SOLAR MARKET ACROSS THE GCC: OPPORTUNITIES FOR DUTCH ENTITIES

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1. Executive Summary

The Solar Energy Value Chain in the Netherlands: Specialist Expertise, Technologies and Systems, and Business Models

- The solar energy value chain across the Netherlands consists of various public sector entities and private sector enterprises that specialize in the research and development, and the production and deployment of various solar materials, industrial equipment, solar modules, solar components, testing and measuring technologies and practices, that are complemented with a specialized expertise in project development, engineering and construction.
- Enterprises operating in the solar value chain across the Netherlands provide specialized expertise, technologies, systems, and practices through various unique business models that are underpinned by first-class technological expertise, high-tech innovative strength combined with world class research and development institutions, under an international outlook that intends to capitalize on growth opportunities across various emerging markets.
- Particular key points of Dutch solar experience include:
    - Integrating into densely-populated and developed environments with limited and expensive space;
    - Integrating solar power into the design of buildings, infrastructure and public spaces;
    - Reducing the environmental footprint of solar power by circular design, re-use and sustainable materials;
    - Adapting the grid and the total energy system to absorb large and variable quantities of solar power effectively.

The Solar Sector in the Gulf Cooperation Council Countries

- The adoption of solar technologies across the utility-scale, distributed and off-grid segments are a key "strategic and economic security" feature of the renewable energy policies introduced by countries across the GCC, in rough priority order:
    - to meet a growing demand for electricity;
    - to free up domestic consumption of hydrocarbons for profitable international exports, and limit gas/LNG imports;
    - to drive economic diversification and create jobs and new industries;
    - to reduce the carbon footprint of industrial production to ensure continued market access, in particular to Europe;
    - to address environmental problems and climate change challenges including the countries' Paris Agreement commitments;
    - to diversify the electricity generation mix with renewable energy.
- Renewable energy policies across the GCC mainly focus on ambitious and large utility-scale deployment of solar technology. These policies are complemented by energy

efficiency targets and attempts to reduce and restructure subsidies.

- At the end of 2019, the GCC had installed renewable capacity of 2.45 GW, which increased from 0.796 GW in the previous year. Of the 2.45 GW, solar PV accounted for 90%, up from 74% of total renewable capacity the year before. Of the 2.1 GW of solar PV installed capacity in the GCC, the UAE accounts for 81% of the installed capacity, Saudi Arabia 16%, and Kuwait 2%.
- The GCC will continue being the fastest growing market in the Middle East for solar installations leading into 2025, as countries across the region have enacted ambitious renewable energy policies and solar capacity targets.
- Beyond renewable energy policies and solar capacity targets, the growth in solar PV deployment across the GCC is driven by:
    - increasing interest by foreign and international developers / companies;
    - an abundant indigenous solar resource;
    - availability of free or low-cost flat desert land;
    - the availability of robust power purchase agreements (PPAs) offered by regional off-takers with explicit or implicit state guarantees;
    - competitive auction mechanisms that have continued to drive down costs and promote transparency;
    - the availability of fiscal support schemes such as low levels of VAT and import duty levied on the early deployment of innovative foreign technologies;
    - the availability of various commercial financing schemes;
    - an environment of low business and investment risk.
- The region's competitive solar PV auction schemes have consistently extracted world-record setting bids. For example, in Q2, 2020, a consortium consisting of EWEA, EDF, and JinkoSolar submitted a bid of US$c 1.35 / kWh for the 2 GW Al Dhafrah solar PV auction in the Emirate of Abu Dhabi.
- The regulatory environment across each respective GCC country has historically evolved according to each country's reliance on hydrocarbons and the quality of its energy companies and institutions. The regulatory structure and institutional framework of the renewable energy and solar sector in each country has adjusted to its respective electricity mix, the establishment of the regulating renewable energy authority under the federal or regional energy authority, and its respective credibility in unlocking the full potential of developing the renewable energy sector.

End-Use Segments and Projects: Opportunities for Dutch Enterprises and Businesses

- The solar PV sector in GCC offers various economic and technical synergies in the deployment of Dutch technologies and expertise. Specific sectors of interest identified relate to:
    - Offshore floating solar projects;
    - Building Integrated Solar Photovoltaic Systems (BIPV), integrated urban design, and solar rooftops;

    - Agriculture and hydroponics;
    - Solar-based steam generation for enhanced oil recovery (EOR);
    - Hybrid (solar and wind) power projects;
    - Street lighting and traffic systems;
    - Exploitation and recycling of solar materials;
    - Solar components and ancillary systems;
    - Various project development services relating to utility-scale and small-scale solar projects.
- The GCC is one of the fastest growing markets for utility-scale solar PV power projects in the world and will continue to be the fastest growing market in the Middle East for solar PV installations leading into 2025, as countries across the region have introduced ambitious but achievable solar capacity targets. Auctions for these projects and their supply chain are highly competitive, and dominated by a few large players, notably Acwa
- Power, Masdar, Marubeni, Total, EDF and Jinko Solar, with Chinese equipment providers in the lead. Still, local content policies and incentives or specialised requirements could be an opportunity for Dutch industrial manufacturers of solar components to produce solar components such as solar cells, solar modules, inverters, trackers, mounting structures, and general electrical components. For each solar component utilized in the solar value chain, the Netherlands has a prominent, respective company.
- Offshore floating solar PV projects are an innovative and an emerging segment of the solar PV value chain. There are initial plans for GCC countries to install offshore floating solar PV projects along the Red Sea and the Persian / Arabian Gulf coastline, as well as on artificial reservoirs. These could supply residential and commercial units nearby such as the Palm Jumeirah and the World Islands in the Emirate of Dubai in the UAE, along the coasts of Qatar and Bahrain, the port city of Jeddah in Saudi Arabia, and to supply electricity to off-grid and offshore oil and gas and/or mining operations along the coastlines.
- The BIPV sector in the GCC region is still in its nascent stages. Recently, most attention has been paid to large, utility scale power projects and rooftop solar projects. However, BIPV technologies can potentially help countries across the GCC target the residential and commercial sector with aesthetic and branding benefits.
- Sustainable agriculture is a growing area. With the COVID-19 pandemic and the longer-term issue of climate change threatening to disrupt global food supply chains, GCC governments have launched various interventions such as increasing domestic productivity of farmers, facilitating imports, reinforcing / reorganizing supply chains and storage, and creating public entities to improve food security. This also emphasised the need for sustainable agricultural practices, potentially including specialised Dutch technologies such as enhanced greenhouses, solar pumps, solar dryers, solar thermal cooling and refrigeration, and agro-photovoltaic technologies.

- Water desalination is of strategic importance to the GCC. Innovative and sustainable technologies are required to develop new water desalination capacity, necessitated by growing demand, depleting groundwater resource and the prospect of food insecurity.
- Enhanced oil recovery (EOR), also known as tertiary oil recovery, is the last stage of extracting crude oil from a reservoir, or boosting the recovery factor. Often energy- and water-intensive, EOR is widely used in Oman and is being adopted elsewhere in the region, including thermal and chemical methods. Concentrated solar steam generation is one area of particular relevance.
- Although, GCC countries do not have a competitive auction scheme designed for hybrid renewable energy capacities, regulators and research and development institutions across the region are open to standalone proposals and the development of pilot projects, with the intention to establish a regional precedent of a hybrid, joint solar PV and wind power project
- Small-scale distributed solar systems are intended to increase efficiency, decrease electrical load and save on fuel delivery, maintenance and cabling costs. They include street lighting, traffic and parking systems, telecommunications towers, water pumping and others.
- In the solar materials segment, Dutch enterprises could manage and support solar PV life-cycle end-of-life from a design and socio-technological perspective. The GCC presents various opportunities on more sustainable materials, and maintenance and recycling of solar PV panels.
- The regional market for battery storage is expected to expand and provide various opportunities for Dutch technologies and expertise. This covers a wide range of battery types, sizes and applications, including large-scale grid storage to cover evening periods, short-term smoothing of output and ancillary grid services, and distributed and off-grid systems. This includes both the batteries themselves and design, optimisation, grid integration and software.
- Finally, the GCC solar sector requires a wide range of solar services, including resource assessment, design, testing, and measuring, project development services, financial, human resources and legal services, and other non-technical services.

2. Abbreviations

ADNOC	Abu Dhabi National Oil Company	LIBOR	London Interbank Offered Rate
AER	Authority for Electricity Regulation (Oman)	LNG	Liquified Natural Gas
APV	Agro-photovoltaic	MOEI	Ministry of Energy and Industry (UAE)
BIPV	Building Integrated Solar Photovoltaic	MEI	Ministry of Energy and Industry (Qatar)
COD	Commercial Operation Date	MEIMR	Ministry for Energy, Industry, and Mineral Resources
c-Si	Crystalline silicon	MEW	Ministry for Electricity and Water (Kuwait)
DEWA	Dubai Electricity and Water Authority	MOCCAE	Ministry of Climate Change and Environment
DGBR	Dubai Green Building Regulations	MOO	Ministry of Oil
DIF	Diffuse Horizontal Irradiance	m-Si	Monocrystalline silicon
DNI	Direct Normal Irradiance	NDC	Nationally Determined Contributions
DOE	Department of Energy (Abu Dhabi, UAE)	NGC	National Grid Company
DSCE	Dubai Supreme Council for Energy	NREAP	National Renewable Energy Action Plan (Bahrain)
ECRA	Electricity and Cogeneration Regulatory Authority (Saudi Arabia)	O&M	Operations and Maintenance
EESL	Energy Efficiency Standardisation and Labelling Programme	OPEC	Organisation of Petroleum Exporting Countries
EOR	Enhanced Oil Recovery	OPWP	Oman Power and Water Procurement Company
ESMA	Emirates Authority for Standardisation and Metrology (UAE)	PAEW	Public Authority for Electricity and Water (Oman)
EWA	Electricity and Water Authority	PPA	Power Purchase Agreements
EWEC	Emirates Water and Electricity Company (Abu Dhabi, UAE)	p-Si	Polycrystalline silicon
GCC	Gulf Cooperation Council Countries	PV	Photovoltaic
GHI	Global Horizontal Irradiance	QSTec	Qatar's Solar Technologies
GSO	Gulf Standards Organisation	REPDO	Renewable Energy Project Development Office
IPP / IWPP	Independent Power Producers / Independent Water and Power Producers	SEC	Saudi Electricity Company
KACARE	King Abdullah City for Atomic and Renewable Energy (Saudi Arabia)	SPC	Supreme Petroleum Council (Abu Dhabi, UAE)
LCOE	Levelized Cost of Electricity	SPV	Special Purpose Vehicle
LED	Light-emitting diodes	VAT	Value Added Tax
WTI	Western Texas Intermediate (Crude Oil)		

3. List of Tables and Illustrations

4. The Solar Energy Value Chain in the Netherlands: Specialist Expertise, Technologies and Systems, and Business Models

The Netherlands is the fifth-largest economy in the European Union (EU) and is a key EU transportation hub. The country is a leading global knowledge economy with a notable history and tradition of innovation that has placed it as a leader in solving complex global challenges.

The Netherlands has a long tradition of sustainable energy practices, including in renewable energy, and specifically in wind energy. The Netherlands' energy sector thrives on its ability to introduce or establish innovative new technologies not limited to fossil-fuel energy, but also renewable energy.

The solar energy value chain across the Netherlands consists of various public sector entities and private sector enterprises that specialize in research and development, solar materials, industrial equipment, solar modules, solar components, testing and measuring technologies and practices, project development, and engineering and construction.

The Netherlands' solar value chain offers access to specialist expertise with applications in offshore and onshore solar energy generation across the residential, agriculture, commercial, industrial, utility-scale, smart cities segment, solar materials, solar components, solar ancillary systems, and various project development-related services.

The Netherlands has made global strides in the areas of renewable energy deployment, energy efficiency, and sustainability through various specialized technologies and systems. The technologies and systems include floating solar photovoltaic (PV) systems, building-integrated solar PV systems, distributed energy systems relating to agricultural farming, solar-based, enhanced crude oil recovery technologies, sustainable solar-based water desalination technologies, and hybrid power systems that combine solar with wind and other renewable energy sources.

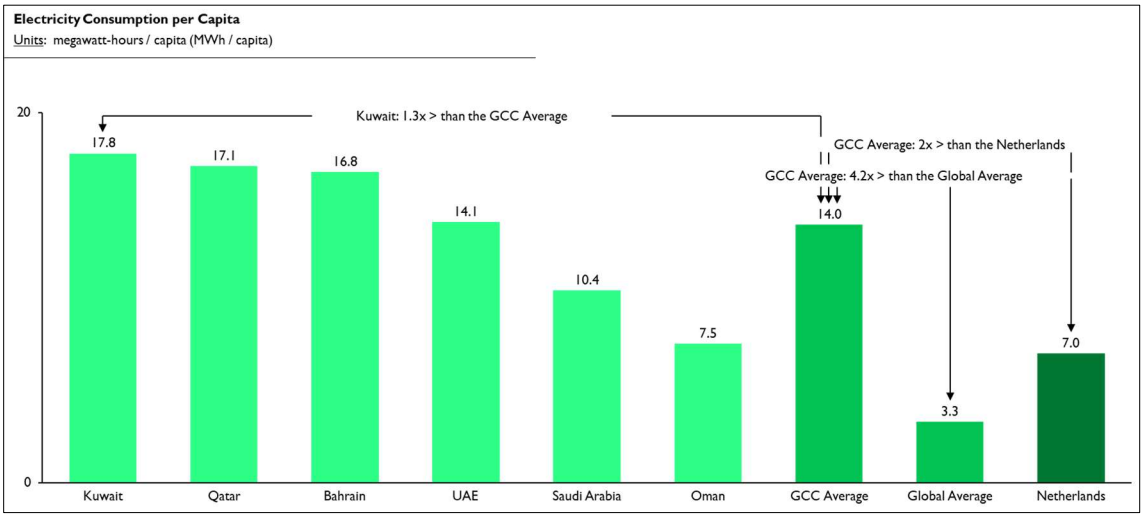
The Gulf Cooperation Council (GCC) bloc in the Middle East is one of the fastest growing markets for the deployment of solar power, as the region begins to treat renewable energy as a strategic asset to drive economic growth and achieve energy security.

In this report, we explore the Gulf Cooperation Council countries in detail, the drivers of growth in the deployment of solar technologies across the region, the economic case for investing in the solar sector, and how Dutch public and private sector enterprises can introduce, deploy, and exploit solar business opportunities across the region.

5. The Solar Sector in the Gulf Cooperation Council Countries

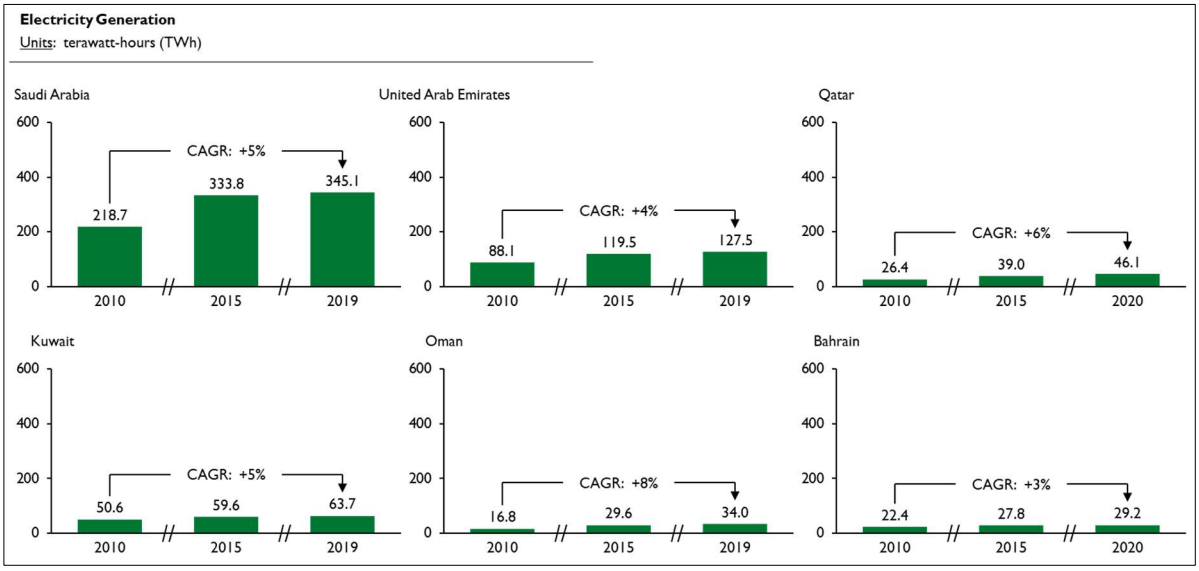
5.1 Strategic Rationale of Developing the Renewable Energy and Solar Sector

In recent years, renewable energy policies have been introduced by countries across the GCC to meet a growing demand for electricity, to diversify the electricity generation mix with renewable energy and to free up domestic consumption of hydrocarbons for profitable international exports, to address environmental problems and climate change challenges, and to drive economic diversification and create jobs. Climatic conditions naturally make solar power (PV and CSP) the most suitable widespread renewable options.



5-A: Electricity Consumption per capita vs Global Average, 2019

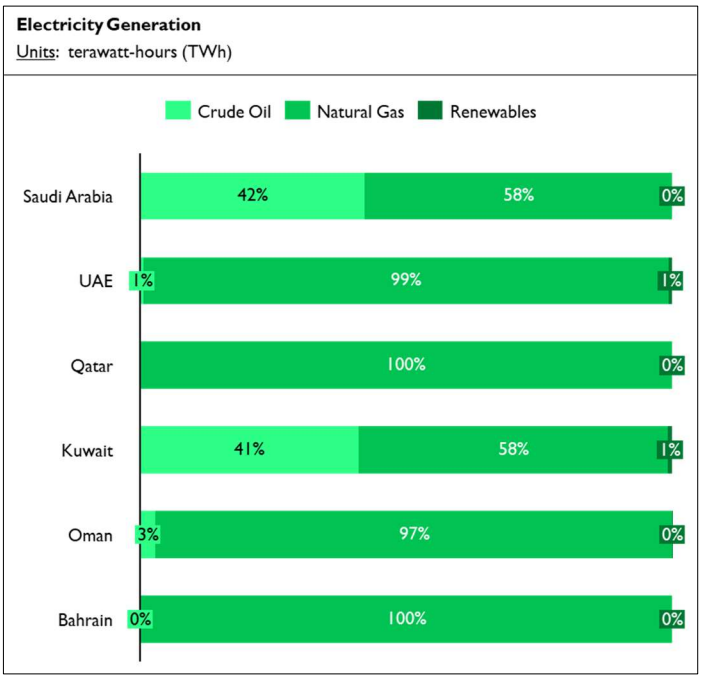
The economic security and economic importance of developing the renewable energy and solar sector begins with the GCC having a very high electricity consumption that averages 14 MWh / capita / year (compare to the global average of 3.3 MWh / capita and the Netherlands with 7.0 MWh / capita). Bahrain, Qatar, Kuwait, and the UAE feature in the top countries globally on electricity consumption per capita.



5-B: Electricity Generation

Regional electricity consumption has increased at an average of 4% / year between 2010 – 2020 due to a population that has increased by 1% / year over the same period, combined with economic growth, increasing industrialization and demand for water desalination.

The hot and arid climate requires high levels of air conditioning and desalination, while historically low energy prices because of subsidies / government regulation along with the availability of low-cost hydrocarbons has led to the development of energy-intensive industries (aluminium, steel, cement, fertilisers, petrochemicals and others), and the use of inefficient equipment and building practices and wasteful consumption habits.



5-C: Electricity Generation Mix, 2019

With the GCC's electricity generation mix dominated by hydrocarbons, mainly natural gas, the deployment of solar power is a key part of long-term energy strategies for countries across the region. These strategies intend to systemically diversify energy consumption and reduce domestic reliance on hydrocarbons, helping them limit imports and/or ensure continuing high levels of exports. GCC countries consume 14% - 32% of their crude oil production internally, with Qatar consuming 23% of its natural gas production. Subsidy reform and economic slowdown has eased pressure on domestic hydrocarbon supply but saving production for export is still desirable.

Without changes in the energy and electricity generation mix, the increasing electricity demand could reduce the availability of crude oil and natural gas for profitable international exports. The GCC's natural gas importers, namely Bahrain, Kuwait, the UAE and Oman[1], incur the cost and potential supply risk of importing LNG.

[1] Oman is a net exporter but imports some gas from Qatar via the Dolphin pipeline. The UAE imports gas both from Qatar via the Dolphin pipeline and as LNG (into Dubai), while also exporting LNG from Abu Dhabi. Kuwait and Bahrain import LNG. Saudi Arabia has considered LNG imports, which may be implemented in future.

In addition to diversifying the energy mix, some government entities in the GCC, such as the Dubai Supreme Council of Energy (DSCE) have taken a forward-looking view on sustainability that factors in the need to increase energy efficiency and rationalise consumption. Various energy efficiency initiatives, carbon capture, and a shift in the energy mix are currently underway, mostly so far in the UAE and Saudi Arabia under the leadership of specialized government entities.

Countries across the GCC face a multitude of climate challenges, which include rising ambient temperatures, desertification, biodiversity loss, food and water insecurity, and rising sea levels. Regional insecurity in drought-affected countries such as Yemen and Syria is a further concern in that it can spill across the GCC's borders.

In 2018, GCC states were among the highest greenhouse gas emitters in the world, with Qatar at 38.2 tonnes CO_2 equivalent (tCO_2e) per capita, Kuwait at 23.9 tCO_2e, the UAE at 22.4 tCO_2e, Bahrain at 21.8 tCO_2e, Saudi Arabia at 18.6 tCO_2e and Oman at 17.6 tCO_2e. This compares to the USA at 16.1 tCO_2e and the Netherlands at 9.5 tCO_2e. In regional metropolises, such as Kuwait City and Riyadh, the frequent haze that covers the city is a consequence of a significant amount of heavy fuel oil and crude oil that is burned in power plants.

Moreover, all GCC members lie on the coastal area of the Persian/Arabian Gulf region, which includes large and small islands and coastal zones that host most of the population (the exception being Saudi Arabia with the inland cities of Riyadh, Makka and Madina), industrial activity, oil and gas operations, and water desalination plants. These zones are highly vulnerable to the impacts of rising sea levels. An example of this is the low-lying geography of Bahrain's islands, combined with high land reclamation and extensive industrial, commercial, and residential activity across the coastal zones highlights the island country's acute vulnerability to climate change induced increase in sea levels.

The continued use of non-renewable water is a key factor in depleting groundwater reserves across GCC countries and puts them at an increased risk of climate impacts. Across the GCC, water supply is dependent on groundwater from deep fossil aquifers, desalinated water, surface water, and reclaimed wastewater.

In countries such as Bahrain, Qatar and the UAE, the depletion of groundwater through agriculture and urbanisation has led to the loss of freshwater springs and fertile lands and has made them dependent on energy-intensive desalination plants for freshwater supply, which has further increased electricity demand. Most GCC desalination plants are thermal, typically co-generation using waste heat from power plants, which are inflexible and energy-inefficient, which has led to a more recent turn to electrically driven reverse osmosis plants that are a better fit with renewable generation.

In addition to water scarcity, the GCC is vulnerable to global spikes in food prices, which could be worsened by climate damage in the world's major farming areas. With only ~10% of

the region's land mass being arable (even with intensive irrigation and modern farming technologies), the region is grappling with the realization that its barren soil and dwindling groundwater supply could increase food insecurity, which has encouraged progress towards a more advanced and sustainable regional agricultural, aquaculture and aquaponics sector.

And finally, a key strategic and economic security element of the renewable energy policies introduced by countries across the GCC is to drive economic diversification and create jobs. These include renewable energy targets and policies, legislative provisions and incentives for foreign participants to develop an indigenous solar value chain and domestic expertise, creating employment opportunities for a young and growing population.

The GCC's drive to diversify its energy and electricity consumption mix with renewable energy is estimated have a material impact on internal oil and gas demand by 2030. However, natural gas will maintain its position as an important input fuel that provides power system flexibility. The speed at which each country diversifies its energy mix and improves its energy efficiency is dependent on the adaptability of the institutional framework and the evolution of the current regulatory and fiscal support mechanisms that drive renewable development.

5.2 Solar Capacities, Renewable Energy Policies, and Energy Efficiency Targets

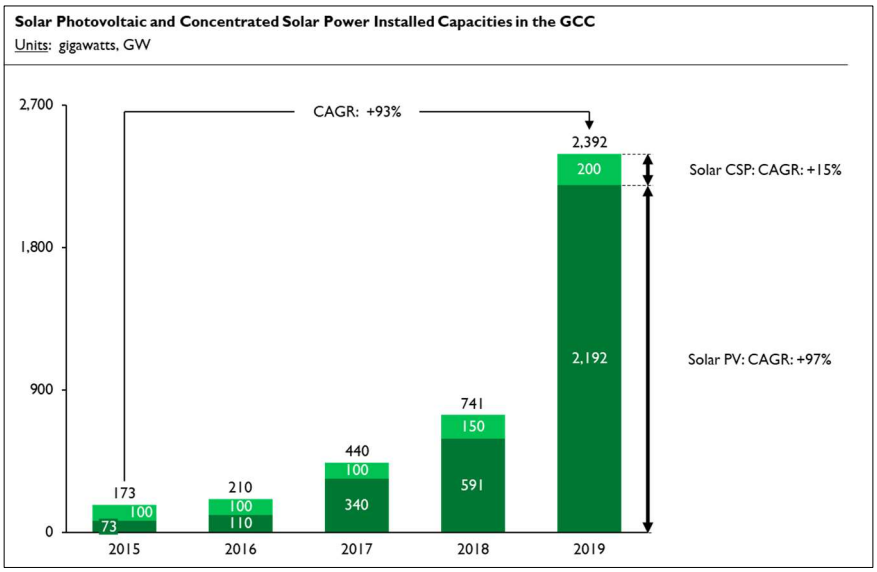
The GCC is witnessing an increasingly ambitious deployment of solar capacities that are supported by long-term renewable energy and energy efficiency targets. Given the region's resource endowment, attention has naturally focussed mostly on solar power, though parts of Saudi Arabia, Oman and Kuwait also have good wind resources, and there is some limited development of waste-to-energy and pumped hydroelectric storage using artificial reservoirs.

Country	Renewable Energy Installed Capacity Targets					Gap to Targeted Installed Capacity
	Solar Photovoltaic	Concentrated Solar Power	Wind	Others	Total Targeted Installed Capacity	
Saudi Arabia	2020: 3.45 GW 2023: 9.5 GW				2020: 3.45 GW 2023: 9.5 GW	2020: 3.3 GW 2023: 9.3 GW
United Arab Emirates	The emirates of Dubai and Abu Dhabi target 7% of their respective electricity generation capacity from renewables by 2020, rising to 25% by 2030, and 75% by 2050 for Dubai only. The emirate of Ras Al Khaimah targets 20% renewables by 2040. The UAE national energy strategy (2017) targets 44% renewables by 2050.					-
Qatar	2020: 200 – 500 MW		-		2020: 500 MW	2020: 457 MW
Kuwait	2030: 3.5 GW	2030: 1.1 GW	2030: 3.1 GW	-	2030: 7.7 GW	2030: 7.6 GW

Oman	Target 10% of electricity generation from renewable sources, mainly solar and bioenergy, by 2025	-
Bahrain	Target 5% of electricity generation from renewable sources by 2025, and 10% of the electricity generation by 2035	-

5-D: Renewable Energy Targets and Gap to Targets

At the end of 2019, the GCC had an installed renewable capacity of 2.45 GW, which increased from 0.796 GW in the previous year. Of the 2.4 GW, solar PV accounted for 90% of the overall renewable energy capacity, up from 74% the year before. Of the 2.1 GW of solar PV installed capacity in the GCC, the UAE accounts for 81% of the installed capacity, Saudi Arabia 16%, and Kuwait 2%.



5-E: Solar PV and Solar CSP Installed Capacities

Installed capacities of solar PV and CSP technologies across the GCC are dominated by a handful of utility-scale flagship projects such as the Mohammed Bin Rashid Al Maktoum Solar Park in Dubai (5 GW intended capacity by 2030, 1.013 GW currently operational and 1.85 GW under construction), the Sweihan (1.177 GW) and Al Dhafra (2 GW) projects in Abu Dhabi, Miraah Solar Steam Project in Oman (1.021 GW thermal), the Al Kharsaah Project in Qatar (0.7 GW under construction), and the Al Dabdaba / Al Shagaya Project in Kuwait (2 GW intended capacity of which 0.05 GW operational, although the rest of the installation is suspended for now).

Country	Utility-Scale Solar Project	Technology	Capacity	Status	Commercial Operation, Year
United Arab Emirates	Mohammed bin Rashid Al Maktoum Solar Park, Phase V	Solar Photovoltaic	900 MW	Under Construction	3Q 2021
	Mohammed bin Rashid Al	Concentrated Solar Power	700 MW	Under Construction	2021

	Maktoum Solar Park, Phase IV	Solar Photovoltaic	250 MW	Under Construction	2021
	Mohammed bin Rashid Al Maktoum Solar Park, Phase III	Solar Photovoltaic	600 MW + 200 MW	Operational	2020
	Mohammed bin Rashid Al Maktoum Solar Park, Phase II	Solar Photovoltaic	200 MW	Operational	2017
	Mohammed bin Rashid Al Maktoum Solar Park, Phase I	Solar Photovoltaic	13 MW	Operational	2013
	Hatta floating solar (Dubai)	Solar Photovoltaic	N/A	Proposal	?
	Al Dhafra Abu Dhabi	Solar Photovoltaic	2000 MW	Under Construction	2022
	Noor Abu Dhabi, Sweihan	Solar Photovoltaic	1177 MW	Operational	2019
	Shams 1	Concentrated Solar Power	100 MW	Operational	2013
	Sharjah Landfill	Solar Photovoltaic	120 MW	Awarded	-
	Ras Al Khaimah	Solar Photovoltaic	15 MW	Expression of interest	2022
Oman	Miraah Solar Thermal	Solar Thermal	1 GW (thermal)	Operational	2018
	Ibri PV Plant	Solar Photovoltaic	500 MW	Development Completed	1Q 2021
	PDO Amin PV Plant	Solar Photovoltaic	100 MW	Operational	2020
Saudi Arabia	Sakaka	Solar Photovoltaic	300 MW	Operational	2019
Qatar	Al-Kharsaah	Solar Photovoltaic	700 MW	Operational	2020
	Siraj Project	Solar Photovoltaic	Phase I: 350 MW Phase II: 450 MW	Phase !: Development Completed/ Phase II: Under Construction	Phase I: 2Q, 2021 Phase II: 2022

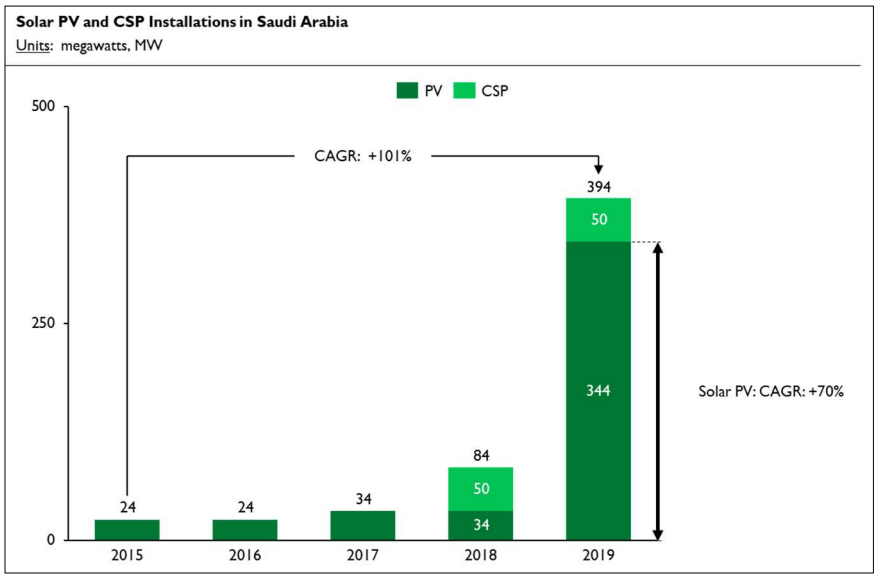
Kuwait	Shagaya	Concentrated Solar Power	50 MW	Operational	2019
		Solar Photovoltaic	10 MW	Operational	2019
	Al Dibdibah/ Shagaya Phase II	Solar Photovoltaic	1.2 GW – 1.5 GW	Abandoned	
Bahrain	Askar Landfill	Solar Photovoltaic	100 MW	Under Development	2Q 2021

5-F: Selected Utility-scale Solar PV and Solar CSP Power Projects in the GCC

The GCC will continue being the fastest growing market in the Middle East for solar PV and CSP installations leading into 2025, as countries have enacted ambitious renewable energy policies and solar capacity targets and have the demand and fiscal capability to deliver.

Saudi Arabia is the largest power and utilities market in the GCC. The country has a total installed capacity of 90 GW, of which 394 MW is from solar power projects. Saudi Arabia is projected to be the largest market in absolute terms for solar installations across the Middle East. With a limited deployment of renewable energy so far, the country's potential far exceeds that of its neighbours mainly owing to its large market size. The implementation of a steady and credible renewable policy, albeit after some years of delay, has turned it into a major growth market.

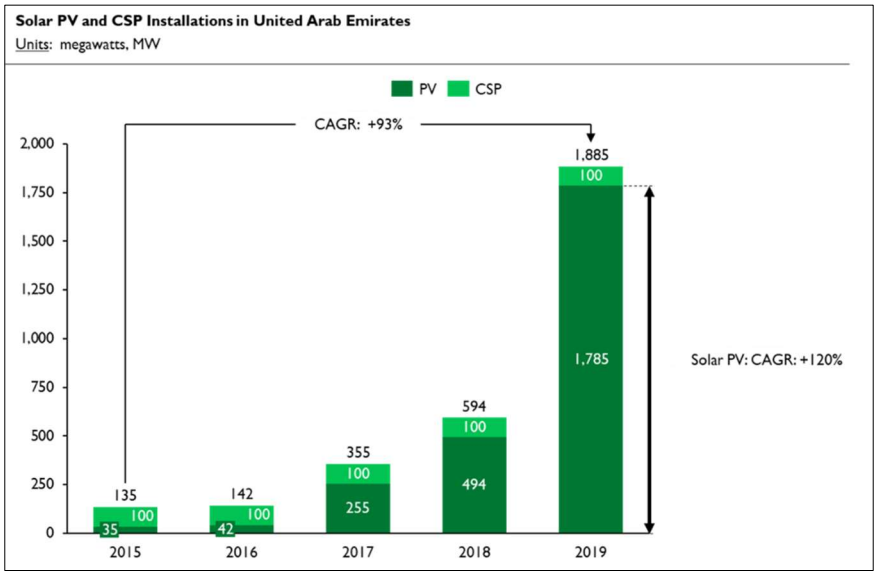
In Q1, 2019, Saudi Arabia increased its renewable energy target to 59 GW of renewables capacity by 2030, which consists of 40 GW of solar PV deployment. It is likely that Saudi Arabia might not meet its medium-term target of 27 GW by 2023 given the repeated false starts and the limited time remaining. However, recent activity has shown signs of progress. As of Q4, 2020, ~3.4GW of solar and wind capacity have been competitively auctioned.



5-G: Solar PV and CSP Installations in Saudi Arabia

In addition to auctions of utility-scale capacities, small scale solar capacities are expected to increase after the introduction of new net-metering legislation, which was introduced in Q3, 2020.

The United Arab Emirates has is the second largest power and utilities market in the GCC



with a total installed capacity of 34 GW, of which 1.7 GW is from solar PV and a 100 MW is from solar CSP. The UAE is the most established market for solar deployment in the GCC and the wider Middle East. The country has only a very general unified energy policy. The UAE's federal structure allows each emirate considerable autonomy in implementing their own renewable energy targets, incentives, and procurement schemes.

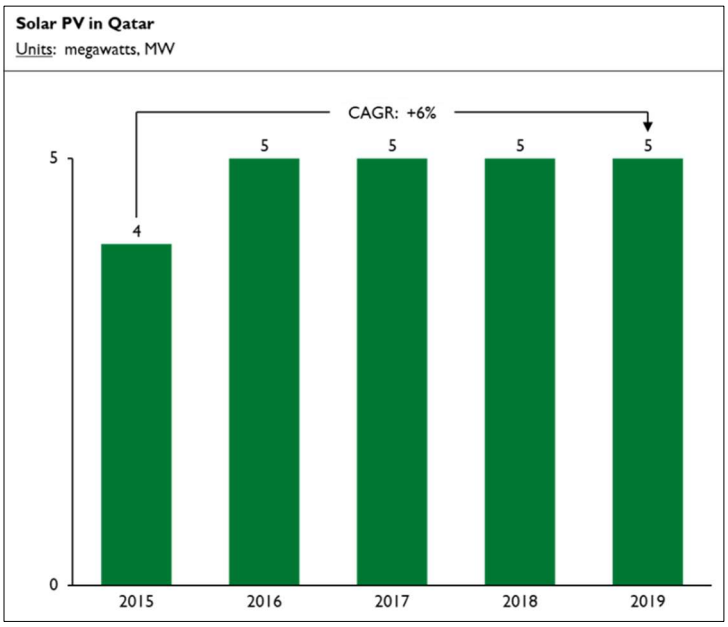
5-H: Solar PV and CSP Installations in the United Arab Emirates

In 2017, the UAE launched "Energy Strategy 2050" the first unified energy strategy in the country to become a law. The strategy aims to expand renewable energy capacity to 50% of the overall electricity mix by 2050 (44% from renewable sources and 6% from nuclear). The country also has short to medium-term targets in line with Vision 2021, with plans to generate 27% of its electricity from clean energy sources, including nuclear power. The emirates of Dubai, Abu Dhabi and Ras Al Khaimah have their own renewable plans and targets as covered in Table 5-D above.

Qatar's power and utilities sector consists of 11 GW of total installed capacity. Solar PV accounts for 5 MW. The country has frequently acknowledged the need to use energy and other natural resources in a more sustainable way. The country's long-term energy policy is focused on natural gas as a replacement for oil-based, electricity generation, as the country's dwindling crude oil reserves were seen early on to be more valuable when exported abroad.

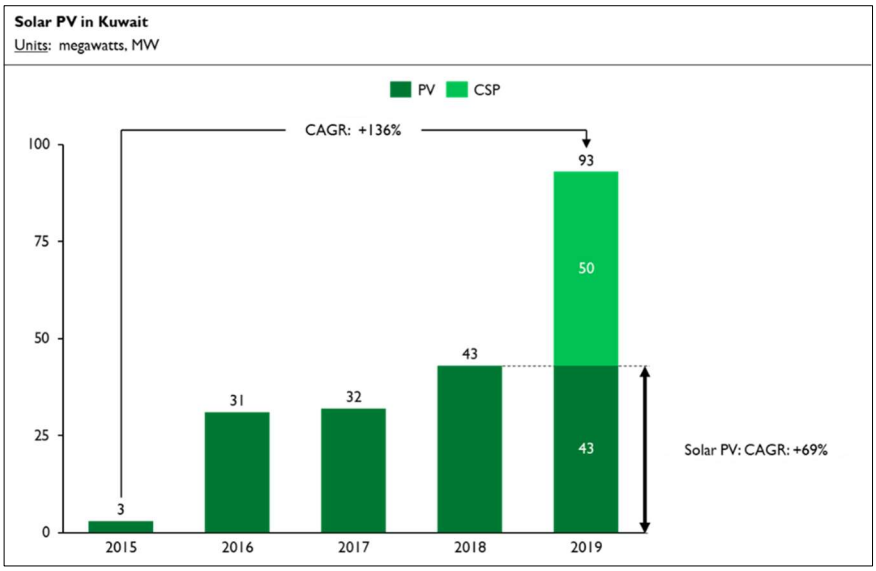
As part of its renewable energy policy, Qatar aims to generate 2% of its electricity from renewable energy sources by 2022, and further increase it to 20% by 2030. The country intends to achieve its target through solar power projects, with 800 MW of solar PV projects being built to support electricity supply for the 2022 FIFA World Cup, and an early ambition

to deploy 10 GW of solar capacity in the country by 2030. Qatar Petroleum has supported development of the 800 MW Al Kharsaah project and a further unnamed 800 MW plan, with a target of 3 GW by 2030, as part of aims to reduce the GHG footprint of its new LNG expansion.



5-I: Solar PV and CSP Installations in Qatar

Kuwait's power system has a total installed capacity of 19 GW, with a total solar PV capacity of 43 MW, which has increased by 69% / year between 2015 – 2019.

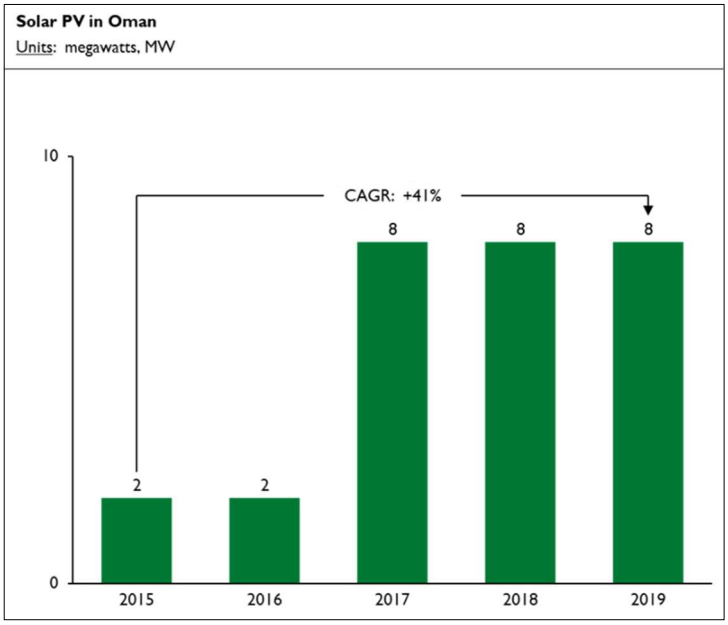


5-J: Solar PV and CSP Installations in Kuwait

Kuwait is the GCC's third largest market for electricity generation and enjoys good solar resources. The country's "Energy Strategy, 2030" intends to secure 15% of electricity generation from renewable energy sources by 2030. With the electricity generation mix mainly reliant on hydrocarbons, including a high share of oil and imported liquefied natural

gas (LNG), a little progress has been made in the past years with the deployment of solar and onshore wind projects. Recently, a major solar power project, the 1.5 GW Al Dabdaba, has been scrapped due to COVID-19 pandemic. The development of renewable energy is in line with the country's overall strategy of freeing up its hydrocarbon resource for value-added sectors, such as crude oil refining and petrochemicals. But political infighting and paralysis between the government and parliament has made it hard for the government to progress major projects in any sector for years, and also prevented progress on issues such as subsidy reform.

Oman's total installed generation capacity stands at 11 GW of which 8 MW consists of solar PV as at the end of 2019. Oman's renewable energy target consists of 11% of electricity generation from renewables by 2023, 16% by 2025 and 30% by 2030. To achieve these targets, the country has planned a renewable energy capacity addition of 3 GW by 2025, including utility-scale solar, wind, and to a smaller extent waste-to-energy. Over 2 GW of solar capacity have been auctioned as of Q3, 2020. Petroleum Development Oman has commissioned the 1021 MW equivalent Al Miraah solar thermal plant, which generates steam for heavy oil recovery.

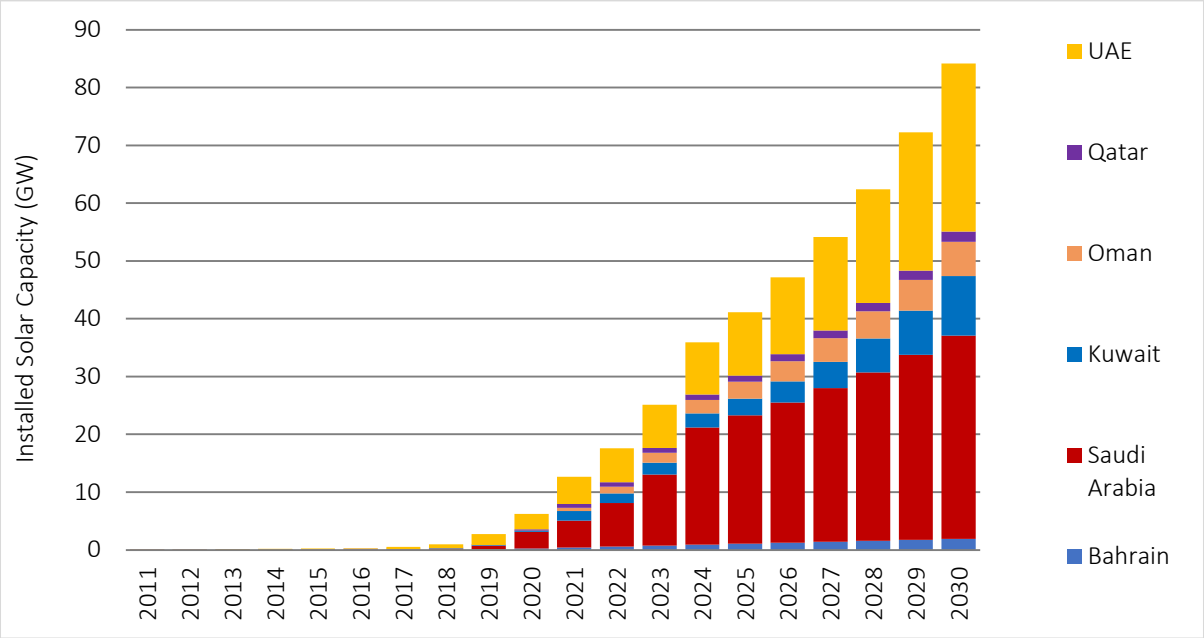


5-K: Solar PV and CSP Installations in Oman

Bahrain is the smallest country in the GCC and the country is a minor producer of crude oil, refined petroleum products, and natural gas. The country has a total installed generation capacity of nearly 4 GW, of which just 6 MW is from renewable sources (5 MW of solar PV and 1 MW of wind). To diversify its energy mix, the government has adopted the National Renewable Energy Action Plan (NREAP) in Q1, 2017. The NREAP outlines a national renewable energy target of 5% by 2025 and 10% by 2035. The envisioned renewable energy mix comprises solar, wind, and waste-to-energy technologies.

Overall, we predict very strong growth in GCC solar installations, reaching more than 80 GW cumulative installed capacity by 2030. This high rate of growth will require expansion of

capabilities throughout the solar sector. Saudi Arabia and the UAE are seen as continuing to be the main markets. Kuwait could emerge as the third leading player, but this is very dependent on political developments. On the other hand, Qatar and Oman appear on a positive trajectory and may advance beyond what is shown here.



5-L: Projected Solar Installation in the GCC

Renewable energy policies across the GCC are mainly focused on ambitious and large utility-scale deployment of solar technology, which are complemented by **energy efficiency** targets. Beyond the strategic and economic significance of energy efficiency, it is necessitated by planned reductions in energy subsidies to ease under-pressure fiscal balances, and as part of compliance to the Nationally Determined Contributions (NDCs) under the Paris Climate Agreement of 2015.

Country	Energy Efficiency Targets (understood to be against "Business-as-Usual" projections)	Year
Saudi Arabia	Reduce electricity consumption by 8% and peak demand by 14%	2021
United Arab Emirates	Reduce power consumption in the Emirate of Dubai by 30%	2030
Qatar	Reduce per capita electricity by 8% and water consumption by 15%	2022
Kuwait	Improve generation efficiency by 15% and reduce energy consumption by 30%	2030
Oman	Reduce greenhouse gas emissions by 2%	2030

Bahrain	Reduce electricity consumption by 6%	2025

5-M: Energy Efficiency Targets

All countries across the GCC have implemented some form of energy efficiency targets. These energy efficiency targets depend on how energy consumption patterns change and are incentivized by regulatory frameworks and support schemes across the residential, agricultural, commercial, industrial, and transport sectors. Selected regulatory frameworks that have been introduced across the region include green building codes, smart cities and smart transport infrastructures, energy tariffs and fuel efficiency standards, standards across the energy-intensive industrial sector, electricity pricing reforms, space and district cooling reforms, and energy efficiency standards relating to lighting and appliances.

In the area of green building codes, Bahrain has implemented these for government buildings. Oman has committed to adopting specified technologies used in the construction and development of sustainable green buildings. Saudi Arabia has implemented the most comprehensive green building codes such that all buildings are required by law to install a thermal insulation to be eligible for an electricity connection. Kuwait has reformed its "Energy Conservation Code" in 2014 in order to specify the minimum energy efficient practices required for new buildings.

Dubai Green Building Regulations (DGBR) have been made compulsory by legislation for all buildings across the emirate, monitored under the "Al Safat Programme", a voluntary green rating scheme for all new buildings. These include mandatory solar water heating for new construction.

Moreover, Dubai has implemented the "Smart Dubai Initiative", a smart city and smart transport infrastructure programme. Under the initiative, ¬ ~200 electric vehicle charging stations have been introduced under an anticipated and estimated supply for electric vehicles reaching 40,000 by 2030. The Dubai Future Foundation estimates that that 25% of all road transport in Dubai will be smart and driverless by 2030, which will result in ~US$ 6bn / year in savings as result of increased efficiency and reduced carbon emissions.

The Emirate of Abu Dhabi has established a Pearl Rating System under the "Estidama Scheme of the Abu Dhabi Urban Planning Council", which evaluates resource depletion, electricity and water consumption, waste management, and natural systems protection to the buildings. Buildings in the private sector are expected to achieve at least a 1 Pearl Rating, in contrast to buildings operated by the public sector with 2 Pearl Rating. These public sector buildings include government-funded buildings, schools, hotels, and mosques.

Saudi Arabia is currently developing the city-wide Riyadh Metro, similar to Dubai Metro, with additional metro systems across Jeddah and Dammam. As part of the public transport system, ~2,400 solar PV modules have been installed on metro carriages. Saudi Arabia has also established the "Saudi Energy Efficiency Centre", to promote electric vehicle penetration

amongst other objectives. Doha is also constructing a metro, with most of the lines completed. Qatar has introduced the "Electric Car Charging Stations Project" under which electric vehicle charging stations will be set up in the country. Bahrain is looking to introduce electric vehicles to combat CO_2 emissions through its motor vehicle standards and has proposed a light railway project to improve public transport, with countries such as Qatar, Kuwait, the UAE, and Saudi Arabia closely monitoring its implementation and success for comparable implementation. The UAE's Etihad Rail is progressing the second phase of a national rail system, mostly so far planned for freight. This could link up with an eventual GCC railway, though implementation of this has lagged.

Moreover, fuel efficiency standards have increased significantly across the region. An example of this is in Saudi Arabia, which has introduced vehicle fuel efficiency standards, with fuel economy labelling as a mandatory requirement for all light vehicles.

The industrial sector accounts for 37% of the energy consumption in the GCC, which is mainly consumed by oil and gas, petrochemicals, aluminium, steel, and cement. With most such companies state-owned, governments in the region have directly mandated efficiency improvements. For example, Petroleum Development Oman (government of Oman 60%, Shell 34%, Total 4%, PTTEP 2%) has developed a solar CSP-based EOR project to provide steam for the Amal heavy oil-field to save gas formerly used for steam generation.

Another key component of energy efficiency targets across the GCC is electricity and water pricing reforms. Dubai in the UAE was the first in the GCC to remove electricity price subsidies for foreign expatriates, with electricity prices now subject to a fuel cost surcharge and 5% VAT. Saudi Arabia has also followed suit with the introduction of VAT in 2018, now raised to 15%, and increases in electricity prices in 2016 and 2018, which reflect an increase in system and input fuel costs. Qatar has introduced an electricity system with slab-tariffs increasing with consumption brackets. Oman has introduced a cost-reflective tariff system in 2017 for ~10,000 users consuming more than 150 MWh per year, which accounts for ~35% of electricity supply.

The key driver of peak demand for electricity in the summer for the GCC is space and district cooling. Advanced district cooling technologies, such as solar and absorption technologies to produce chilled water, have been proposed in Qatar. Saudi Arabia has invested in a turbine inlet air chilling system to increase electricity output during off-peak times and store the energy to be used in peak times through a solar thermal energy storage tank. The Emirate of Dubai, UAE has introduced steps under the demand side management strategy to include higher insulation standards and minimum cooling equipment requirements for new buildings.

In summary, the short and medium- term outlook for solar technologies is promising, especially in the GCC's largest energy market, Saudi Arabia, and the region's most established market, the UAE. The deployment of solar technologies in other GCC countries has progressed slowly relatively but has recently accelerated significantly in Oman and Qatar.

The cost-competitiveness of various utility-scale, small-scale, and self-generation solar projects as they achieve commercial operations, and the prospects for accelerated solar deployment uptake are positive given the availability of an abundant indigenous solar resource and how renewable energy policies and targets have incentivised international and private sector involvement through various fiscal and regulatory support schemes.

5.3 Drivers of the Solar Sector in the GCC

Beyond clearly defined renewable energy policies and solar capacity targets, the GCC's impressive growth in utility-scale solar PV deployment is due to increasing interest by foreign and international developers / companies that have capitalized on:

- an abundant indigenous solar resource,
- available free or low-cost, flat desert land,
- the availability of robust power purchase agreements (PPAs) offered by regional off-takers with explicit or implicit state guarantees,
- a competitive auction mechanism, driving down costs and promoting transparency, building on a legacy of some two decades of independent power producers (IPPs) in the fossil fuel power sector,
- the availability of fiscal support schemes such as low levels of VAT and import duty levied on the early deployment of innovative foreign technologies,
- the availability of various commercial financing schemes,
- under an environment of low business and investment risk.

The GCC has an excellent solar resource specifically for electricity generation from solar PV technologies, measured by the Global Horizontal Irradiance (GHI), the total amount of shortwave radiation received from above by a surface horizontal to the ground, which includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DIF).

Country	GHI Range (kWh / m^2 / year)
Saudi Arabia	2,000 – 2,450
United Arab Emirates	2,050 – 2,275
Qatar	2,050 – 2,200
Kuwait	2,000 – 2,125
Oman	2,045 – 2,483

Bahrain	2,008 – 2,154
GCC Average	2,025 – 2,281

5-N: Solar Resource: Global Horizontal Irradiance

The region's average GHI ranges between 2,025 – 2,281 kWh / m^2 / year with the upper limit extending to 2,500 kWh / m^2 / year across the southwestern region of Oman, and 2,400 kWh / m^2 / year across the northwestern and central region of Saudi Arabia. Combined with an increasing use of solar tracking devices and bifacial panels, developers achieve record-setting capacity factors for solar PV projects, on average 20% or better.

In contrast to solar PV technologies, DNI levels that are relevant for solar CSP technologies is generally high but variable across the region. Saudi Arabia is estimated to have the best DNI levels in the GCC, particularly in its west. A combination of dust and high humidity/haze levels across the region has influenced and limited the choice of a suitable solar CSP technology. Yet this has not stopped solar CSP projects from being developed in the region. An example of this the Phase IV of the Mohammed Bid Rashid Al Maktoum Solar Park in the Emirate of Dubai, with 700 MW currently under development.

In addition to an abundant solar resource, another key driver of interest in the solar sector from foreign and private sector developers / companies is the availability of robust power PPAs that are awarded through competitive auction schemes that are specifically designed to allocate solar PV or solar CSP capacities.

Competitive solar auctions are a key element of renewable energy policies across the region. The auctions are designed to procure large quantities of power at the lowest available price. Their structure reduces the project risks for investors and developers since they offer guaranteed revenues over a fixed period of time, improve cost efficiency due to price competition, improve volumes and budget control, and increase the predictability of electricity supply from solar power projects.

Another driver of low levelized costs of electricity (LCOE) for utility-scale solar PV across the region is the "bankable" nature of PPAs awarded at the auctions. Saudi Arabia, the UAE, and Oman offer standardized PPAs with an economic life of 20 – 25 years that are legislated specifically for solar PV projects, whereas in Qatar and Kuwait similar PPAs for solar PV capacities are devised on a project-by-project basis. All solar PV PPAs offer a guaranteed purchase obligation, where the offtaker is obliged to pay for all the electricity output of the generators.

Costs are further reduced by the very large scale of these projects (1-2 GW in recent examples), the success and low risk of the existing plants, the low technical risk, the highly competitive bidding environment, and bidders' willingness to pay up-front for expected cost reductions in the supply chain over the 1-2 years of project execution. The introduction of

bifacial panels, boosting output by 10-20% given reflections from high-albedo desert sand, is the main recent technical innovation, also helping to reduce costs.

The region's competitive solar PV auction schemes have consistently extracted world-record setting bids. For example, in 2018, a consortium consisting of ADWEA, Marubeni Corporation, and JinkoSolar submitted a bid of US$c 2.42 / kWh at the 1.07 GW Sweihan solar PV auction in Abu Dhabi. In Q1, 2020, a consortium consisting of Marubeni Corporation and Total submitted a bid of US$c 1.56 / kWh for the 800 MW Al Kharsaah solar PV auction in Qatar. And in Q2, 2020, a consortium consisting of Taqa/Masdar, EDF, and JinkoSolar submitted a bid of US$c 1.35 / kWh for the 2 GW Al Dhafrah solar PV auction in the Emirate of Abu Dhabi.

Country	Project	Technology and Installed Capacity	Development Consortium	Auction Date	Auction Bid, US$c/kWh	Status	Commercial Operation, Year
UAE, Abu Dhabi	Sweihan Project	Solar Photovoltaic, 1.2 GW	EWEC, Marubeni, & JinkoSolar	20-9-2016	2.42	Operational	2019
Qatar	Al Kharsaah	Solar Photovoltaic, 800 MW	Siraj, Marubeni & Total	23-1-2020	1.56	Under Development	2022
UAE, Dubai	Al Dhafrah Project	Solar Photovoltaic, 1.2 GW	EWEC, TAQA, Masdar, EDF, & JinkoSolar	28-4-2020	1.35	Under Development	2022
Saudi Arabia	Shu'aiba (formerly Faisaliah)	Solar Photovoltaic, 0.6 GW	Acwa Power / Masdar	8-4-2021	1.04	Awarded	2022?

5-O: Recent Lowest Auction Bids for Utility-scale Solar PV Projects

Although GCC countries do not provide specific financial incentives for utility-scale solar beyond the PPAs, they are favoured by the zero corporate income tax environment, zero or low levels of VAT (except in Saudi Arabia) and low import duties.

Attractive features of commercial financing directed towards utility-scale solar PV projects in the GCC typically include low interest rates that range between 120 – 200 basis points (bps) over the benchmark London Interbank Offered Rate (LIBOR), long debt financing tenors up to 20 years, and high debt-to-equity ratios that ranges between 70% - 90%, which allow acceptable equity returns even while overall project returns are low.

Project	Developer	Offtaker	Investment	Conditions	Financiers
Shams 1, 100 MW CSP, Dubai, UAE	MASDAR, Total, and Abengoa	25 Year PPA with EWEC	US$ 153M Equity and US$ 612M Debt	80% Debt-to-Equity Ratio over a 22 Year Tenor	UNB, NBAD, Natixis, Société Générale Mizuho, Bank of Tokyo, Mitsubishi, Sumitomo, WestLB, and KfW
MBRAMSP II, 200 MW Solar PV, Dubai, UAE	ACWA Power and TSK	25 Year PPA with DEWA	US$ 326M	86% Debt-to-Equity Ratio over a 27	First Gulf Bank, National Commercial Bank, and Samba Financial Group

				Year Tenor	
MBRAMSP III, 800 MW Solar PV, Dubai, UAE	MASDAR, Abdul Lateef Jamil, and EDF	DEWA	US$ 940M (with US$ 650M in Debt)	70% Debt-to-Equity Ratio	UNB, IDB, APICORP, Natixis, Siemens Financial, Korea Development Bank, and EDC
MBRAMSP IV, 700 MW CSP + 250 MW Solar PV Dubai, UAE	ACWA Power, Shanghai Electric	35 Year PPA with DEWA	US$ 4.3bn (with US$ 1.5bn in Debt)	70% Debt-to-Equity Ratio	ICBC, Bank of China, Agricultural Bank of China, China Minsheng Bank, and the Silk Road Fund
Sweihan, 1.2 GW, Abu Dhabi, UAE	EWEC, Marubeni Corporation, & JinkSolar	25 Year PPA with EWEC	US$ 870M (with US$ 650M in Debt)	75% Debt-to-Equity Ratio over a 26 Year Tenor	Natixis, CA-CIB, BNPP, MUFG, MUTB, the Norinchukin Bank, SMBC, First Abu Dhabi Bank

5-P: Financing Structures of Selected Utility-Scale Solar PV and CSP Projects

The availability of favourable commercial financing schemes is attributed to a low business and investment risk environment. For example, countries across the GCC have reliable off-takers. Timely payments are guaranteed by offtakers with an implicit or explicit sovereign guarantee, and subsequently the risk and cost of financing is low. In most cases, such as in the Emirates of Abu Dhabi and Dubai in the UAE, the offtaker owns a large equity stake in the project. In addition to this, GCC currencies are pegged to the US Dollar (US$), which effectively decreases currency risk (Kuwait's is pegged to a basket, but closely follows the US$). And solar PV auctions are designed to include a strict pre-qualification stage that only allows a small number of established developers with sound technical capabilities and creditworthiness to make it to the final bidding rounds. Their capabilities and track record ensure they do not have a problem in attracting low-cost finance from local banks as well as the global financial markets.

In contrast to utility-scale solar PV projects, smaller-scale distributed and rooftop projects have faced a more challenging environment, for six main reasons,

- retail electricity prices are low and often subsidised, making rooftop solar PV uncompetitive,
- the very low achieved bid prices in utility-scale auctions and the ready availability of open land have encouraged state utilities to focus on that sector rather than incentivising rooftop solar,
- with less environmental pressure and a later start in solar than in Europe – GCC governments have not been inclined to offer subsidies, feed-in tariffs or other incentives, and corporates have not faced much consumer pressure to move to renewables,
- as there is no personal or corporate income tax in the GCC, there is no scope to use tax credits or exemptions to incentivise solar,
- the largely transient and renting population of expatriates is not inclined to invest in solar power installations with a lengthy payback period, while house sales and rental

rates do not reward those with solar panels,

- and, smaller-scale solar projects incur significant challenges in raising equity and debt financing across the GCC. Financing institutions are typically less willing to finance these projects amid high costs of developing smaller projects, combined with long payback periods, and the lack of public offtaker guarantees. Thus, developers resort to more costly financing schemes that increase project costs.

However, there has been growing success in the commercial and industrial (C&I) solar rooftop sector, though not in residential applications. Dubai's net metering scheme "Shams Dubai", along with relatively high tariffs for high-volume consumers, has supported the emergence of financial leasing arrangements for solar PV rooftop installations through which building owners pay a periodic (mostly monthly) charge depending on net consumption of solar energy, and building owners can eventually own the rooftop installations.

As a result, various private sector companies have capitalized on the opportunity to cater to the small-scale segment. For example, UAE-based firm Yellow Door Energy offers leasing arrangements for rooftop installations by which building owners pay periodic bills based on the net consumption of electricity. Other regional companies such as Siraj Power and Enviromena operate a business model that consists of turnkey leasing solutions, which includes project financing, development, construction, and operation of small-scale solar projects. Enerwhere, a provider of distributed and off-grid systems, offers fees based on service provision rather than energy consumed.

Thus, a key hindrance to financing small-scale solar projects in the region is the lack of standardized PPAs, that increases transaction costs, time required for project development, and development overrun costs, affecting the bankability of these projects. A possible solution to the problem is a "solar partners model" through which the electricity offtaker aggregates rooftop solar PV owners in a specific area and auctions the combined capacity under a PPA directly with the successful bidders (similar to a utility-scale solar PV auction). This effectively lowers the project financing risk and has the added advantage of bringing costs down through a competitive auction mechanism. An example of this is the Phase II – Sahim Residential Solar programme in Oman, which allows offtakers / developers to aggregate and auction rooftop solar PV in a specified area.

The success of the region's solar PV industry is thus still largely driven by the utility-scale segment. Solar PV as an asset class across the GCC that has the potential to generate significant equity returns over the next 35 years and has begun to attract the interest of institutional and infrastructure investors.

5.4 Regulatory Structure and Institutional Framework

The regulatory environment across each GCC country has historically evolved according to each country's reliance on hydrocarbons. The regulatory structure and institutional framework in each country has adjusted to its respective electricity mix, the establishment of

the regulating renewable energy authority under the federal or regional energy authority, and its respective capability and credibility in developing the renewable energy sector.

Saudi Arabia's energy sector is governed by the Ministry of Energy, formerly the Ministry for Energy, Industry, and Mineral Resources (MEIMR), and within it the Renewable Energy Project Development Office (REPDO). The ministry coordinates with other public sector organisations. These organizations include King Abdullah City for Atomic and Renewable Energy (KACARE), King Abdullah City for Science and Technology (KACST), King Abdullah University of Science and Technology (KAUST), King Abdullah Petroleum Studies and Research Center (KAPSARC), Saudi Aramco (the state oil company), the Saudi Electricity Company (SEC), and the Electricity and Cogeneration Regulatory Authority (ECRA).

After initial renewable energy plans led by KACARE did not advance, the Ministry of Energy established REPDO in 2017 as the national renewable energy regulatory and procurement authority. REPDO reports to a committee consisting of MEIM, KACARE, ECRA, Saudi Aramco, and SEC.

SEC is the national electricity company of Saudi Arabia and specializes in the generation, distribution, and transmission of electricity across the country. It is also the sole off-taker for electricity production in the country. The National Grid Company (NGC) is a subsidiary of SEC and is responsible for operating and maintaining the national electricity transmission grid.

The United Arab Emirates' Ministry of Energy and Industry (MEI) is responsible for proposing and developing policies, legislation, and strategies to regulate the UAE's energy, water, and natural resources sector. The MEI oversees the UAE's "National Energy Plan, 2050", which is the country's first national energy strategy. In addition to the MEI, the Ministry of Climate Change and Environment (MOCCAE) is responsible for international and domestic climate change affairs and oversees the implementation of the national "Green Agenda, 2030" and the "Climate Change Plan". However, most actual policy development and implementation is done at the level of individual emirates and by the state-owned utilities, Emirates Water and Electricity Company (EWEC), Dubai Electricity and Water Authority (DEWA), Sharjah Electricity and Water Authority (SEWA) and others.

The Department of Energy (DOE-Abu Dhabi) develops and enforces policies and legislation for the emirate's energy sector and regulates the activities of the emirate's electricity company, EWEC, which is responsible for water production, electricity generation, and renewable energy development in Abu Dhabi and the Northern Emirates (Ras Al Khaimah, Fujairah, Ajman and Umm Al Quwain). EWEC is sole off-taker for electricity production in Abu Dhabi while the Federal Electricity and Water Authority (FEWA) distributes and sells power in the four northern emirates, nearly all of which is procured from EWEC. The Energy Efficiency and Renewables Office in Ras Al Khaimah has also taken a lead on solar power in that emirate.

In the emirate of Dubai, the Dubai Supreme Council for Energy (DSCE) is entrusted with

policymaking, planning, and regulating the energy sector. Similarly to EWEC, DEWA conducts auctions, and purchases utility-scale renewable energy generation and pays for small-scale solar installations via its net metering programme. DEWA has a strong influence over the decisions of the DCSE.

Qatar has not introduced a dedicated regulatory authority that enforces its renewable energy policy and targets. In fact, the country's overall energy sector (including the renewable energy sector) is regulated by the Ministry of Energy and Industry (MEaI). The ministry also regulates the activities of the national electricity company Kahramaa, which is the sole offtaker for conventional and renewable power projects. The energy minister, who is also chief executive of Qatar Petroleum, ensures that QP has a strong role in the country's renewable development. Siraj Energy is a solar developer launched as a joint venture between Kahramaa (60%) and QP (40%).

Kuwait's energy sector's regulatory structure consists of three institutions. The Supreme Petroleum Council (SPC) regulates the country's hydrocarbon sector. It is supported in this by the Ministry of Oil (MOO). The power sector (including the renewable energy sector) is regulated by the Ministry for Electricity and Water (MEW), which owns and operates the power system, regulates the sector, and oversees grid operation, transmission, and distribution.

In Oman, the Public Authority for Electricity and Water (PAEW) is the main planning and supervising body for the production and supply of conventional and renewable electricity across Oman. PAEW oversees the operations of the Oman Power and Water Procurement Company (OPWP), which is the authorized electricity off-taker for IPP and IWPP projects in Oman. It also undertakes long-term electricity and water generation planning.

In Bahrain, the Electricity and Water Authority (EWA) governs the conventional and renewable power and utilities sector, owns electricity generation, transmission, and distribution infrastructure. EWA is regulated by the Supreme Committee for Natural Resources and Economic Security, which advises the government on energy policymaking.

In addition to the respective regulating institutions that oversee the renewable energy sector, a key feature of the regulatory landscape is the role of various research and development institutions that provide counsel to the respective renewable energy authority. A notable example in the region is the Abu Dhabi Future Energy Company (Masdar). Its role is to promote and develop renewable energy technologies through education, research, development and deployment. Masdar has become a project developer in the UAE and around the world, with a large portfolio of solar PV and CSP projects as well as wind.

Similarly to Masdar, in Saudi Arabia, KACARE has had the aim of engaging in research, development, and policy advice relating to renewable energy and nuclear technologies. The institution employs international researchers who work on energy markets and economics, energy efficiency and productivity, energy and environmental technologies, and carbon

management.

Other regional research and development institutions include Qatar Environment and Energy Research Institute and the Bahrain Solar Industry Association, which are mandated with roles similar to Masdar and KACARE.

6. End-Use Segments and Projects: Opportunities for Dutch Enterprises and Businesses

Over the last decade, the Netherlands has acquired a prominent position in research and development, and the development of innovative solar PV technologies with application to the utility-scale and small-scale segment.

Through increasing interactions between the GCC countries and the Netherlands, the solar PV sector in GCC offer various economic and technical synergies in the deployment of Dutch technologies and expertise relating to Offshore Floating Solar Projects, Building Integrated Solar Photovoltaic Systems (BIPV) and Solar Rooftops, Agricultural Farming and Hydroponics, Solar-based Steam Generation for Enhanced Oil Recovery, Hybrid (Solar and Wind) Power Projects, Street Lighting and Traffic Systems, Exploitation and Recycling of Solar Materials, Solar Components, Ancillary Systems, and various Project Development Services relating to utility-scale and small-scale solar projects.

Dutch companies operating provide a strong high-tech expertise across these applications through robust global supply chains and product quality, combined with flexible business strategies and models that could provide distinct capabilities in productivity, cost price competitiveness, and innovation across electricity and energy consumption / generation in the offshore, residential, agricultural, industrial, smart cities, utility-scale, and solar materials segment.

6.1 Offshore Segment: Floating Solar PV Power Projects

Offshore floating solar PV projects are an innovative and an emerging segment of the solar PV value chain. At the end of 2018, the global floating solar PV installation stands at 1.1 GW. Demand for offshore floating solar PV projects is mainly driven by maritime countries and islands, where sufficient land is unavailable. In addition to land scarcity, offshore floating solar PV projects are particularly suited to countries with a significant hydropower resource, where the electricity transmission and distribution systems connected to hydropower projects are complemented with floating solar PV technologies.

Since floating solar PV technologies are still in their infancy, several engineering and construction challenges need to be overcome. For example, anchoring systems must be designed to withstand the dynamic forces of waves and strong winds, and given the novelty of the technology, mooring / anchoring specialists and operations and maintenance (O&M) companies typically have limited experience in applying such systems to offshore floating PV plants. Hence, offshore floating PV installations are almost always moving to some extent, which increase with wind speeds and load.

The world's largest offshore floating solar power project is currently being constructed in the state of Madhya Pradesh in India with total capacity of 600 MW. Other examples of global offshore solar PV projects are the 70 MW project located in a former coal-mining area of the Anhui Province in China, the 78 MW project in the Panji District of Huainan City in China, and a 2 MW project constructed by Norway-based, Statkraft in Albania.

Region	Total Surface Area Available (km^2)	Number of Water Bodies Assessed	Floating PV Potential (GW)		Potential Annual Electricity Generation (GWh / year)	
			% of Surface Area Used		% of Total Surface Area Used	
			5%	10%	5%	10%
North America	126,017	2,248	630	1,260	704,076	1,408,153
South America	36,271	299	181	363	290,753	581,507
Europe	20,424	1,082	102	204	97,868	195,736
Africa	101,130	724	506	1,011	835,824	1,671,648
Middle East and Asia	115,621	2,041	578	1,156	643,456	1,286,911
Australia and Oceania	4,991	254	25	50	33,565	67,131
Total	404,454	6,648	2,022	4,044	2,605,542	5,211,086

6-A: Peak Capacity and Electricity Generation of Floating Solar on Freshwater Manmade Reservoirs (Source: Global Solar Atlas and Lehner et al, *High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management*, 2011)

In the GCC, UAE-based, solar-hybrid solutions provider and a developer of commercial-scale solar hybrid projects, Enerwhere is the first company in the region to build an offshore solar PV project on the private resort island of Nurai in the Emirate of Abu Dhabi, UAE. The project, which will supply electricity to the resort, is being built on seawater. An added advantage of the project is the opportunity cost saved on building a power project on valuable beach real estate.

The emirate of Ras Al Khaimah in the UAE has also looked into the potential of marine floating solar, while DEWA is considering a pilot floating solar plant on the lake at the Hatta dam. Offshore floating solar PV projects could be installed along the Red Sea and the Persian / Arabian Gulf coastline to supply electricity to residential and commercial units nearby such as the Palm Jumeirah and the World Islands in Dubai, along the coasts of Qatar and Bahrain, the port city of Jeddah in Saudi Arabia, and supply electricity to off-grid and offshore oil and gas and/or mining operations along the coastlines.

Nonetheless, the GCC offers opportunities for floating solar experts through various joint research and ambitious pilot projects for floating solar farms in large, urbanized areas with high demand for energy located on or near the coast or rivers, where there is a large amount of usable space and wind, waves, and tides that create a challenging environment.

6.2 Residential Segment: The Building Integrated Photovoltaic and Solar Rooftop Market

BIPV systems, which include roof tiles known as solar shingles, provide several advantages across urbanized areas and can be deployed to surfaces such as rooftops, windows, walls, and/or as an integrated solution with an active and/or passive function. A key passive feature

of BIPV systems is thermal and acoustic insulation, which complement electricity generation. Other BIPV systems, incorporate real-time thermal or lighting regulation. BIPV systems, offer the potential for cost-reduction through savings on roofing materials, as well as efficiencies and time saving in labour and construction costs.

The BIPV sector in the GCC is still nascent, but can develop in the residential and commercial sector, with aesthetic and branding advantages.

Selected examples of BIPV projects across the GCC include the DEWA Headquarters and Research and Development Centre in Dubai and the Makkah Royal Clock Tower in the Holy City of Makkah, Saudi Arabia. The DEWA Research and Development Centre was completed last year and incorporates different coloured solar PV glass panels that are fixed on the façade. The DEWA Headquarters was completed in 2019 and includes ~10,000 m^2 of BIPV, which helps make it a net zero energy building. The Makkah Royal Clock Tower was constructed in 2012 and includes a glass orb on top of the tower. The glass serves as part of a viewing deck and incorporates 233 solar PV panels cut into the shape of a dome to help generate the electricity for the functioning clock.

The deployment of BIPV systems on residential and commercial building structures in urban developments across cities such as Riyadh, Jeddah, Dubai, Abu Dhabi, Doha, Kuwait City, and Muscat can help achieve cost-savings and allow buildings to increase their overall energy efficiency. In addition to this, as sustainability requirements and green codes for buildings become stricter, BIPV systems could help reduce net energy consumption. Apart from enhancing the visual aesthetics of the buildings, BIPV systems are flexible enough to be designed to blend with the rest of the environment. BIPV systems are proven to provide costs savings on labour and construction costs versus expensive solar PV rooftops and thermal systems. The mass production of customized BIPV systems that are standardized to the region is a market opportunity on its own for large-scale production, which can help further unlock cost-savings for end users in the GCC.

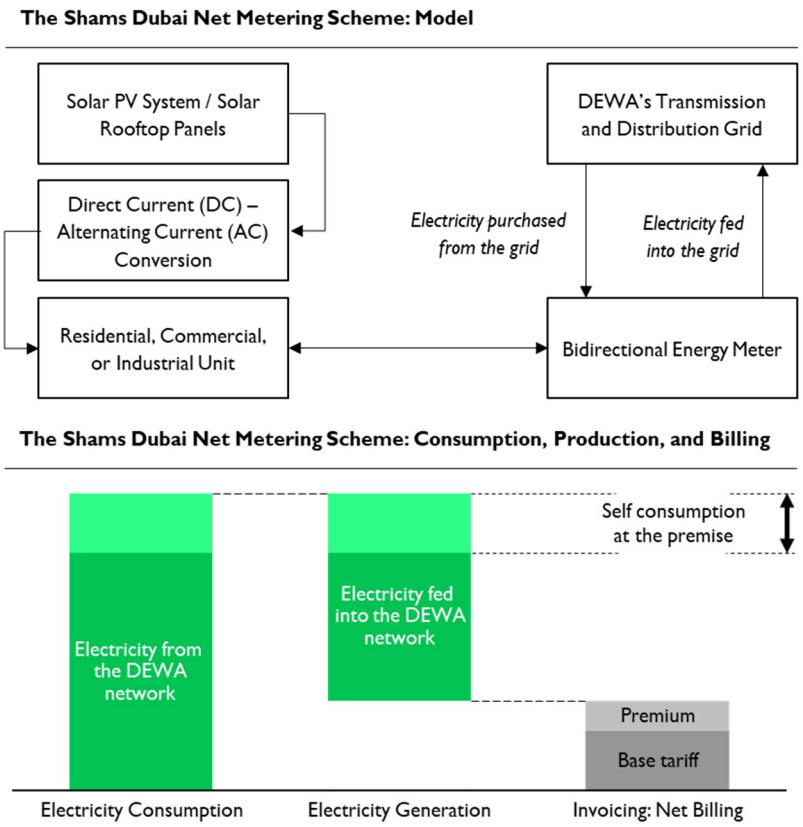
However, selected barriers to penetrating the BIPV technology market in the GCC include lack of regulatory, safety standards, and building standards specific to BIPV products. These have to be updated or augmented across the region to ensure the integration of BIPV elements that provide sufficient credits towards different certifications, such as LEED silver, gold, or platinum. Another barrier to BIPV penetration across the region is the added cost of retrofitting existing buildings.

In contrast to BIPV systems, rooftop solar PV technologies are the preferred choice of renewable energy generation for the residential, commercial, and industrial segments in the GCC. Rooftop solar PV is a niche market across the region, with the Emirate of Dubai and Abu Dhabi, having made the most progress in encouraging the technologies through various small-scale projects and net-metering arrangements.

Dubai's state electricity company DEWA has introduced the "Shams Dubai Programme",

which allows residential, commercial, and industrial users to install rooftop solar PV panels to generate electricity. The scheme allows end-users an opportunity to reduce their electricity consumption bill with a billing mechanism based on the net monthly consumption of electricity. Surplus electricity not used consumed immediately is fed into the grid at a fixed price, and the consumer is only billed at the end of the month for the net amount used. If an end user produces more electricity in a month than they have consumed, the net billing calculations are rolled over to the following month, which further decreases the electricity bill in the following month. However, the consumer does not receive payment for excess generation.

At the end of Q4, 2019, the Emirate of Dubai had a total installed rooftop solar PV capacity of 125 MW, which consists of ~1,300 solar PV panels. By March 2021, this had increased to 298.7 MW on 6727 buildings[2].



6-B: Explanation of the Shams Dubai Programme (Net Metering Scheme)

Another example of the deployment of rooftop solar PV in the region is found in Oman. In Q2 2017, the Oman Authority for Electricity Regulation (AER) introduced the "Sahim Scheme", which is structured in two phases. Phase I was in introduced in Q2 2017 and allows residential and commercial units to install rooftop solar PV systems at their own cost, supply electricity in exchange in for a feed-in-tariff. As part of Phase II, the AER has introduced a

[2]https://www.zawya.com/mena/en/projects/story/PROJECTS_Dubai_installs_299_megawatts_of_rooftop_solar-ZAWYA20210414123842/

competitive auction scheme that is designed to allocate 1 GW of rooftop solar PV for small-scale projects leading into 2030, where specialized developers participate an auction scheme to build, own, and operate rooftop PV systems at various residential communities across Muscat.

A key differentiating factor between the schemes in Dubai and Oman is that Shams Dubai is a net metering scheme and Sahim is a feed-in-tariff scheme. Net metering provides end user customers with a tariff that is equal to the rate they pay for electricity, which is the retail tariff of electricity, in contrast to feed-in-tariffs where an end user customer is paid a tariff at a rate that equal to the value of the market value of the electricity at that time, which can be either higher or lower than the retail tariff.

The rooftop solar PV segment provides prospective Dutch players to capitalize on three main market opportunities in the region. Firstly, financing rooftop solar PV technologies has been a challenge, and lessons learned from the Sahim Scheme in Oman still indicates that most end users are not willing to incur the high capital cost of installing the rooftop solar PV panels. Thus, a business model that offers the installation of rooftop solar PV technologies through an attractive leasing plan could mitigate these upfront capital costs. Secondly, both Sahim and Shams Dubai have introduced simple mobile applications allowing prospective end user customers to identify economic advantages of installing rooftop solar PV panels, an area which solar software developers could explore. And finally, both schemes have introduced ambitious capacity deployment targets leading into 2030, which creates domestic opportunities in manufacturing, installation, and projects development for small and medium-size enterprises.

6.3 Agriculture Segment: Agricultural Farming

With the COVID-19 pandemic disrupting global food supply chains around the world, GCC governments have launched various interventions, such as increasing domestic productivity of local farmers, facilitating imports, reinforcing / reorganizing supply chains, and creating a public entities and units to enforce and improve their food security.

Currently, the GCC imports ~85% of its domestic food supply, including 93% of domestic supply of cereals, 62% of the domestic supply of meat, and 56% of the domestic supply of fruits and vegetables[3]. Although the region is considered one of the most "food-secure" regions in the world as per the "Global Food Security Index", nonetheless, given the disruption of global food chain supplies and its limited arable land and reliance on food imports, the GCC is exposed to the risk of vulnerable food shortages.

To mitigate this, governments across the GCC have introduced various short-term and long-term measure. Short-term measures include emergency stocks, financial exemptions and subsidies to domestic farmers and agriculture businesses, mobility exceptions during

[3] https://www.strategyand.pwc.com/m1/en/articles/2020/how-gcc-countries-can-ensure-their-food-security.html

lockdown for essential agricultural workers, along with support from industrial companies specializing in packaging and distribution, which has preserved short-term food security.

However, in the long-term, governments across the GCC will continue to introduce measures to maintain the stability of imported food supplies, in addition to increasing domestic output. In the latter case, GCC governments can establish agricultural practices, such as genetically modified crops, desert agriculture, seawater farming and aquaculture, vertical and urban farming, aquaponics, and precision agriculture, which are already in use in countries such as the Netherlands, which can facilitate agricultural yield and efficiency.

Although off-grid, small-scale solar PV technologies and projects can support agricultural productivity across all the stages of the food value chain, from irrigation to food production, post-harvesting processes, processing of agricultural-commodities, and food preservation for storage and transport.

With increasing water scarcity across the GCC, off-grid, solar technologies can be a reliable method for agricultural irrigation in areas that lack access to the electricity transmission and distributions system. Technologies such as solar pumps can provide sustainable, reliable, and cost-effective electricity generation for irrigation, in contrast to diesel-powered pumps. Solar pump technologies can also be complemented with hybrid systems that also produce electricity from wind or biomass.

In post-harvest storage, transport, distribution, off-grid, solar thermal technologies can be used to dry vegetables, fruits, grains, rice, fish, corn, and other agricultural products. An example of an applicable solar-based technology that could be deployed is solar dryers, which heats the air, creates an air flow that removes the moisture, and dries the food. Solar dryers are simple to build using woodworking tools and basic skills and are easy to use.

In addition to solar dryers, and another technology that could preserve agricultural output is solar thermal cooling. Solar thermal refrigerators can be used for food preservation, storage, and transport in areas that lack electricity or have a high intensity of solar radiations. Although the technology is still not very affordable, a prospective pilot project in the GCC could demonstrate the socio-economic benefits.

A generalized solar-based electricity generation system with application to the agricultural segment is Agrophotovoltaic (APV), which combine solar PV and agriculture on the same land and consists of growing crops underneath ground-mounted solar PV panels, which results in higher electricity production, higher crop yields, and less water. Another advantage of APV systems is that certain types of crops, such as tomatoes and cucumbers (that are indigenously produced across the GCC), grow better underneath shades of solar PV panels, as they are protected from direct sunlight, experience less water loss via transpiration, effectively reducing water consumption and maintaining production.

The successful deployment of solar pumps, solar dryers, solar thermal cooling and refrigeration, and Agrophotovoltaic technologies depends on a sound business model that

ensures their affordability and reliability as a technological system or as a service. Innovative models through pilot projects or by financing at the enterprise or project-level could help establish these approaches.

6.4 Commercial and Industrial Segment: Solar-based, EOR and Water Desalination

Enhanced oil recovery (EOR), also known as tertiary oil recovery, is the last stage of extracting crude oil from a reservoir, boosting recovery factor, or used for hard-to-recover resources such as heavy oil. EOR involves changing the properties of the hydrocarbons underground to enhance its extraction. The three major groups of EOR techniques are thermal recovery that is used mainly for heavy oil, miscible natural gas or carbon dioxide injection, and chemical and polymer injection.

Solar thermal systems can be used to generate steam, which is injected into crude oil wells as part of thermal EOR techniques. Solar EOR techniques are a niche application of solar power that is increasingly being applied across various oil and gas operations. As the technology matures the cost has decreased.

Oman is a global leader in solar EOR. In recent times, the country has increased its crude oil production through various advanced EOR techniques. Oman has 1 GW thermal equivalent of solar powered, EOR systems that produce steam at the Amal viscous crude oil field, through the Miraah solar thermal power project. The project is owned by Petroleum Development Oman (PDO) and was constructed by GlassPoint Solar and achieved COD in Q1, 2018. It generates 6,000 tonnes / day of solar steam, with concentrated solar collectors in greenhouses that protect them from wind and sandstorms. The EOR project has enhanced well productivity by up to 300%, while saving natural gas that would otherwise be burnt for steam generation and also reducing CO_2 emissions.

However, GlassPoint Solar filed for liquidation in Q1, 2020. The company was a US-based, enterprise that specialized in designing and manufacturing solar steam generators that utilize solar thermal technology to generate steam for industrial processes. The Netherlands-based, international oil company, Royal Dutch Shell (which holds 34% of PDO), through its venture capital arm held an equity stake worth US$ 26M in the company. Nonetheless, Shell continues to explore other innovative green technologies that could be utilized in EOR techniques.

Another opportunity in the GCC is solar powered water desalination. 81% of the global water desalination capacity is installed in the GCC, which produces 41% of the global supply of desalinated water. Countries across the GCC are increasingly exploring long-term sustainable techniques and processes that improve water efficiency, whilst increasing the current new water desalination capacity.

The Jebel Ali Jebel Ali SWRO Desalination Project in the Emirate of Dubai, UAE is a pilot project that is currently under development and is expected to achieve COD in Q2, 2021. The project will utilize solar PV-thermal technology for multi-effect water distillation. As part of

the desalination project, the solar PV-thermal unit is designed to produce sufficient thermal energy and electricity to run the desalination facility off-grid for 24 hours a day. During the day, excess electricity from solar energy is stored in hot water tanks and battery units that power the project's operations at night.

A notable company in the solar value chain in the Netherlands that has been active in global water desalination is the Den Haag-based Elemental Water Makers. The company specialises in solar-powered water desalination projects as system integrator, through in-house patented technologies deployed in collaboration with various external civil work partners, architects, developers, suppliers, and contractors on more than dozen projects across Europe, Southeast Asia, East Africa, West Africa, and the Caribbean. In 2018, Elemental Water Makers won the 1st Prize in the Mohammed bin Rashid Al Maktoum Global Water Award of the Deputy Ruler of Dubai out of 138 organisations that are active in water desalination, based on business model scalability and innovative solutions.

6.5 Utility-Scale Segment: Solar PV and Hybrid (Solar and Wind) Power Projects

As noted, utility-scale is the most established segment of the solar industry in the GCC. We anticipate an increasing competition for solar PV assets, as additional companies enter the market. This provides various opportunities for Dutch enterprises that operate across the entire solar energy value chain, in project development, engineering and construction, supply of technological components, testing and measuring equipment, supply of solar cells, films, and modules, utilization of innovative solar materials, and research and development. The specialist quality, reliability, high-tech expertise, and innovation laboratories exhibited by Dutch companies could enable access.

In addition to utility-scale solar PV projects, and contrary to common perceptions, some countries in the GCC, such as Kuwait, Oman, and Saudi Arabia have a very good indigenous wind resource. A consortium consisting of Masdar and EDF Renewables is currently developing the 400 MW Dumat Al Jandal wind power project in the northern area of Al Jouf in Saudi Arabia, which will be the country's first wind project and the largest in the Middle East. It is expected to achieve COD by 2022.

Country	Average Annual Wind Speed (metres per second, m/s)
Saudi Arabia	7.3
United Arab Emirates	6.5
Qatar	7.2
Kuwait	7.6
Oman	8.3
Bahrain	6.8
GCC Average	7.2

6-C: Wind Resource: Annual Average Wind Speed

The area of Al Jouf, like the rest of the northern region of Saudi Arabia, has an abundant solar resource in addition to the indigenous wind resource, where the average solar GHI ranges between 2,000 – 2,450 kWh / m^2 / year. This provides an opportunity to construct a hybrid power project consisting of utility-scale, deployment of solar PV panels and wind turbines. The Neom project in north-western Saudi Arabia is planning a combined solar and wind development to produce "green" hydrogen, combining the two renewable resources to achieve high-capacity factors.

Although GCC countries do not have a competitive auction scheme designed for hybrid renewable energy capacities, regulators and research and development institutions across the region are open to standalone proposals and the development of pilot projects.

6.6 Smart Cities Segment: Street Lighting and Traffic Systems

Energy efficiency targets introduced across the GCC are part of a broader sustainable programmes to promote renewable energy penetration and other low-carbon energy sources. These programmes include setting targets for improvements in energy efficiency, reforming energy pricing structures, introducing energy efficiency standards for buildings, street lighting, traffic systems, vehicles and appliances, and raising consumer awareness on energy-efficient practices.

A smart city infrastructure initiative in Qatar, Kuwait, Oman, and Bahrain could consist of efficient electrified transport systems, smart communities with energy demand response and variable renewable energy balancing through real-time adjustments in street lighting, traffic systems, district cooling, water desalination, and battery storage.

The Msheireb urban development in Doha, Qatar, features a high level of LEED certified buildings, walkability, a battery-powered tram, solar PV panels and solar water heating.

The Smart Dubai Initiative or Dubai Smart City was introduced in 2013. The initiative consists of various projects, *inter alia* the "Dubai Sustainable City Project", which is a residential community featuring solar powered street lighting and traffic systems, electric vehicles, and high-efficiency air conditioning and district cooling.

In the Emirate of Abu Dhabi, UAE, Masdar City aims to be the world's first carbon-neutral city that utilizes solar power and energy efficient architecture, inspired by traditional Arab cities. Finally, the planned city of Neom in northwest Saudi Arabia intends to be served entirely by renewable energy.

A key feature of the Dubai Smart City Initiative, Masdar City, and Neom is solar powered public lighting, street lighting, and traffic systems, which are expected to reduce energy consumption through the replacement of incandescent lights with light-emitting diodes (LEDs).

The success of these projects provides an opportunity to utilize similar measures across new city development and/or as part of a wider smart city infrastructure programme, which

specialized technology providers, or smart city infrastructure developers could explore business synergies and opportunities on.

6.7 Solar Materials Segment: Exploitation and Recycling

For now, the solar PV industry is at a very early stage in the GCC and systems are not close to the end of their lives. But given the GCC's vast planned deployment of solar PV, end-of-life recycling is expected eventually to be an important part of a sustainable, economically viable, and increasingly renewables-based, energy future. Although the region lacks the institutional framework to unlock the benefits of the end-of-life solar PV supply, it is expected to be introduced as power purchase agreements relating to large flagship and utility-scale projects expire by 2035-40 and a surge in solar PV panel waste materialises. In addition to private sector enterprises to capitalize on a market opportunity, this provides Dutch research and development institutions across solar materials and general materials value chain an opportunity to counsel regional regulators on supporting end-of-life management from a design and socio-technological perspective.

For example, as solar PV waste increases, new markets and industries are expected to emerge, which will create new international trade opportunities for various materials, and lead to the development of various local opportunities for the energy and waste sectors.

The framework of a circular economy, such as "cradle-to-cradle opportunities", and the conventional principles of waste management, such as reduce, reuse, and recycle can be applied to decommissioned solar PV panels. The most common option is the reduction of material in solar PV panels and an increase in efficiency, which is attributed to strong market growth, scarcity of raw materials used in solar PV panels, and cost-pricing pressures on solar PV panel prices that is driving efficient mass production, reduced material use, material substitution, and the development of technologies with an efficient architecture type.

The second most common option is to reuse, which includes different repair and reuse technological processes. Recycling is the least preferred option and only takes place after the first two options have been exhausted. Recycling provides for the treatment of decommissioned solar PV panels and can extract raw materials for the manufacturing of new solar PV panels or other products.

In summary, the GCC represents various opportunities on the exploitation, maintenance, and recycling of solar PV panels. The region offers a first mover advantage to Dutch players through pilot projects, investments, and innovative financing structures for solar PV end-of-life management, which will likely set a regional precedent that could determine the institutional framework and help overcome future regulatory and financing barriers.

6.8 Solar Components: Supply Chain

The main solar components of a utility-scale or small-scale solar PV power project that project developers and industrial manufacturers consider producing domestically are the

solar cells, solar modules, inverters, trackers, mounting structures, and general electrical components that used on the balance of system installations. For example, producers of main components of solar PV power project with an installed capacity of 50 MW require 50,225 person-days of labour input, with the production of solar cells requiring 50% of the manufacturing labour input, solar modules at 21%, inverters at 17%, and solar trackers and structures with 14%.

Solar PV modules consist of solar cells that constitute the basic building blocks that collect the sun's light. Inverters are the power system devices that are connected to the DC side of the solar PV system and the AC side of the electrical grid. Trackers are instruments that are used to increase the solar resource on the PV panel's surface and subsequently increase the electrical energy output of the system. And finally, another key component of solar systems is mounting structures, typically a set of steel or aluminium racking units that are used to hold the solar PV modules in an optimal position to capture the solar resource.

The domestic solar value chain across the GCC is expected to expand over the coming years as solar technologies are increasingly deployed. As demand for solar technologies increases and a market for solar components and equipment develops domestically or regionally, which Dutch manufacturers could benefit in several ways.

Firstly, the GCC is located in the middle of three major demand centres for renewable energy equipment and technology, which are Southern Europe, Sub Saharan and East Africa, and South Asia. Secondly, the GCC offers a well-developed and established infrastructure for fast and efficient shipping and supply chain management of domestic products. Thirdly, the corporate tax and foreign ownership structures in economic freezones are an additional incentive for investments. And finally, input labour and energy prices are still relatively low in most GCC countries. All of these factors have encouraged companies to set up domestic solar PV component manufacturing facilities of various types across the region, even if these remain relatively limited compared to China or other major solar manufacturing hubs.

An additional driver of the expansion of domestic solar PV components value chain the local content requirement. GCC countries including Kuwait, Oman, and Saudi Arabia have introduced various local content requirements, which include project development services, operations and maintenance, and engineering, procurement, and construction jobs. For example, the Sakaka solar PV project with an installed capacity of 300 MW requires a minimum local content requirement of 30%. The local content requirement is not limited to the domestic manufacturing of components – instead, it applies to the entire value chain.

Polysilicon	Inverters	Mounting Structures	Solar Modules
IDEA Polysilicon, REC Silicon (Saudi Arabia) QSTEC (Qatar)	AEC, New Energy (Saudi Arabia) Noor Solar (UAE)	Al Jazira, Tiger Profiles (UAE)	Almaden, DUSOL, Noor Solar, SOLON (UAE) Qatar Solar Energy (Qatar)

6-D: Selected Domestic Industrial Manufacturers of Solar PV Components in the GCC

A large proportion of solar components and equipment for PV projects in the GCC are manufactured at industrial units operated by foreign companies, with local suppliers increasingly trying to position themselves at various parts of the value chain.

Saudi Arabia has announced plans to develop large-scale polysilicon production facilities. IDEA Polysilicon announced plans to set up a facility in Yanbu Industrial City in the city of Yanbu. The production facility is expected to manufacture 5,000 tonnes / year of polysilicon, of which 1,500 tonnes would be used to produce 55M solar wafers with a total nameplate capacity of 180 MW. In addition to this, high-purity silicon would be produced for domestic manufacturing of electronics and semi-conductors. In 2014, United States-based SunEdison, conducted a feasibility study with the Saudi Arabia-based National Industrial Clusters Development Programme, the Public Investment Fund, and the Saudi Arabian Investment Company to develop a solar PV manufacturing unit with a production capacity of 3 GW of polysilicon, which would be used to produce in-house solar PV modules that will supplied to regional and global markets. However this does not seem to have progressed.

Qatar's Solar Technologies (QSTec), a joint venture between Qatar Foundation, SolarWorld AG, and the Qatar Development Bank, operates a polysilicon production facility in Ras Laffan Industrial City. At full production capacity, it produces 8,000 tonnes / year of high-purity polysilicon, with plans to expand production capacity to 45,000 tonnes / year.

In Dubai, companies such as First Solar have manufactured solar PV panels for Phase I of the Mohammed bin Rashid Al Maktoum Solar Park and continue to establish themselves.

In addition to First Solar, companies such as UAE-based Noor Solar Technologies specialize in various system solutions. The company intends to expand its product range beyond solar PV panels to modules and inverters integrated with battery storage. Noor Solar Technologies has also partnered with UAE-based Emirates Glass to produce solar panels for BIPV systems and continues to seek additional partnership opportunities in this segment. Other UAE-based companies such as Al Maden Solar specialise in manufacturing 180 kW rooftop solar PV systems for agricultural units.

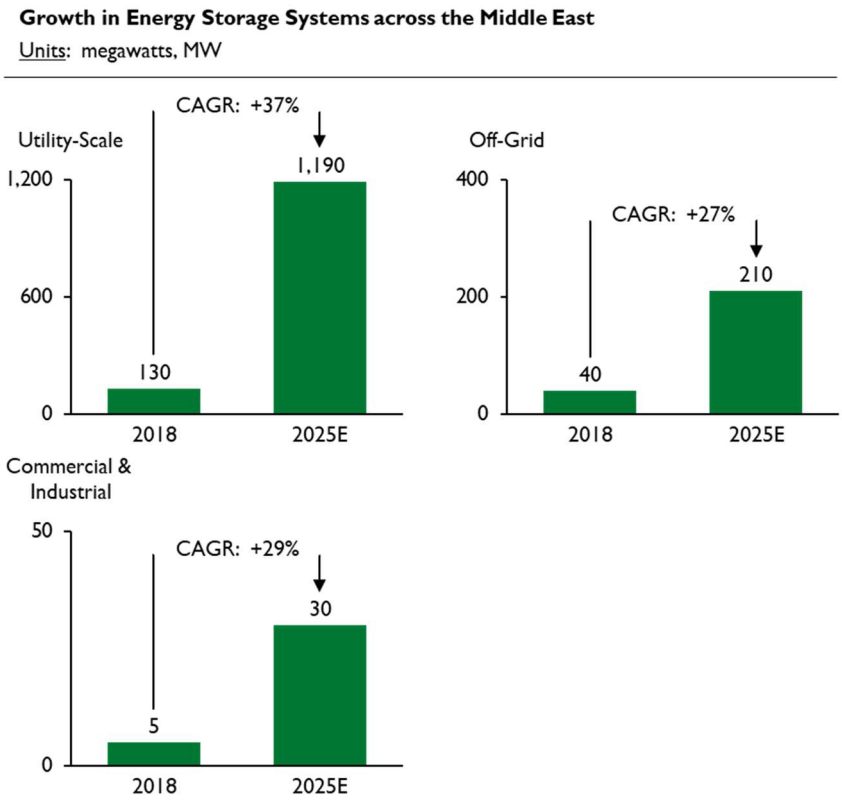
6.9 Solar Ancillary Systems: Battery Storage Systems

Battery storage systems and other technologies permit higher system flexibility, which is a crucial factor in incorporating a larger share of variable solar PV technologies. Electricity storage through battery storage systems provides end users in the agricultural, residential, commercial, industrial, and transport sectors with effective and reliable self-generating electricity systems and renewable-based mini-grids.

Battery storage systems are most commonly used for electricity storage for standalone, self-generating systems that power off-grid operations, such as remote and offshore work sites, mines, construction sites, military bases, farms and stables, remote resorts, telecom towers,

parking meters, solar streetlights, and solar water pumping. In addition to distributed and off-grid energy systems, further cost reductions will drive battery use for electricity storage in utility-scale solar PV power projects. There are different types of batteries storage systems, with lead-acid batteries being the most widely used across the GCC due to their low price and lifeline of 5–10 years. Other types of battery storage systems provide a higher storage density such as lithium-ion, nickel-cadmium and nickel-metal hydride types, but they are more expensive than lead-acid.

For PV, battert storage systems are installed to comply with grid limitations imposed by the transmission and distribution operators, as well as ensuring reliable baseload production.



6-E: Growth in Energy Storage Systems across the MENA Region (Source: Navigant Research)

Across the GCC, the battery storage segment provides different market opportunities for Dutch enterprises. The deployment of battery storage systems varies by application and requirements that are unique to each location. For islands and off-grid, desert locations, the high cost of delivering diesel fuel has led to a need for 24-hour power availability. In terms of residential, commercial, and industrial units, PV complemented with battery storage can increase the effective share of demand met with solar.

Furthermore, large-scale deployments of solar PV capacities expected through various utility-scale projects across the GCC in the medium to long-term is expected to create additional demand for battery storage systems, to smooth-out variable electricity generation. In

addition to storing excess output for later periods, battery storage systems are a crucial component in periods of high demand, providing time-shifting of demand. The variability of utility-scale power projects has negative consequences for the voltage levels in the transmission and distribution system and the overall stability of the system. For example, a large cloud that blocks the sun may cause the output of a solar PV panel to decrease up to ~90% almost instantly. Battery storage systems across utility-scale solar PV projects allow for smoothing that helps maintain system reliability and voltage.

6.10 Services: Testing, Measuring, Project Development, Finance, and Other Services

Beyond offshore and onshore, utility-scale, small-scale, and offshore solar PV generation, and various opportunities across the solar materials, solar components, and battery storage systems, the solar sector across the GCC provides various opportunities for companies operating across the solar value chain from the Netherlands, including production, testing, and measuring equipment, project development services, financial services, and other non-technical services.

Since the diffusion of solar PV is still in the growth phase, the GCC like the rest of emerging markets around the world is exposed to unreliable and failing products. The Norway-based internationally accredited registrar and classifications company, DNV GL, has estimated that ~30% of 100 solar PV projects analysed around the world indicate serious defects.

As the GCC implements the necessary infrastructure, this presents a market opportunity for Dutch entities to further improve the development and enhancement of solar technologies in the fields of standards, certifications, testing processes, accreditation, coordination with inspection bodies, metrology, and market surveillance.

In terms of solar materials, components, technologies, and equipment used in a solar PV balance of system, electrical standards include defining methods and equivalent specifications that harmonize the market. Certifications involve assessing and testing a product, service, organisational management system, and project's qualification in correspondence with the enforced standards. Testing processes include verifying the conformity of the technological systems and testing for quality, performance, safety, and reliability standards, which are followed by an accreditation process by an inspection body that assess their conformity against recognised standards.

The Netherlands, given its strong expertise in research and development of various solar technologies and semiconductors, features various complementary producers of solar systems. In addition to the manufacturing of various solar systems, the Dutch solar energy value chain includes companies involved in testing and measuring.

International project developers typically enter joint ventures or equity investment consortiums on solar PV projects with regional companies, such as Acwa Power, which continues to develop and operate the largest portfolio of conventional and renewable energy power projects across the GCC. Another option for international project developers is Masdar

Clean Energy, which operates a smaller portfolio of projects compared to Acwa Power, and is a subsidiary unit of Masdar.

In addition to opportunities involved in the testing, measurement, accreditation of solar components, and project development services – the solar sector across the GCC across various segments provides various opportunities for Dutch financial institutions through corporate and project financing schemes, as well as business and legal consulting services, and specialized technical and non-technical consulting services relating to different technologies, systems, and projects.

7. Appendix

7.1 The Gulf Cooperation Council Countries

The Gulf Cooperation Council (GCC) is a regional intergovernmental political and economic union comprised of the six Arab countries along the western Persian/Arabian Gulf region, which include Saudi Arabia, the UAE, Qatar, Kuwait, Bahrain, and Oman.

7-A: View of the Gulf Cooperation Council Countries

The GCC was ratified in May 1981, for the purpose of unifying its members as the council's charter states. At the time of its inception, the key objective was to protect the member states from possible threats of the Iran-Iraq war.

The GCC is a loose union covering a band of social, political, economic, and security issues that concern six states that share cultural, social, and geographical ties. At times, these states cooperate and at other times they compete. At the time of its inception, the union agreed to formally implement an economic customs union, a common market, and a common currency, the last two of which has it has failed to achieve in the initially agreed timeline. The GCC has some achievements such as the customs union, security cooperation, coordination on banking, trade, tariffs and tax, and a connected electrical grid; however when its members are in competition, it is weaker than the sum of its parts.

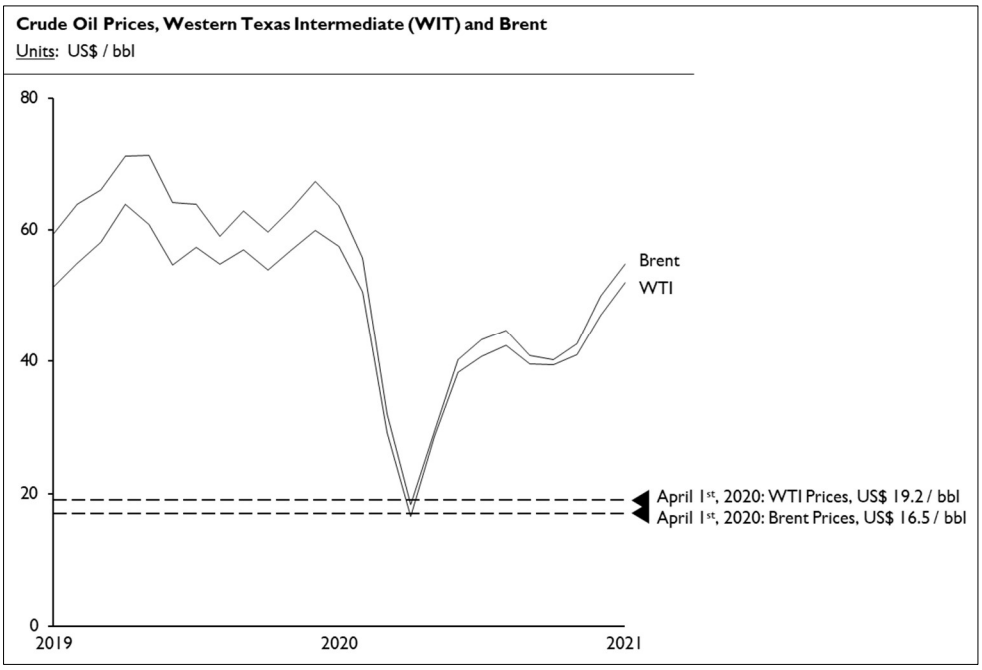
The collective economy of the GCC has undergone several phases, influenced by various economic legislations, trade pacts that enhanced economic growth and economic stability,

through periods of global economic crisis. These include the economic boom during 2003-8 with rising oil prices led by Chinese demand growth, the Global Financial Crisis of 2008 – 2009 and the sharp decrease in crude oil prices in late 2014. However, economic coordination is minimal between the GCC member states, as each country individually seeks to direct its market policy and investments in line to its orientations and plans towards economic diversification and strategic goals.

7.2 The COVID-19 Pandemic, Fall in Crude Oil Prices, and Economic Outlook

The COVID-19 pandemic quickly triggered an oil demand shock, which led to a brief price war between Saudi Arabia and Russia in March-April 2020. The decrease in crude oil prices was attributed to weakness in oil product consumption driven mostly by the decrease in transport due to lockdowns, flight bans and work-from-home policies.

Although the two countries and other oil exporters then successfully cooperated in the OPEC+ production cuts that led to a partial rebound in prices, the oil dependent GCC economies still suffered from sharply decreased revenues. With crude oil prices decreasing significantly in Q1, 2020, the crude oil market experienced a robust recovery in Q2, 2020 following the supply cut deal with average crude oil prices reviving to US$ 42/bbl in Q3, 2020.



7-B: Crude Oil Prices (Western Texas Intermediate and Brent)

In Q2 2020, global crude oil production decreased by 12% from 100 Mbbl/d to 88 Mbbl, due to the OPEC+ cuts and to shut-ins by other producers when prices fell to uneconomic levels, and has remained below the pre-pandemic level. The main near-term risk to crude oil price forecasts is the duration of the pandemic, including the risk of subsequent waves of COVID-19 cases and the speed at which the vaccine programmes and other pandemic management programmes are introduced to achieve herd immunity.

The pandemic is expected to leave a legacy on crude oil consumption. Over the next 2 – 5

years crude oil consumption is estimated to remain below the pre-pandemic level and is likely to be further impacted by changes in consumption patterns across various sectors.

The GCC countries faced a double economic impact from the ongoing COVID-19 pandemic and the subsequent decrease in global crude oil prices. Annual real GDP in the GCC is expected to have decreased by ~6% in 2020 with the loss of economic activity equally balanced between the hydrocarbon and non-hydrocarbon sector. Economic growth is expected to increase by ~3% / year leading into 2023, driven by the non-hydrocarbon sector, which is estimated to account for ~56% of the overall economic growth across the GCC.

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	GCC Average
Foreign Currency Ratings		B+ / Stable / B	AA- / Negative / A-1+	B+ / Stable / B	AA- / Stable / A-1+	A- / Stable / A-2	AA / Stable / A-1+	-
Hydrocarbon Sector, % of Real GDP, 2019		17.9%	53%	41.4%	46.8%	37.8	29.8%	38%
Annual Average Change in Real GDP, 2020		-5.0%	-7.0%	-5.0%	-4.4%	-4.5%	-8.6%	-5.8%
Percentage contribution to Annual Change in GDP, 2020	Hydrocarbon Sector	-	66.4%	49.7%	17.6%	70.6%	37.8%	49.6%
	Non-Hydrocarbon Sector	100%	33.6%	50.3%	82.4%	29.4%	62.2%	50.4%
Annual Average Change in Real GDP, 2021 - 2023		2.4%	4.5%	2.6%	1.8%	2.4%	2.5%	2.5%
Percentage contribution to Annual Change in GDP, 2021 – 2023	Hydrocarbon Sector	7.6%	80.7%	41.8%	4.5%	46.7%	38%	44.2%
	Non-Hydrocarbon Sector	92.4%	19.3%	58.2%	95.5%	53.3%	62%	55.8%

7-C: Estimated Economic Forecasts for the GCC (S&P Global Ratings)

GCC economies have implemented a range of appropriate measures to mitigate the economic damage, including fiscal stimuli, expansionary monetary policies, and an injection of liquidity into the banking and financial system. The decrease in crude oil prices have caused a sharp deterioration of external and fiscal balances, and fiscal strains are evident in countries with higher debt levels.

In the largest GCC economy, Saudi Arabia, the COVID-19 pandemic has decreased its net exports and real GDP due to OPEC+ crude oil production cuts. The government's fiscal consolidation measures consisted of an increase in Value-Added Tax (VAT) to 15% from 5%, which was expected to decrease domestic consumption in H2, 2020. In addition, the government did not permit international visitors to undertake annual religious pilgrimages

due to pandemic-related restrictions. In the medium-term, the real GDP growth rate is expected to increase to 3% by the end of 2022, and in the longer-term, the government will continue to pursue its Vision 2030 Programme, which is largely aimed at supporting the non-hydrocarbon economy and social transformation of the country through a set of large projects.

The UAE's economy is dominated by the local economies of the Emirate of Abu Dhabi, which accounted for 59% of the GDP in 2019, followed by the Emirate of Dubai, which made up 28%. The UAE's non-hydrocarbon sector is expected to have declined by 5% in 2020 given the decrease in tourism and real estate activity, but to expand 3% in 2021 and 2022. Overall, the economy shrank by 5.7% last year and is anticipated to grow 2.3% this year.

Growth prospects in Abu Dhabi are linked to the hydrocarbons sector. The hydrocarbon sector is expected to expand from 2022 as OPEC+'s crude oil production limits are lifted and new natural gas production comes online. Abu Dhabi's non-hydrocarbon sector's recovery will be driven by public investment in the industrial sector, mainly petrochemicals, logistics, and construction.

In contrast to Abu Dhabi, the hydrocarbon sector has a minimal direct role on the emirate's economic activity, but an important indirect one given the impact of crude oil prices on regional demand. The delayed Expo 2020 will now take place in 2021 – 2022, which should provide a platform for an economic recovery driven by the tourism and financial sector.

Qatar's hydrocarbon sector is ~80% dependent on the natural gas sector and ~20% on the crude oil sector, in contrast to most GCC economies where the crude oil sector dominates. Real GDP growth through 2023 is estimated to remain below the historical average due to a slowdown in construction and associated sectors. However, from 2025 – 2027, following extensive investment in expanding LNG production from the North Field, supply of liquefied natural gas is estimated to increase to 126 million tons annually, supporting further economic growth.

Kuwait's economy is the most directly dependent on the hydrocarbon sector across the GCC economies. The country's economic growth was sluggish before the COVID-19 pandemic, with output expanding by just 0.4% in 2019 and 1.3% in 2018. Against the backdrop of the pandemic, the government has announced a renewed Kuwaitization effort, where nationals replace foreign workers. It is expected that the non-hydrocarbon sector will contribute a minimal role in Kuwait's recovery over the next 2 – 3 years.

GDP growth had already been subdued in Oman, averaging ~0.2% between 2017-2019. The number of expatriates has declined 15% in 2019 and is estimated to have decreased by 5% in 2020. The pandemic-induced decreased economic activity has severely slowed global tourism and has led to delays in public-sector capital spending, two factors which weighed heavily on the non-hydrocarbon sector in 2020.

Bahrain's economy is the least dependent on the hydrocarbon sector compared to the other

GCC economies, but its budgetary dependence on oil earnings remains high. Real GDP is likely to recover to 2019 levels midway through 2022 on the back of government plans to promote infrastructure development, including several large projects such as the refinery modernization programme, and the planned development of offshore unconventional oil and gas resources.

7.3 Long-Term Economic Diversification Strategy in the GCC

The GCC countries are increasingly aware of the threat of climate change policy for their traditional business models of exporting hydrocarbons and energy-intensive materials, including the expansion of renewable energy, the growth of electric vehicles potentially causing a peak in world oil demand, carbon pricing, possibly European carbon border tariffs, and other measures. This has ultimately necessitated structural economic reforms and the need for a long-term economic diversification strategy.

As part of these reforms, governments across the GCC have undergone various fiscal consolidation efforts, which consist of a long-term decrease in government spending, including reductions in energy (fuel and electricity) subsidies and setting tariffs closer to market prices, and new revenue-raising measures, notably value-added tax, VAT, planned across the GCC and so far, implemented in Saudi Arabia, Oman, Bahrain and the UAE.

The economic diversification strategies of GCC economies are intended to develop the tertiary sector of the economy, which collectively accounts for ~50% - 60% of the regional GDP across the GCC and mainly includes the financial, healthcare, consumer staples, and consumer discretionary sectors. In addition to the tertiary segment, these strategies also provide provisions for relaxed foreign and private sector investment in the industrial and manufacturing sector. Part of this includes generating more value from the hydrocarbon sector through more sophisticated uses, and "future-proofing" it by improving efficiency, reducing GHG emissions and targeting non-emitting uses of hydrocarbons.

Country	Long-Term Economic Diversification Strategy
Saudi Arabia	▪ Saudi Arabia launched its "Vision 2030" in 2016 as a comprehensive strategy to diversify the Saudi Arabian economy away from its reliance on hydrocarbons, under the three themes of "A vibrant society", "A thriving economy" and "An ambitious nation". ▪ As part of the strategy, various so-called vision realisation programmes are introduced, which include *inter alia* the newly empowered Public Investment Fund programme that is mandated with investing in various sectors that diversify the Saudi Arabian economy.
United Arab Emirates	▪ The UAE has introduced the "Vision 2021", "UAE Energy Strategy 2050", "UAE Green Growth Strategy", "UAE Future Strategy", and "UAE Centennial Plan, 2071", which highlight economic diversification and technological innovation as key foci to future economic development. ▪ The country has positioned itself as a regional hub for research, innovation, and sustainable energy with the latter recognised as a new growth sector with vast potential.
Qatar	▪ Qatar's "National Vision 2030" aims to strike a balance between a hydrocarbon-based and a "diversified", knowledge-based economy. ▪ In addition to this, the country has introduced "Qatar's Second National Development Strategy, 2018–2022" that plans for increasing natural resource management and includes provisions to increase in the use of renewables in the country's energy mix.

Kuwait	▪ "New Kuwait National Development Plan" and current "Five-Year Development Plan" aims to position Kuwait as a regional trade and financial hub, and with a key focus on economic diversification.
Oman	▪ Oman's "Vision 2020" and the subsequent "Five-Year Development Plan" call for economic diversification, and introduce objectives, policies, and mechanisms to expand the non-hydrocarbon sector through increased private sector participation.
Bahrain	▪ Bahrain's "Economic Vision 2030" provisions for shift from an economy built on hydrocarbons to a productive and globally competitive economy, that is driven by a pioneering private sector.

7-D: Long-Term Economic Diversification Strategies in the GCC

8. Notes and References

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