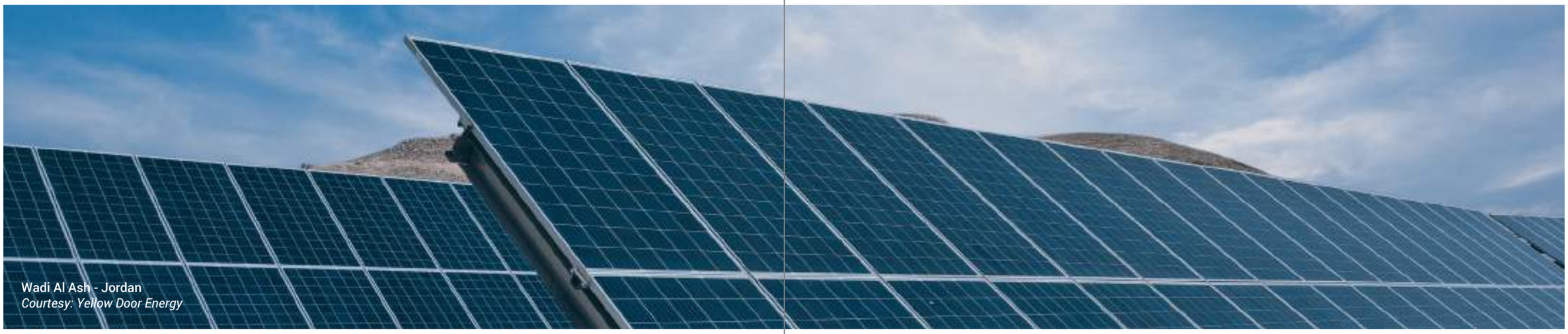
I. CURRENT SITUATION

Tunisia's power sector relies heavily on natural gas, with the fuel accounting for 97.5 per cent of power generation. Between 2010 and 2020, domestic oil and gas production dropped by 54% and 47% respectively, while primary energy demand has risen by 15% for the same period. Moreover, the country's reliance on energy imports increased from 7% in 2010 to 60% in 2018. Therefore, diversifying the energy mix and developing renewable energy is a key priority for the North African country.

While solar rooftop and irrigation market have continued to develop in the last 2 years, C&I and governmental projects faced some challenges. Although 774MW of solar IPP capacity hs been awarded under the authorization and concession regimes, none of the projects have made it to the execution stage. Tunisia has therefore not been able to meet the previously announced objective of 12% of renewable generation by 2020. The country remains committed to the development of renewables, however, and has set a target for renewables to account for 30 per cent of its total power generation by 2030.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

A net metering framework was established in Tunisia in 2009. The lack of visibility on the government subsidies for rooftop installers have created some disturbances in the market during 2020-2021. However, growth was noticeable, as solar gained momentum with homeowners, farmers and small industrials. Yet, in 2021, there were no further renewables regulations or policies updates in the country.



Wadi Al Ash - Jordan
Courtesy: Yellow Door Energy

III. PROJECT UPDATES IN 2021

Most solar projects are currently on hold in Tunisia due to the current situation in the country.

After two first rounds of solar tenders, for 70MW in 2017 and 60MW in 2019, Tunisia launched two more rounds in 2020. Round 4 will, like Round 1 and 2, be split into smaller projects of 1MW to 10MW.

» Third Round: 500 MW Solar Tender

In 2020, Tunisian Ministry of Mines and Energy awarded contracts to developers for 500MW of capacity under the third round. The project includes a 200MW solar plant in the province of Tatouine in the Sahara Desert, two 100MW solar PV facilities in the provinces of Kaiouran and Gafsca and two 50MW solar parks in the provinces of Sidi Bouzid and Tozeur.

- **300 MW PV Plants -** A 200MW facility in Tataouine and two 50MW schemes in Tozeur and Sidi Bouzid will be constructed by Scatec Solar. It is anticipated that the projects could reach financial close in Q2 2022, with all of the project agreements signed and awaiting final ratification from parliament.
- **100 MW Kaiouran PV Plant -** TBEA Xinjiang New Energy and AMEA Power were awarded a contract to develop the 100MW Kaiouran PV IPP. However, the PPA has not yet been signed, and the project is on hold.
- **100MW Gafsa PV Plant -** The Tunisian Ministry of Mines and Energy and STEG awarded a consortium led by ENGIE and NAREVA to build a 120MW PV plant in Morocco. The plant is expected to generate power for more than 100,000 homes and reduce 150,000 tons of CO2 emissions per year. Currently, the project is on hold until further notice.

» Fourth Round: 70MW Solar Scheme

The fourth round of the solar tender having a total capacity of 70MW was divided into 16 projects, ten projects of 1MW and six projects of 10MW each. In Q1 of 2021, the Ministry of Energy, Mines and Renewable Energies announced receiving 57 project proposals for the full capacity. The ministry received 40 proposals for ten projects of 1MW, and 17 proposals were submitted for the 10MW projects. The ministry announced that the bids fell between €35/MWh and €37/MWh, but the lowest was €0.035/kWh. Ultimately, 20-year PPAs shall be signed with the Tunisian Electricity & Gas Company (STEG) as the offtaker of all PV plant projects.

» Solar Rooftop

The solar rooftop market is mature, and the population has potential to adopt solar energy. In Tunisia, private loans through STEG are available for the homeowners to reduce the equity needed for their installations. Increasing competitiveness in the market and an increase in electricity prices would help the rooftop market to achieve growth in the coming years.

However, some challenges remain such as the lack of visibility on the National Agency for Energy Control (ANME) subsidies, and there are ongoing discussions to remove them. Furthermore, the country suffered from temporary unavailability of bi-directional meters, which might cause delay with the development of projects.

» Hydrogen

Tunisia signed an agreement with Germany on December 15, 2020, endorsing the Tunisian-German Alliance for Green Hydrogen. Under this agreement, Germany granted Tunisia a donation of €31 million in order to build a pilot plant and begin studies for developing regulatory framework of green hydrogen in Tunisia. With abundant solar resources and a strategic geographical position, Tunisia has the potential to play a major role in the hydrogen market.

IV. CHALLENGES AND OUTLOOK

The current delay with the approval of projects has stalled Tunisia's progress with developing a successful clean energy sector. Therefore, speeding up project execution and regaining investors trust is a key element in driving the sector forward. Creating a task force to expedite all of the delayed projects and establishing a framework to ensure future projects are approved and executed in an efficient manner is critical if Tunisia is to succeed with its renewable energy targets.

Tunisia has still room for large utility scale and C&I as projects have been delayed for years. If Tunisia can deliver on its planned targets, Tunisia could emerge as interesting proposition for investors and solar contractors but increased experienced labour and competent engineering would make this transition period even faster. Not only would solar allow the country to decrease its energy dependency and reduce the budget costs, it could also set the basis for the next big-business opportunity: green hydrogen manufacturing and potentially exporting to Europe.

Carrefour Majid Al Futtaim - Jordan
Courtesy: Yellow Door Energy

N. UNITED ARAB EMIRATES

Total Power Capacity by 2020	RE installed capacity	RE target by 2030
35,227 MW	**2,540 MW**	**14,000 MW**

Source : IRENA

I. CURRENT SITUATION

UAE has emerged as one of the leading MENA countries in terms of developing clean energy and setting ambitious solar targets. The country has already installed more than 2.5 GW of solar energy. Its strategic target includes a pledge to achieve Net Zero emissions by 2050. UAE aligns its goals with the Paris Agreement to reduce Green Gas Emissions (GGE) limiting the rise in global temperature to 1.5oC. However, a closer target was set for 2030 aiming for a 23.5% GGE reduction.

The country has already invested more than $40bn in the clean energy sector to date. Installed clean energy capacity could reach 14GW by 2030.

II. UPDATES ON REGULATIONS AND FRAMEWORKS

» Environmental, Social and Governance (ESG) Policy

A new policy was launched in Q1 2021 to support Abu Dhabi Investment Office (ADIO) initiatives and public-private partnership (PPP) programmes. ADIO's investment and decision-making processes are to align with the new policy standards. The adoption of ESG policies will stimulate investments in clean energy and sustainability initiatives.

» Clean Energy Certificates

In August 2021, the Department of Energy in Abu Dhabi (DoE) launched a regulatory policy to issue Clean Energy Certificates. It sets the principles to implement a green energy certificates scheme in Abu Dhabi as a part of its commitment to encourage a sustainable future. The policy will identify power produced by clean energy and other sources to establish a reliable accreditation system to reduce the emirate's carbon footprint.

» DEWA Training Initiative

In September 2021, DEWA signed an MOU with the Arab Youth Centre to train young leaders in the clean and renewable energy sector, especially solar. Fostering competitiveness and increasing knowledge in young people will not only provide job opportunities for local citizens in the clean energy sector but will also accelerate the socioeconomic development of the country.

Classic Fashion - Jordan
Courtesy: Yellow Door Energy

III. PROJECT UPDATES IN 2021

Abu Dhabi:

» Planned Solar Schemes

In November 2021, Abu Dhabi government announced a plan to install 8.8GW of renewables capacity by 2025. This will include two PV solar plants with a combined capacity of 2GW areand another PV project with a capacity ranging 1-1.5GW.

In December 2021, Abu Dhabi-based Emirates Water & Electricity Company (Ewec) started to move ahead with the procurement process for the emirate's next major solar project, receiving proposals from consultants for the transaction advisory (TA) role on Abu Dhabi's third major PV project.

» Al-Dhafra PV Project

EWEC awarded the contract to develop the 2GW Al-Dhafra solar plant to a consortium of France's EDF and China's Jinko Power in mid-2020. Taqa and Masdar will own a combined 60% of the project, with the developer consortium to hold the remaining 40%. Al-Dhafra is currently being constructed in Abu Dhabi, once operational, it will be largest PV project in the Middle East. The plant will be constructed using around 3.5 million solar panels reducing emissions by 2.4 million metric tonnes per year.

Abu Dhabi's first major PV solar project, the 1.17GW Noor Abu Dhabi IPP was commissioned in July 2019. The Noor project was the largest single site PV project in the world when commissioned.

Dubai:

» Mohammad Bin Rashid MBR Solar Park

The largest single site solar park in the world will have a capacity of 5GW by 2030. Phases 1,2 and 3 are already operational while phases four and five are under development.

Phase 4 - The fourth phase of the MBR solar park, which will consist of 700MW CSP solar and 250MW PV solar is currently under development. The project will utilise three technologies to produce clean energy: 600MW from parabolic basin (three units of 200MW each), 100MW from a solar power tower (based on molten salt technology) and 250MW from PV solar panels.

The solar tower at phase four of the MBR project is almost built, more than 80% of construction is now completed. Once fully operational, the project is expected to provide electricity to around 320,000 residences and reduce 1.6 million tons of carbon emissions every year. A consortium led by DEWA and ACWA Power formed a project company, Noor Energy 1, to design, build, and operate the plant. DEWA owns 51% of the company while ACWA Power holds 25%, and the Silk Road Fund owns 24%. The project is being commissioned in phases and is expected to be fully operational in 2023.

Phase 5 - In August 2021, the first 300MW of the 900MW PV fifth phase of the MBR solar park was inaugurated. Acwa Power is developing the 900MW phase 5 solar project, which will require total investment of about $570m. When completed, the project will provide clean energy to over 270,000 residences in Dubai and will reduce 1.18 million tonnes of carbon emissions annually. The whole project will be commissioned in stages until 2023.

Pilot Storage Project - An energy storage pilot project using lithium-ion batteries was launched at the MBR park in September 2021. It is expected to have a 1.21MW power capacity and an energy capacity of 8.61MWh with a life span of up to 10 years.

MBR Green Hydrogen Project Ingeneration - The first green hydrogen pilot project in the UAE was inaugurated in the Mohammed bin Rashid Al Maktoum Solar Park in May 2021. The pilot project was developed by Germany's Siemens Energy in partnership with DEWA and Expo 2020. According to DEWA, the project "aims to demonstrate the production of green hydrogen from solar power, as well as the storage and re-electrification of hydrogen, turning hydrogen back into electricity."

DEWA HQ

DEWA awarded ALEC Energy in mid-2021 a contract to deploy solar PV at its headquarters in Al-Jaddaf. PV panels will be installed on the roof and façade of the new headquarters, covering an area of 21,150 square metres generating 4.8MW of power.

Carport Solar Installations

In 2021, Siraj Power announced it was installing a 1MW solar carport for Lulu Group. Furthermore, the same developer has also been awarded a contract to develop a 2MW solar carport solar installation at Dubai's Sevens stadium.

Floating PV

In January 2021, a floating PV tender was launched by DEWA to construct a pilot project in Dubai. Six bids were submitted in April and the lowest bid had a price of almost $819,500 by Yeo Contracting.

EXPO 2020 – Sustainability District

The sustainability district at Expo2020 showcased 1,055 solar panels at the 'Energy Tree' as part of the EXPO site's unique architecture. The drought tolerant Ghaf Tree is surrounded by 18 smaller rotating energy trees around it generating power for the building. Following the event, the building will be converted into a permanent museum dedicated to science and sustainability.

Gulf Cryo - UAE
Courtesy: Yellow Door Energy

Northern Emirates:

Sharjah - Smart Energy Storage Solutions Pilot

A pilot project to deploy and test the latest technologies and innovations in energy management systems is planned in the emirate of Sharjah. This followed the announcement that Sharjah Sustainable City would be allowing residents access to renewable energy storage solutions. SEE Institute, Sharjah Sustainable City's research and development arm, signed a Memorandum of Understanding with German-based Hager Group to deliver the scheme.

RAK - 15MWp Solar Project

In 2020, the Energy Efficiency and Renewables Office (REEM) of Ras Al Khaimah Municipality launched its first 15MW solar distributed solar project. The municipality prequalified 21 companies out of more than 80 to submit their proposals to implement the project.

**The emirate is also studying utility and floating solar PV, wind farms, ocean energy, and green hydrogen projects, according to Zawya.*

Hydrogen

Hydrogen Hub

In Q4 2021, Masdar and ENGIE joined forces by signing a strategic alliance agreement to study the development of a green hydrogen hub. The implementation of the project is worth $5bn and could deploy a capacity reaching at least 2GW by 2030.

2GW Green Hydrogen to Ammonia Project - Abu Dhabi

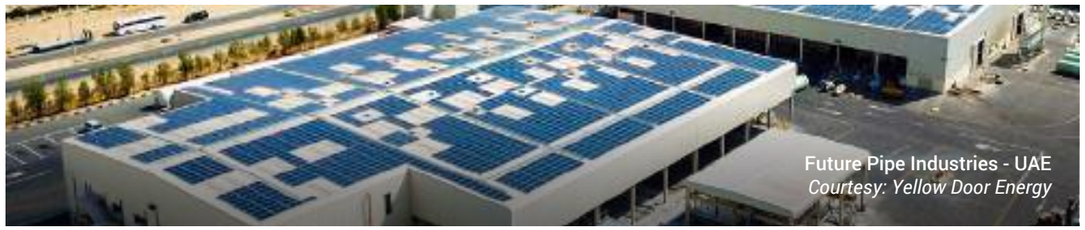
A 2GW planned green hydrogen to ammonia project between Abu Dhabi National Energy Company PJSC (TAQA) and Abu Dhabi Ports was announced in mid-2021. The two entities signed an MoU to develop proposals for a green ammonia export facility to be based in Khalifa Industrial Zone Abu Dhabi (KIZAD).

First Green Hydrogen - Steel Production Project

TAQA and Emirates Steel signed an MoU in mid-2021 to develop a green hydrogen project to enable the production of the first green steel in the MENA region.

IV. CHALLENGES AND OUTLOOK

The UAE is focusing it plans on developing the country's strategic mission for a clean energy future; solar, floating, and green hydrogen projects are increasing exponentially. In November 2021, his Highness Sheikh Mohammed bin Rashid Al Maktoum announced that UAE had won its bid to host COP28 in 2023, the largest global conference on climate and environmental issues. Furthermore, UAE's current and future vision is working on a net zero emissions target pushing further the efforts of the Northern Emirates and the development of renewable projects.



Future Pipe Industries - UAE
Courtesy: Yellow Door Energy

11. Conclusion

There is an obvious movement in the Middle East and North Africa countries towards net zero carbon and an urge to transition to cleaner energy. Although in 2021 we've seen probably the biggest hurdle that the solar energy sector has experienced, after an ascending decade, the challenges have only brought innovation and the opportunity to reduce costs with the implementation of technology. Fluctuations in pricing and challenges in the logistics have pushed manufacturers to evaluate the opportunity of establishing manufacturing plants in strategic locations to serve the region. Northern Africa has a unique geographical position and can easily become a long-term energy exporter to both Africa and Europe.

Individual countries aspirations towards renewable energy are drivers towards hiring consultants to write policies or improve on existing regulations. This seems like a lengthy process but capturing PV energy from the biggest source in the universe is a constant journey. As the quote says "Lead others to lead, not follow" – the goal is for each country to maximize on their potential. In the next decade, this could mean either off-grid or mini-grid for some, while others complement the existing utility provided grid.

Individual countries aspirations towards renewable energy are drivers towards hiring consultants to write policies or improve on existing regulations. This seems like a lengthy process but capturing PV energy from the biggest source in the universe is a constant journey. As the quote says "Lead others to lead, not follow" – the goal is for each country to maximize on their potential. In the next decade, this could mean either off-grid or mini-grid for some, while others complement the existing utility provided grid.

The focus in 2022 will be on energy storage, green hydrogen, IoT, AI, but a big focus should also be on education and the implementation programs that create a local workforce ready to manage a solar plant for 20-30 years.

United Foods-UAE
Courtesy: Yellow Door Energy
Photo Courtesy: Ghadir Shaar

12. Glossary Of Terms

BOM	Bill of Materials
AI	Artificial Intelligence
LCOE	Levelised Cost of Electricity
COP28	Conference of the Parties
OPWP	Oman Power & Water Procurement Company
MENA	Middle East and North Africa
CCUS	Carbon capture, Utilisation and Storage
PERC	Passivated Emitter Rear Contact
MBB	Multi Busbar
TOPCon	Tunnel Oxide Passivated Contacts
HIT	Heterojunction Technology
HJT	Heterojunction Technology
HOT	Heterojunction Oxide Tunneling
Voc	Open Circuit Voltage
HSAT	Horizontal Single Axis Tracking
ITRPV	International Technology Roadmap for Photovoltaics
IBC	Interdigitated Back Contact
Wp	Watt Peak
FPV	Floating Photovoltaics
HDPE	High-Density Polyethylene
CSP	Concentrated Solar Power
C&I	Commercial & Industrial
VPP	Virtual Power Plants
DER	Distributed Energy Resources
V2G	Vehicle to Grid
GIS	Geographic Information Systems
PPA	Power Purchase Agreement
API	Application Programming Interfaces
VRE	Variable Renewable Energy
IoT	Internet of Things
TMY	Typical Meteorolgical Year
GPU	Graphics Processing Units
SCADA	Supervisory Control and Data Acquisition
PLC	Programmable Logic Controllers
SDLC	Secure Development Lifecyle
FAT	Factory acceptance tests

SAT	Site Acceptance Tests
YA	Yield Assessments
LTYP	Long-Term Yield Predictions
IRR	Internal Rate of Return
NPV	Net Present Value
PV	Photovoltaic
PID	Potential Induced Degradation
LeTID	Light and elevated Temperature Induced Degradation
LCA	Life Cycle Assessment
SSMR	Standing Seam Metal Roofing
ROI	Return on Investment
IMP	Insulated metal panels
DEWA	Dubai Electricity and Water Authority
MBR	Mohammed bin Rashid
NCA	Lithium Nickel Cobalt Aluminum Oxid
NMC	Lithium Nickel Manganese Cobalt Oxide
LFP	Lithium Iron Phosphate
NaS	Sodium Sulfur
CREG	Algerian Electricity & Gas Regulation Commission
SEA	Sustainable Energy Authority
NREAP	National Renewable Energy Action Plan
NEEAR	National Energy Efficiency Action Plan
EWA	Electricity and Water Authority
BIC	Bahrain International Circuit
BOOM	Build, Own, Operate and Maintain
COP26	United Nations Climate Change Conference of the Parties
ASPC	Abyodos Solar Power Company
EBRD	European Bank for Reconstruction and Development
AfDB	African Development Bank
GCF	Green Climate Fund
EEHC	Egyptian Electricity Holding Company
Deme	Dredging, Environmental and Marine Engineering Group
KAPP	Kuwait Authority of Public Partnership
MEW	Ministry of electricity and Water
ISCC	Integrated Solar Combined-Cycle
O&M	Operations and Maintenance

KNPC	Kuwait National Petroleum
EDL	Electricity of Lebanon
LCEC	Lebanese Centre for Energy Conservation
LIBNOR	Lebanese Standards Institution
HV	High Voltage
MV	Medium Voltage
Masen	Moroccan Agency for Sustainable Energy
Onee	National Office of Electricity & Water
CCC	Consolidated Contractors Company
IRENA	International Renewable Energy Agency
APSR	Authority for Public Services Regulation
PDO	Petroleum Development Oman
EDO	Energy Development Oman
ONEIC	Oman National Engineering and Investment Company SAOG
SSDC	Salalah Sanitary Drainage Company
MoC	Memorandum of Collaboration
Sezad	Special Econom-ic Zone at Duqm
JDA	Joint development Agreement
QNV	Qatar's National Vision
PPP	Public-Private Partnership
SPV	Special Purpose Vehicle
HBKU	Hamad Bin Khalifa University
QEERI	Qatar Environment and Energy Research Institute
QP	Qatar Petroleum
IPP	Independent Power Producers
EOI	Expressions of Interest
STEG	Tunisian Electricity & Gas Company
ANME	National Agency for Energy Control
GGE	Green Gas Emissions
ESG	Environmental, Social and Governance
ADIO	Abu Dhabi Investment Office
DoE	Department of Energy in Abu Dhabi
Ewec	Emirates Water & Electricity Company
TA	Transaction Advisory
REEM	Energy Efficiency and Renewables Office
KIZAD	Khalifa Industrial Zone Abu Dhabi
NREA	New & Renewable Energy Authority

Board members

Ahmed Nada
President

Alexandre Allegue
Vice-President

Denisa Fainis
General Secretary

Gurmeet Kaur
Communications and Marketing Director

Khawla Albloushi
Finance Governance and Government Relations Director

Romain Riche
International Development Director

MESIA Team

Hinde Liepmannsohn
Operations and Marketing Director

Mohammed Alzaidi
Membership Associate

Dania Musallam
Research and Content Manager

Picture Courtesy: Ghadir Shaar - GSL - UAE

MESIA

جمعية الشرق الاوسط لصناعات الطاقة الشمسية

Middle East Solar Industry Association

Empowering Solar across the Middle East

OFFICE NO.16, DUBAI INVESTMENT PARK 1
DUBAI, UAE

www.mesia.com