EIC INSIGHT REPORT

Solar

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Disclaimer

Due to lack of visibility on projects in China; the number of solar PV projects that the EIC tracks are artificially low.

As of August 2022, the tracking threshold for global solar PV projects was changed to 30MW capacity projects; which has been taken into account in the following report. The term 'Utility scale solar PV' will be used throughout the report to describe projects above 30MW.

01 ——

Introduction

With a global effort to pursue net zero emissions, clean energy capacity is growing as an increasing number of countries begin to adopt renewable energy, with solar PV being a popular technology type of choice. Over 30% of utility scale renewable projects – inclusive of onshore wind, offshore wind, solar CSP and hydroelectricity – that have come into operation between 2013 and 2023 are solar PV projects, accounting for an estimated total capacity of over 154GW of global utility scale PV capacity, according to EICDataStream and EICAssetMap.

Since 2020, oil prices have been volatile and are likely to remain highly uncertain due to factors that may impact global supply and demand. For example, factors impacting supply include EU's sanctions on Russia as a result of the ongoing invasion of Ukraine, and factors impacting demand include the concerns of a global recession and the easing of COVID-19 restrictions and lockdowns in China. This proven market volatility associated with hydrocarbons has made governments begin to seriously look into alternative sources of energy particularly renewables. This can be observed in the solar PV project pipeline. According to EICDataStream, over 500GW of solar PV could come online between 2023 and 2025, globally indicating the ambition from government and the private sector to seek energy from alternative sources to fossil fuels.

As well as ambitions in energy security and independence, global sentiment has shifted towards greater carbon neutrality and decarbonisation. Countries across the globe are increasingly committing to net zero targets and many private sector companies aiming for environmental, social, and governance (ESG) targets, which has also contributed to solar PV adoption. The technology itself has proven to be versatile and can be deployed in various environments, be it rooftop, floating or ground-mounted enabling power generation in rural areas too. It's intermittent nature and flexibility when coupled with energy storage can also improve grid capacity, particularly in areas with poor grid infrastructure. It is however, the cost for solar that is a key driver for investment into the sector. According to the International Renewable Energy Agency (IRENA), the levelised cost of electricity (LCOE) of newly operational utility scale solar PV projects has declined by 88% between 2010 and 2021, on a global average from USD$0.417/kWh to USD$0.048/kWh. In that same period, the cost of solar PV modules continuously declined though in 2021, a slight increase was observed with supply chain disruptions leading to higher materials costs. Increased costs in silicon, silver, copper, and aluminium used for equipment like mounting systems or cables was observed and this problem was further exacerbated by other COVID-19 related shipping challenges. Individual market policy decisions had some impact too, for example import duty associated with Chinese solar equipment at the US border. That being said, in the longer term, cost of materials will likely stabilise as well as increasing efficiencies in solar PV technology can be predicted to offset the current temporary cost increase, to enable the costs of solar to decline again.

Figure 1.1 demonstrates global solar potential and highlights regions of greater potential than others – the colour scale indicates areas in red have greater irradiation. Asia Pacific (APAC) region and the Americas have good solar potential, and this is reflected in their adoption of the power source; North America and South America each planning 20% and 17% of total planned solar PV capacity in pipeline and the APAC region alone, is responsible for 40% of planned capacity to 2025, according to EICDataStream. Greatest solar potential can be observed in the Middle East and North Africa (MENA) and Sub-Saharan Africa (SSA) regions yet are among regions that have historically slow adoption of solar PV and together are planning just 10% of the planned capacity pipeline for start-up to 2025. Despite this, we are seeing significantly large projects come out of MENA and SSA, often driven by foreign investment. It is worth noting that much of the analysis for planned projects and those under development will have an upper limit of up to 2025 due to the short timescales on the development of solar PV projects as well as the line of sight of projects being announced.

Global solar potential

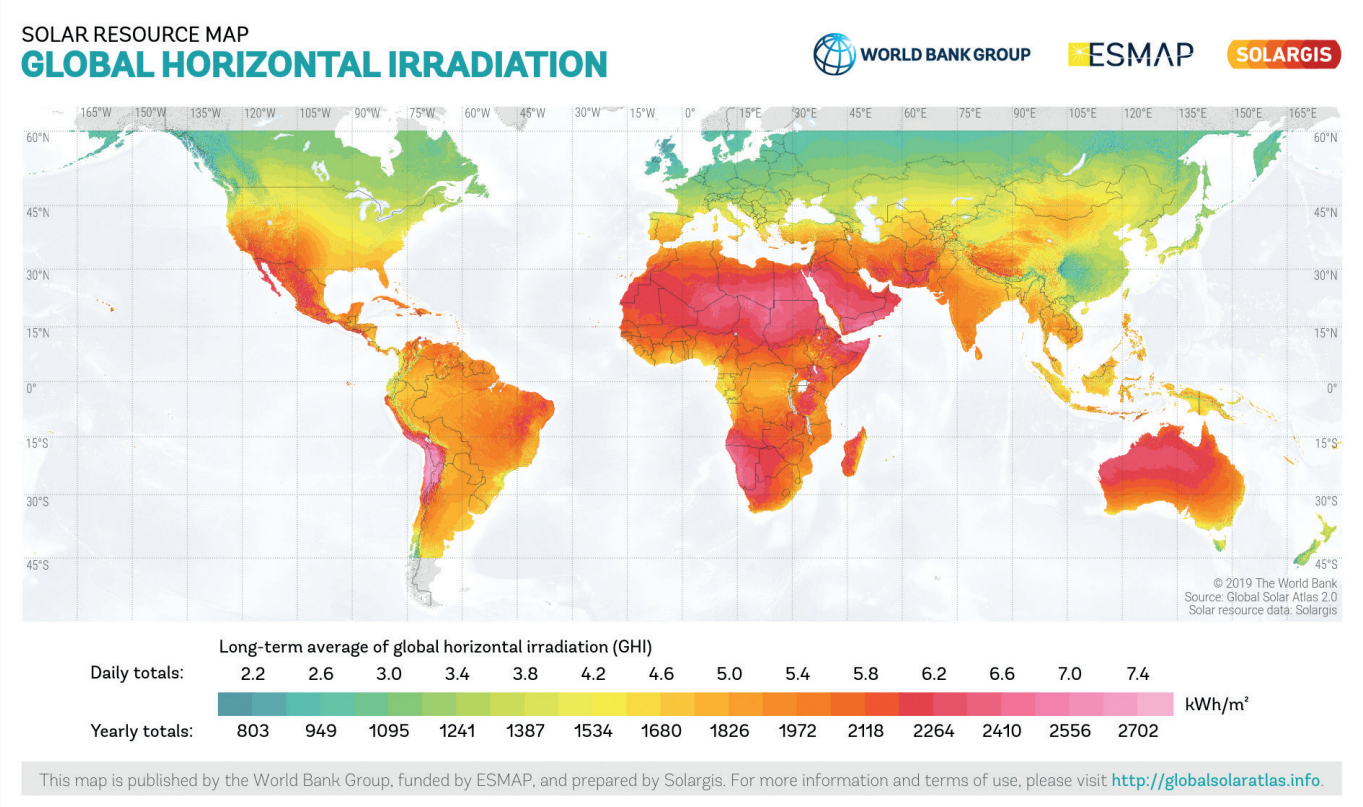

Figure 1.1. Global solar potential © The World Bank Group

Source: Solar Gis

Solar PV capacity in planning and development to 2025 by region

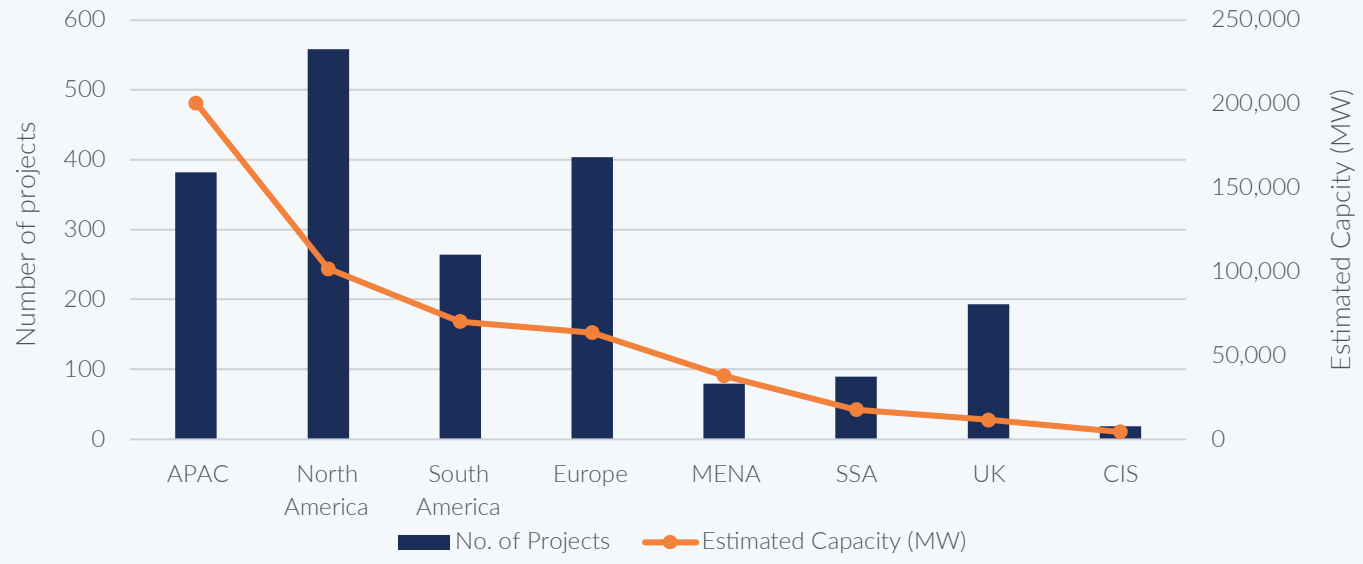

Figure 1.2. Solar PV capacity in planning and development to 2025 by region.

Source: EICDataStream

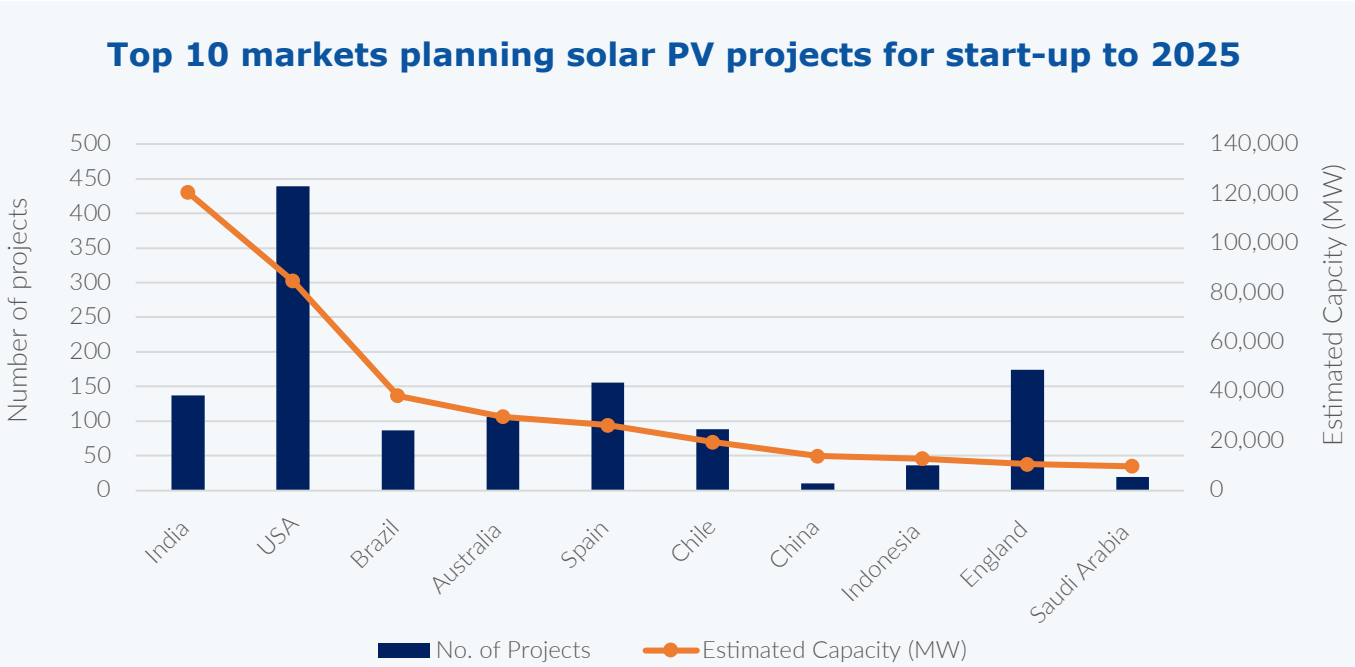

Figure 1.3. *Top 10 markets planning solar PV projects for start-up to 2025*

Source: EICDataStream

According to EICDataStream, North America and Europe are leading in the number of projects whereas the APAC region is leading in estimated capacity with just over half of the region's estimated pipeline of capacity attributed to India alone who has over 120GW of solar PV capacity planned or in development. India's solar PV ambitions are evident with the government announcing a 500GW of total non-fossil capacity and net zero emissions by 2070 during COP26 in 2021. Other APAC countries amongst the top ten markets include Australia who is pursuing green hydrogen ambitions and Indonesia who is aiming to develop solar PV to meet increasing electricity demand. The USA is a key market as the country is rapidly increasing its renewable energy capacity. The current Biden administration announced ambitions to meet 40% of total electricity demand with solar power by 2035, and the recent passing of the Inflation Reduction Act in 2022 which aims to support renewable energy adoption via tax credits and other incentives. In Europe, Spain are a leading market and a key market globally who are contributing to the European Commission's increased renewable energy target to 45% by 2030 as outlined in the REPowerEU Plan, whilst the region responds to the energy crisis as a result of Russia's ongoing invasion of Ukraine. Globally, political support is a key driver in solar PV adoption with various strategies and incentives such as auctions, contracts for difference and feed-in tariffs supporting capacity growth. In this report, insights on key regional markets as well as leading operator and contractor trends will be explored, highlighting the significant growth of the sector.

02 ——

United Kingdom (UK)

The UK solar PV power market is to make a resurgence and is expected to grow following energy targets established in the 2022 Energy Security Strategy: 70GW by 2035. In the UK, current operational capacity of utility scale projects is over 6.6GW – of which 1.7 GW capacity in large-scale and utility plants with 30 MW and greater capacity is operational – according to EICAssetMap. However, over the next six years, the pipeline of opportunities is sizeable. Should announced projects proceed, over 11GW of solar PV capacity could become operational by 2025. This growth in the solar PV market can be attributed to evolving government policies and pressure to meet power demand using renewables sources to decrease current dependency of fossils fuels to thus decrease carbon footprints. The declining cost of solar PV technologies has made them cost competitive with fossil fuel sources and the return of subsidy mechanisms such as the Contracts for Difference (CfD) scheme will continue to drive the solar PV power market. Contrastingly, slow adoption of utility scale solar PV plants, lack of new initiatives and permitting issues are expected to hinder growth in the coming years.

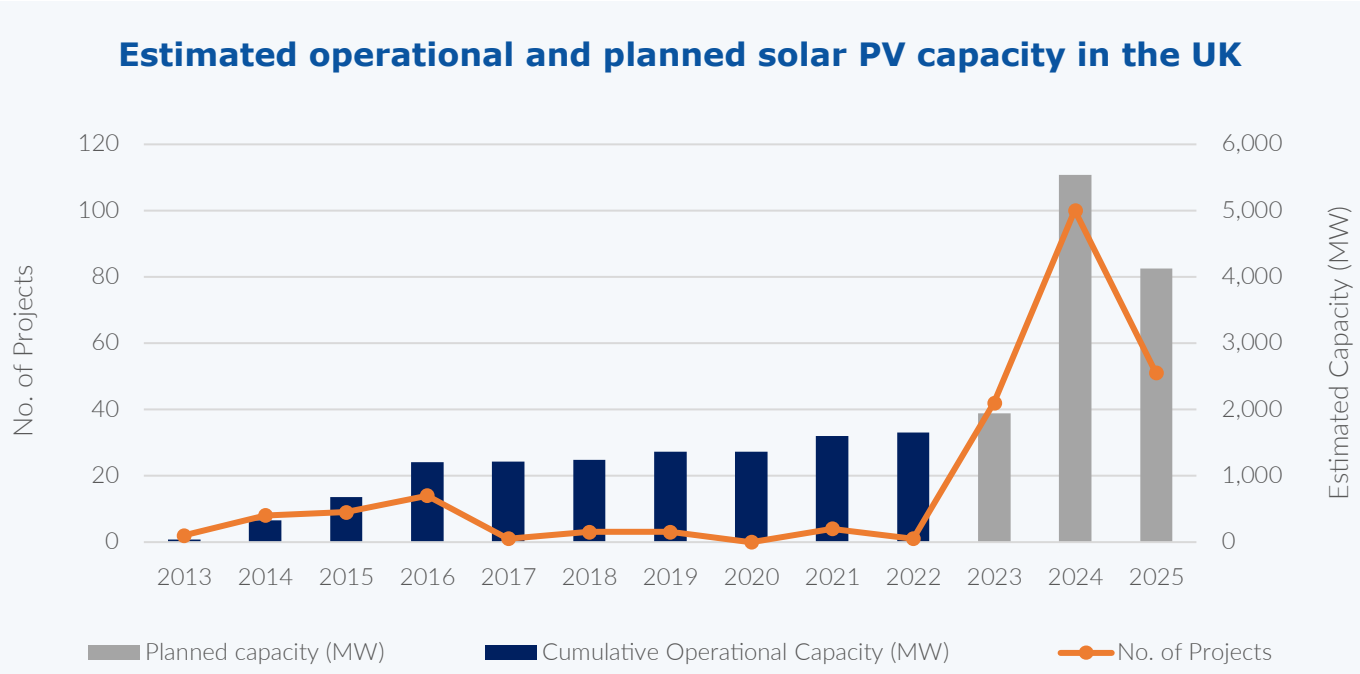

Figure 2.1. *Estimated operational and planned solar PV capacity in the UK*

Source: EICDataStream

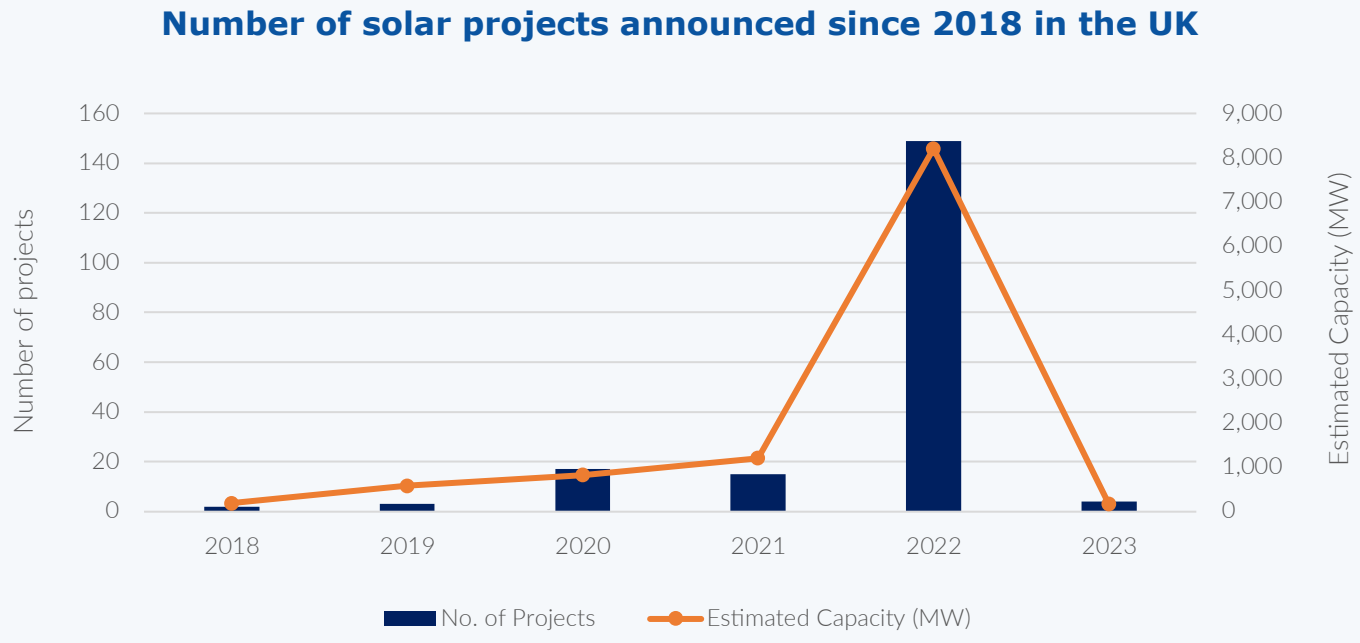

Figure 2.2. *Number of solar projects announced since 2018 in the UK.*

Source: EICDataStream

Strategy/ policies	Period	Target/purpose	Outcome
Renewables Obligation (RO)	2002–2017	Previously one of the main mechanisms for large utility scale renewable electricity projects. Required electricity supplier to source increasing share of electricity they supplied from renewable sources	Reforms in policy namely the Energy Act in 2013 which introduced the Contracts for Difference Scheme as a cheaper alternative to incentivising renewable capacity
UK Solar PV Strategy	2014–2020	20GW solar PV capacity by 2020	Target not met by previous coalition government nor carried forward into current governmental strategy
British Energy Security Strategy	2022–	70GW by 2035	Improvements required in permitting process and network infrastructure to enable ramp up in capacity
Net Zero Strategy	2021–2050	Net zero by 2050	More clarity required in enabling policies; CfD scheme for example

Table 2.1. *Summary of UK policies supporting solar PV*

After the exclusion of solar PV from CfD auctions following the first round in 2015 as well as the closure of the RO in 2017, solar PV capacity growth has been stunted. According to EICAssetMap, just over 400MW of utility scale solar PV capacity came online between 2019 and 2022 with only one 50MW project entering operation in 2022. According to the Renewable Energy Planning Database, over 30 projects have received planning permission including developments by operators like Enso Energy and Elgin Energy in 2022. Yet no projects that have been granted permission came into operation that year. It is expected that by 2025 more projects will become operational, as clarity is expected for policies to enable governments 70GW capacity target by 2035.

In April 2022, BEIS released the British Energy Security Strategy as a long-term solution to the energy crisis. The policy came at a time where the post-Brexit and post-pandemic economy was facing very volatile energy prices which have also been pushed higher with Russia's invasion of Ukraine. Despite political instability during the second half of 2022, government plans to ramp up deployment for roof and ground appear to still be in action. With intermediate goals including to update planning documents by 2023 and enabling improvements in network infrastructure by 2024, the Strategy highlighted methods to deployment with particular focus on annual CfD auctions. Separately, the strategy highlights the ambition for up to 1GW of electrolytic green hydrogen capacity by 2025; it is therefore predicted that a ramp up in renewable capacity will be observed as green hydrogen production utilises energy produced by onshore wind and solar PV.

In October 2021, BEIS published the UK's Net Zero Strategy, with the ultimate aim of ensuring that the UK hits its net zero emissions target by 2050. As part of the strategy, the government identified the need to prioritise critical system enablers; the Contracts for Difference (CfD) scheme is an example of one of these enablers. Aside from the CfD scheme, the government has also acknowledged the need to ensure that the planning system has the capacity to support the deployment of low carbon energy infrastructure. This is intended to be achieved by updating the Energy National Policy Statements (NPSs).

National Policy Statements

Energy-related National Policy Statements (NPSs) set out the national policy and form the framework for decision-making on applications for development consent under the 2008 Act for energy-related Nationally Significant Infrastructure Projects (NSIPs). Of these NPS, EN-3 covers renewable energy infrastructure. The existing EN-3 NSP does not refer to solar generation specifically; whilst being promoted under the NPS, this has led to developers of utility scale solar PV projects (over 50 MW in England and over 350 MW in Wales), to follow a prolonged route to gaining planning permissions.

Changes to energy NPS are expected in 2023 with a BEIS consultation currently underway at time of writing which will propose changes to NPSs to provide greater clarity on the need and urgency for low carbon infrastructure. When determining applications for development consent, the draft NPS EN-1 establishes that the Secretary of State, should assess the planning consent application on the basis that the government has already established that there is an urgent need for those types of infrastructure referred to in the document. Currently solar PV farm developers are required to produce their own statements towards making a case for the solar PV technology being a technology of urgent need; changes to the EN-1 now pre-establishes solar PV as a technology of urgent need, which will discontinue solar PV farm developers producing their own statements.

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Proposed changes to the NPS include making additions to EN-3 which will provide specific guidance on solar PV and provide a much stronger basis for promoting the pipeline of utility scale solar PV farms expected over the next five years. The proposed new guidance will make clear the different types of panel layout and technology used such as: south-facing, east-west or tracker etc. and acknowledge that the final design may not be known pre-consent. Provision will also be made for the potential use of energy storage instead of panels, where viable.

Additionally, the guidance will set out site selection criteria which will impact the determination of development consent and will include factors such as environment and biodiversity impacts (and to also include the potential to make net gain), landscape and visual impacts (including glint and glare), and land use and heritage considerations. The guidance will also clarify that the combined capacity of the installed inverters on solar PV sites (to be measured in AC) should be used to determine the capacity thresholds for solar PV projects and in turn, determines the size of projects which can be considered at local authority level rather than through the NSIP route (under Section 15 of the 2008 Act). This draft proposal, whilst promising, makes it clear that developers will need to be flexible throughout the process, and in the final design consented by the DCO (Development Consent Order). Once the policy is implemented, we can expect to see refinement of the solar PV guidance in EN-3 and therefore the easier implementation of solar PV projects.

In the April 2022 Energy Security Strategy, amendment of National Policy Statement was a priority within the planning system however with focus to assist in offshore wind deployment. Further clarity is required on the impact of amended NPS solar PV development.

Contracts-for-Difference scheme

Two of the five projects that had been allocated capacity in the first round of the Contracts for Difference (CfD) scheme eventually failed as they were considered uneconomical. The market was seen as well-established and had all the government support it required, which resulted in the exclusion of the solar PV technology until 2021. Industry bodies questioned the exclusion of solar PV from the Contracts for Difference scheme which had led to a subsidy-free UK solar market between 2016 and 2021. Consequently, we have seen stunted growth of the UK solar PV market. It is only due to the falling costs of operation for solar PV over the last decade has there been implementation of some solar PV capacity since 2016; solar PV (as well as onshore wind) has become one of the lowest cost renewable solutions with their costs associated continuing to fall.

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The UK government announced the fourth round of the Contracts for Difference (AR4 CfD) scheme in December 2021 which will provide support of £285 million (USD $368 million/EUR 311 million) per year for renewable electricity generation projects between 2023 and 2027. Consisting of three pots, AR4 saw the return of solar PV and onshore wind competing in Pot 1 after a four-year hiatus, and a cap of 3.5GW imposed on both onshore wind and solar PV capacity. Along with this announcement, the government plan to auction capacity via the CfD scheme annually which could significantly increase renewable and solar PV capacity.

Of the 11GW awarded in renewable and low carbon technology capacity, over 2.2GW of solar PV capacity was secured at a price of £45.99/MWh in the round after results were announced in July 2022. A total of 66 solar projects secured contracts with capacities ranging from 6MW to 112MW. The results were a clear market indicator to future developments and investors over the next decade. Those who are awarded contracts are, to an extent, risk free and CfDs have proven to be an additional route to market aside from PPAs. However, this poses a question; with the falling costs associated with solar PV, how developers will continue to make profits? Perhaps a business model more reliant on PPAs is the mid to long-term solution to make solar PV development profitable whilst the large and utility scale market matures.

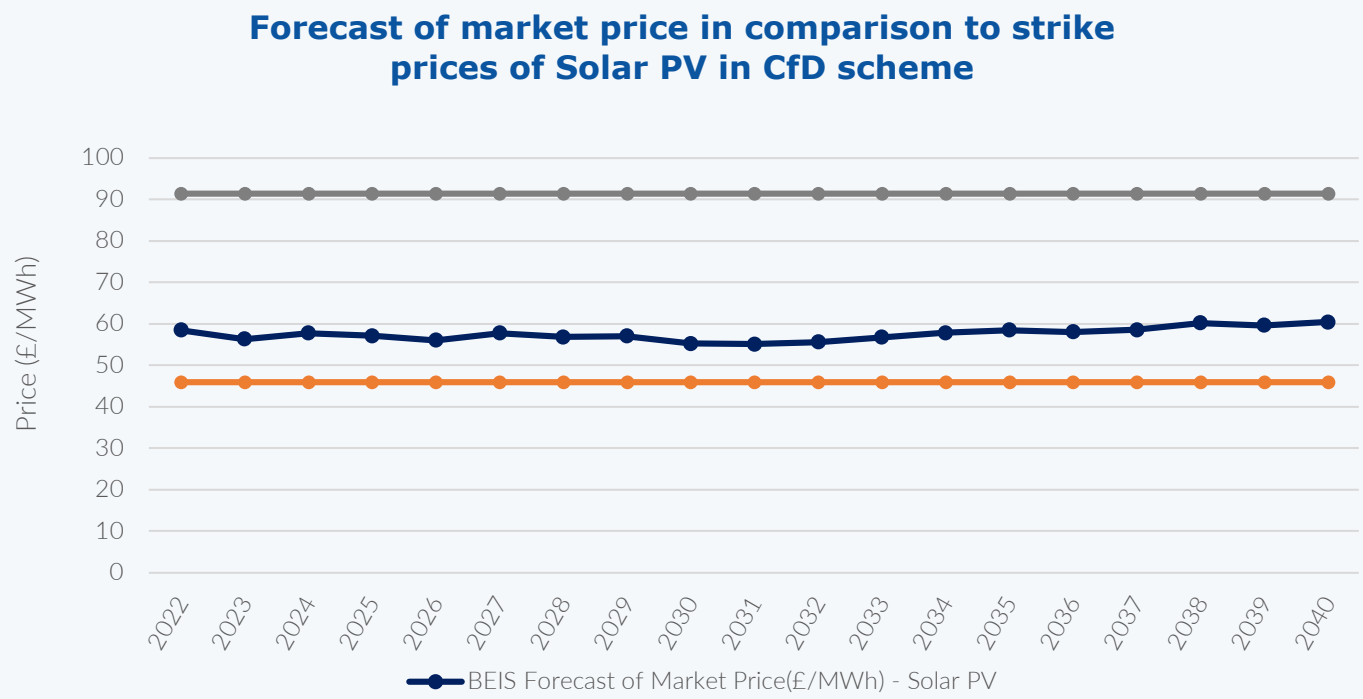
	Allocation Round 1 (AR1) 2014-15				Allocation Round 4 (AR4) 2021-22			
Technology Type	Pot	Administrative strike price (£/MWh)*	Clearing price (£/MWh)**	Capacity awarded (MW)	Pot	Administrative strike price (£/MWh)*	Clearing price (£/MWh)**	Capacity Cap (MW)
Energy from Waste (with CHP)	1	80	80	94.75	1	121	45.99	30
Offshore Wind	2	148	117.14	1162	3	46	37.35	6994.34
Floating Offshore Wind			N/A		2	122	87.3	32
Onshore Wind	1	93	80.58	784.55	1	53	42.47	887.96
Solar PV	1	115	76.41	71.55	1	47	45.99	2209.41
Tidal Stream	2	305	N/A		2	211	178.54	40.82

Table 2.2. *Comparing strike prices for some technologies in Allocation 1 (AR1) and Allocation Round 4 (AR4).*

**Estimated for applicable delivery years (Round 1; 2014-15, Round 4; 2023-2027)*

***Average cost of Round 1 and Round 4 outcome for applicable delivery years (AR1: 2014-2019; AR4 (2023-2027).*

NB: AR1: Pot 1 for established technologies, Pot 2 for less established technologies, Pot 3 for biomass conversion. AR4: Biomass conversion is excluded from CfD AR4 and future bid rounds; Pot 3 was replaced by Offshore Wind as a result. Remote Island Wind and Floating Offshore Wind were introduced to the CfD scheme as separate technologies in AR3 and AR4, respectively.



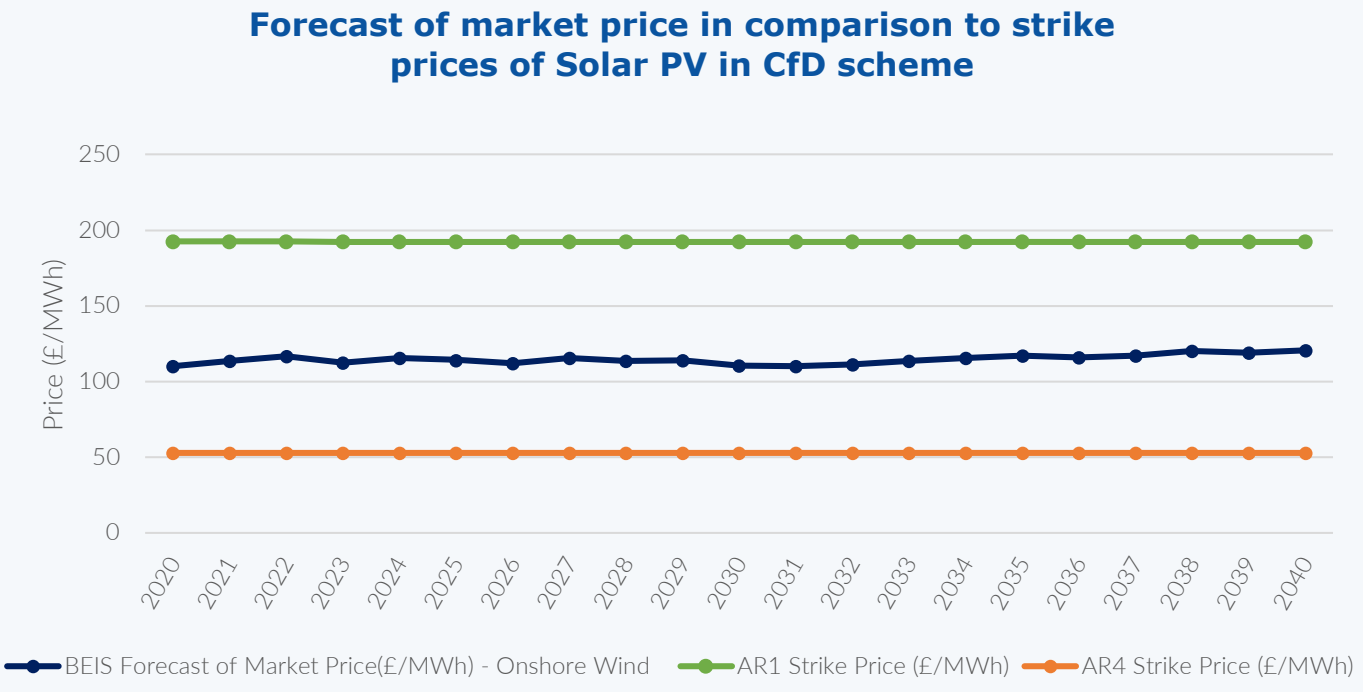


Figure 2.3. *Comparison of forecasted market price and strike price predicted for solar PV (A) and onshore wind (B)*
Source: Low Carbon Contracts Company (LCCC) and BEIS.

Onshore Wind vs Solar

Consisting of three pots, offshore wind capacity was allocated in its own pot (Pot 3) and will receive much of the CfD budget – £200million per year – with almost 7GW in capacity being awarded. A total of £55 million per year will go to Pot 2 which has been reserved for emerging technologies such as wave, tidal and anaerobic digestion projects with at least 5 MW of capacity and no capacity cap, and of which will ringfence support of £24 million for floating offshore wind projects. Of the Pot 2 technologies, over 650 MW of capacity was awarded to tidal, floating offshore wind and remote island wind projects. Pot 1 with a capacity cap of 5GW, consisted of for established technologies, such as hydro and energy from waste; over 3GW of solar PV, onshore wind and energy-from-waste capacity have been awarded and will be funded with £10 million per year.

Since the initial round in 2015, there hasn't been a Pot 1 auction for established technologies. The third round in 2019 saw a success of funding for 5.8GW of projects, with the majority being allocated to 5.5GW of offshore wind. Onshore wind capacity peaked in 2017, then followed with a resurgence in 2019 with support for onshore wind on remote islands. The situation for solar PV projects appeared more dire; having been locked out of CfDs since 2015, and the closure of the Renewables Obligation in March 2017, subsidies and support for large scale deployment had been halted. However, now with this fourth round, we can look forward to steady growth for both technologies, especially solar PV.

Staunch supporters of UK solar PV welcomed the government's decision to allow solar PV and onshore wind back into the CfD scheme. In this current round, the administrative strike prices predicted, placed solar PV amongst the cheapest technologies in the scheme – and the cheapest in Pot 1. With the costs of solar PV and onshore wind continuing to fall, these two technologies can drive the decarbonisation of the UK energy market at scale, whilst being cost-effective for consumers too. The strike price is generally in line with market prices; arguably, a CfD contract could be seen as not necessarily representing a subsidy. Instead, the benefit of the CfD scheme for solar PV is the reduction in market risk which in turn enables investors to achieve reduced CAPEX and therefore bringing down cost for consumers. In the long term, the steadying of the market price will hence strike confidence and build greater certainty for investors in the cost of solar PV and the price they will receive for future generations.

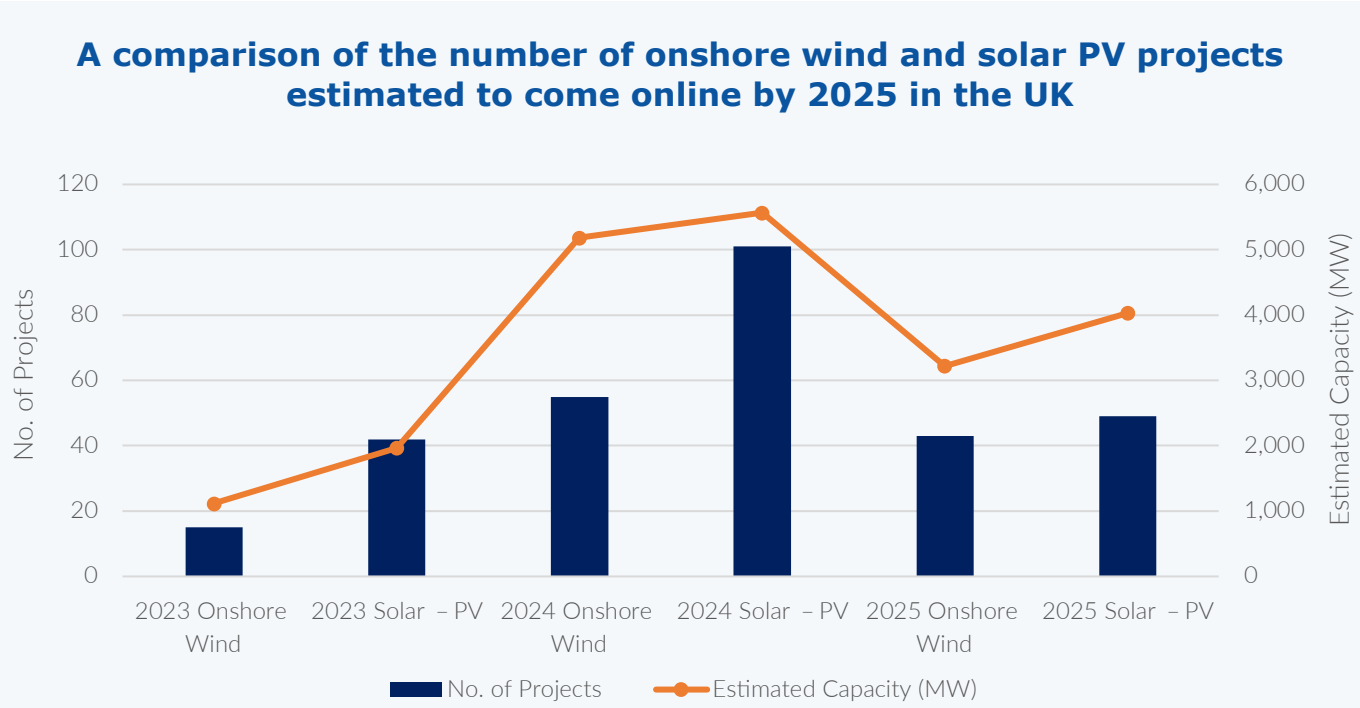


Figure 2.4. A comparison of the number of onshore wind and solar PV projects estimated to come online by 2025 in the UK.
Source: EICDataStream

Figure 2.4 compares the estimated capacity for onshore wind and solar PV projects for start-up by 2025. Of the projects announced so far, over 11.5GW of solar PV and over 9.5GW of onshore wind capacity is predicted to come online by the end of 2025. Following recent political instability, the new Prime Minister, Rishi Sunak, has been known to support renewables unlike his predecessor. Additionally, the passing of an Energy Bill has been paused though that is likely to be passed in the next year which could improve planning and permitting processes as outlined in the Energy Security Strategy. It is therefore likely, that onshore wind and solar PV capacity will ramp up towards the end of the decade if these permitting processes are improved as well as if solar PV continues to be awarded subsidies in the CfD scheme.

With increased interest in maximising UK solar potential, the UK solar PV market is beginning to gather momentum, once again. According to EICDataStream, over 11GW of solar PV capacity additions are currently in development or proposed for development. By the end of 2023, almost 2GW in solar capacity is predicted to come online in the UK – solar projects have short delivery timescales with even larger scale projects being able to begin supplying power to the grid within six months of construction, which makes them attractive for developers looking for quick deployment of renewable energy. The most recent CfD round saw over 2.2GW of solar project capacity be awarded contracts many of which were utility scale projects. Quinbrook Infrastructure Partners' 350MW Cleve Hill (or Fortress) Solar PV project gained a CfD contract supporting 112MW of its total capacity, making it the first nationally significant solar farm to gain a CfD contract.

Figure 2.5 shows the top operators in the UK and Figure 2.6 is a geographical summary of key projects that are in planning. JBM Solar are a leading operator in the UK who are developing over 1GW of solar PV projects in the UK. In the most recent CfD round (AR4), the company was awarded CfD contracts for over 300MW in solar PV project capacity of the 2.2GW total capacity awarded in solar PV. JBM have an ambition to deliver grid-connected solar projects by 2025 in the UK. Enso Energy are another major player in the UK market who targeting 1 GW of subsidy-free solar capacity in England and Wales in a joint-venture agreement with Macquarie's Green Investment Group (GIG). According to EICDataStream, Enso Energy alone is planning almost 1GW of solar PV capacity and is developing projects such as the 50MW Warpole Bank solar project which was successful in securing a CfD contract in the most recent auction, as well as the 160MW Alaw Mon Solar PV project in Anglesey, Wales.

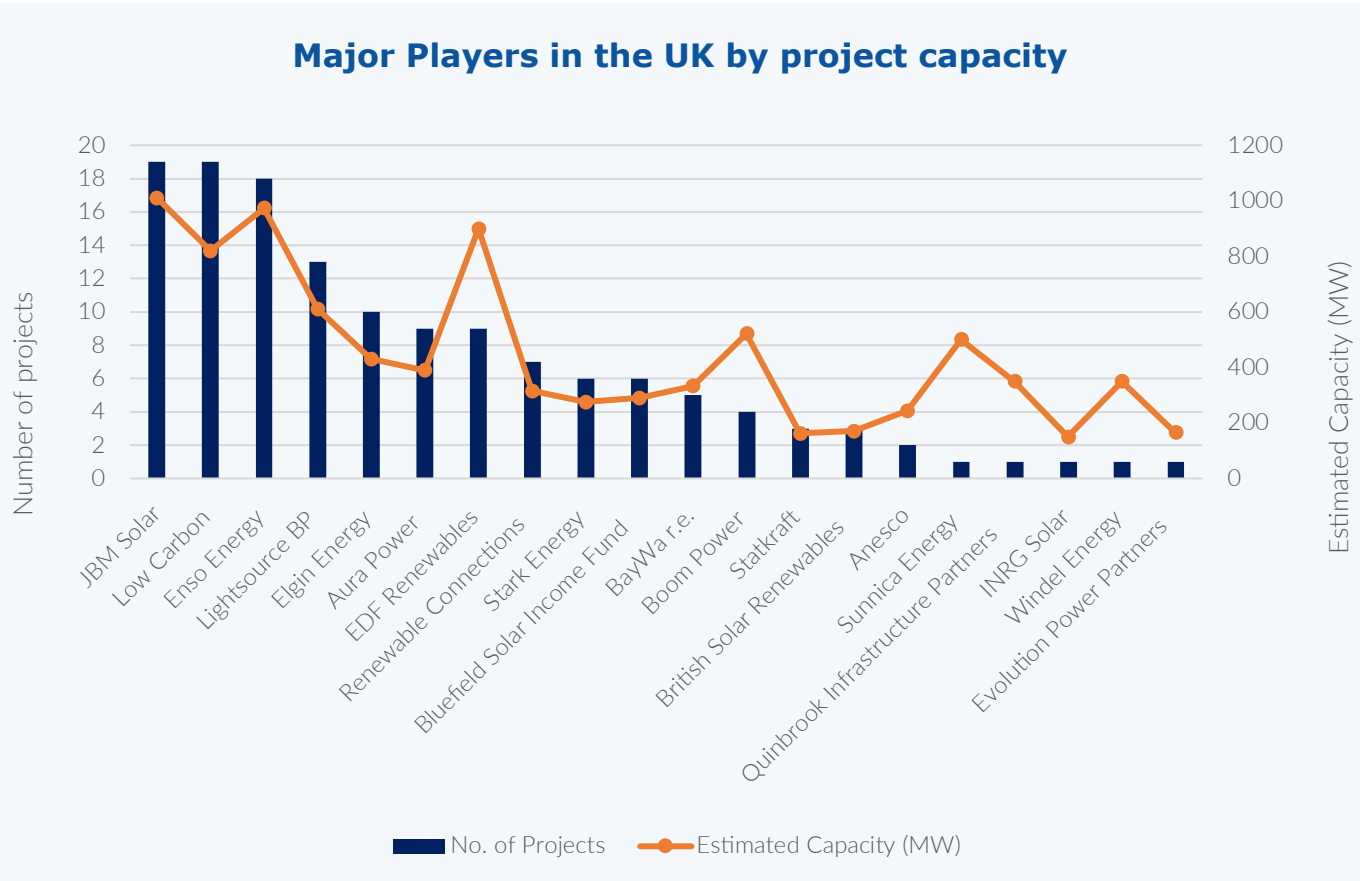


Figure 2.5. *Major Players in the UK by project capacity.*

Source: EICDataStream

Map of UK projects

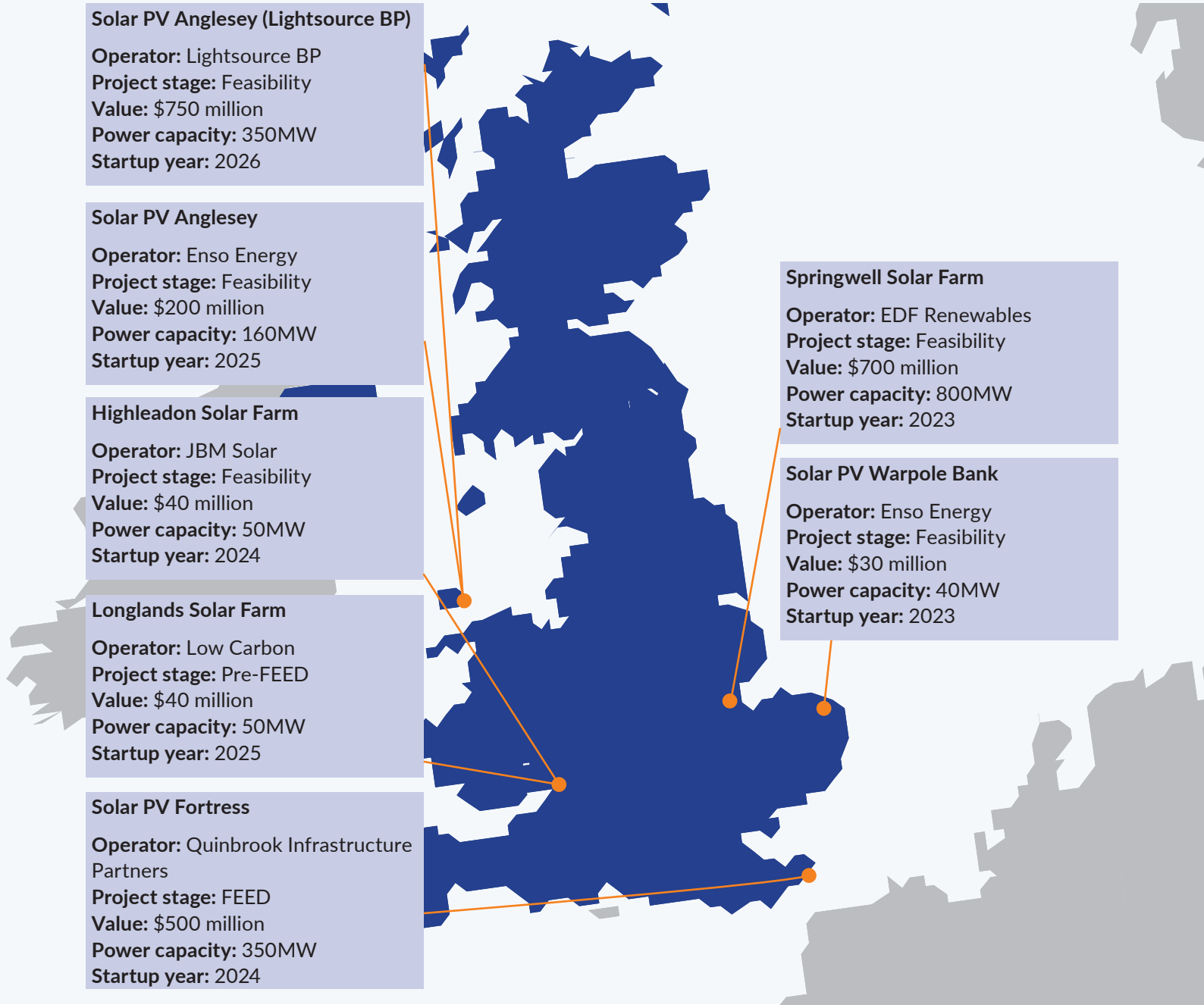


Figure 2.6. Summary of key projects and major players in the UK.

Source: EICDataStream

EDF Renewables is developing around 900MW of solar PV capacity across nine projects which is contributing to their ambition in growing their renewable business. EDF Renewables' "Plan for a Green Recovery" is a £50 billion low carbon programme to help the UK government achieve net zero, which aims to bring approximately 12GW of wind, nuclear and solar generating capacity by 2035. This would effectively meet 20% of UK energy demand; that being said, EDF plans to meet 14% of UK energy demand with nuclear energy alone. According to EICDataStream, EDF Renewables is currently proposing developments with over 1GW in onshore and offshore wind capacity alongside its 900 MW solar PV pipeline.

In December 2017, BP and Lightsource Energy announced BP's USD$200 million investment into Lightsource for a 43% stake and two years later purchased additional equity to become an equal partner in Lightsource BP. Following the merger with the oil giant, Lightsource BP have over 600MW of solar PV capacity across 13 projects planned in the UK which is part of their wider global capacity to develop 25GW of solar PV projects by 2025. In the most recent CfD round, Lightsource secured contracts for three projects with a combined capacity of almost 150MW.

2.1 Analyst Opinion

The UK solar sector has bounced back well after the impacts of Covid-19 and has made good progress, and we have seen that the country is gradually increasing installed solar capacity each year. Going forward we expect now to see that the UK should easily deploy a minimum of 1GW of solar every year and assuming there won't be any major roadblocks the UK is predicted to see 2-3GW in 2024. Although to reach the target of 40GW of solar capacity by 2030 this means an average of just over 3GW each year, which the UK very much has the capability to achieve. From the analyst's perspective in 2022 alone there have been more than ever before of solar projects being introduced by major developers, such as EDF, Lightsource BP, BayWa r.e. and Elgin Energy, and have mostly gained planning consent from their local authority or the Planning Inspectorate upon which it becomes relatively quick to start producing electricity from construction, all this with the support of subsidies such as the Contract for Difference in the future shows that the market is very attractive. When it comes to where the work is being done, we see that local companies are being contracted such as Anesco and BELECTRIC as EPC, but with OEM, supply mostly comes from China as it is a cheaper option alongside the fact that solar panel manufacturing is mostly based there. With solar being the cheapest form of renewable energy and the country's aim to reduce its reliance on oil and gas we expect to see solar be a huge part in the energy mix.

Nabil Ahmed, Energy Analyst

03 ——

Global markets

According to EICDataStream, over 63 GW of solar PV capacity is planned and under development in Europe (excl. the UK) with predicted start up by 2025, making Europe a major global solar market. There is steady growth over the next couple of years as more projects are announced as shown by Figure 3.1.2.

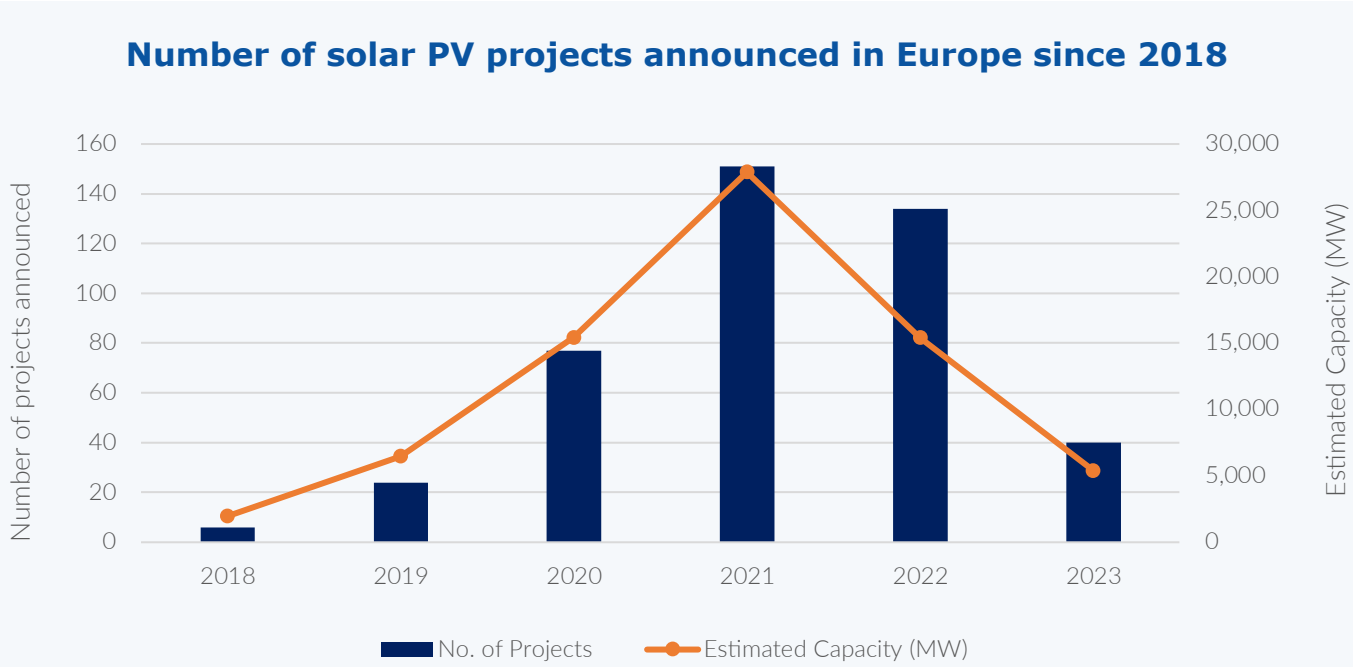


Figure 3.1.1 *Number of solar PV projects announced in Europe since 2018.*

Source: EICDataStream

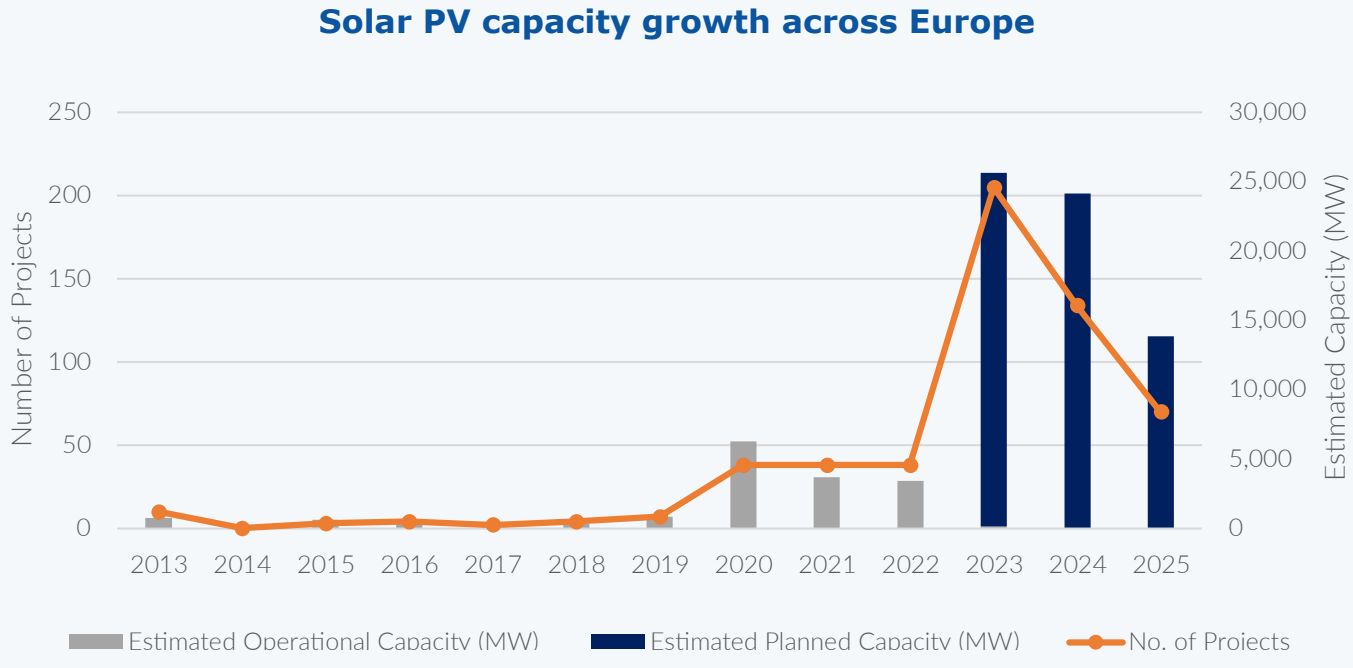


Figure 3.1.2. *Solar PV capacity growth across Europe.*

Source: EICAssetMap and EICDataStream

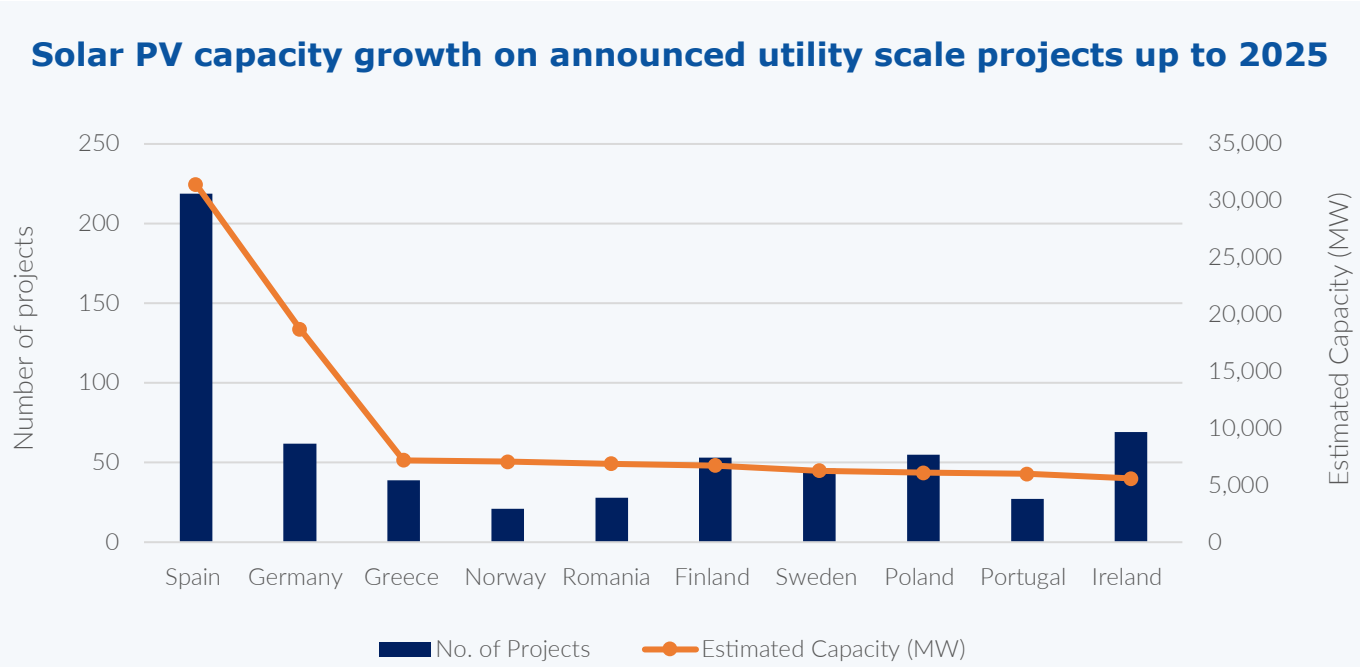


Figure 3.1.3 *Solar PV capacity growth on announced utility scale projects up to 2025 (Top 10 markets).*
Source: EICDataStream

With an estimated CAPEX of over USD$55 billion for the development of utility scale-solar PV to 2025, the region is clearly moving towards the decarbonisation and electrification of the energy sector. Figure 3.1.3 demonstrates the top ten countries in Europe that are planning to develop solar PV capacity. Germany is amongst the leading markets in the region with an estimated operational capacity of almost 60 GW according to BSW, Germany's leading solar association, though this is inclusive of residential solar. From the above figure it can be seen that Spain is leading in planned utility scale solar PV development. With over 26 GW currently estimated to come online by the end of 2025, Spain has high ambitions to tap into its solar potential. Greece is a noteworthy emerging market with over 5 GW of solar PV capacity predicted to come online by 2025 as the country begins to phase out coal power. Another emerging solar market, which has previously faced difficulties, is Ireland. A nascent market with policy in development and an auction mechanism to facilitate solar PV, Ireland is attracting investment and planning over 2 GW of solar PV by 2025.

The European Union

Many of the 27 countries of the European Union (EU) are seeing greater penetration of solar PV in their energy mix. The European Green Deal and the REPowerEU Plan have recognised energy generated from solar power as a key component in the EU's transition to clean energy. The deployment of solar energy is picking up pace and is contributing to reducing the EU's dependence on imported fossil fuels and protecting consumers from volatile energy prices. As part of the REPowerEU Plan, the EU released its Solar Energy Strategy in May 2022. The Strategy outlines initiatives to accelerate solar deployment in EU countries and is aiming to bring online over 320 GW of solar PV by 2025 (including residential and commercial scale) and around 600 GW by 2030. Development of the energy source is highly competitive in the EU and policies established over the last decade have assisted in bringing PV costs down by over 82%. The Strategy proposes initiatives to assist in accelerating rooftop solar deployment as well as promoting the development of a skilled workforce in the solar sector.

Europe has committed to becoming a climate neutral continent by 2050 which is further complicated by energy security challenges the region faces. Supply chain bottlenecks have formed as a result of Russia's invasion of Ukraine and the subsequent ambitious targets announced to ensure security of supply and to replace Russian imports of gas. With this ramp-up in targets (See Table 3.1.1) many markets are scaling up solar capacity at an accelerated pace, more than what grids can handle which is resulting in curtailment – stopping of power generation – in some markets as the European energy storage market has yet to mature.

As well as the much-needed incorporation of energy storage, the length of current permitting processes still exceeds the EU limit of two years in many EU countries and will need to be shortened to reach committed targets for solar PV capacity on time. That being said a temporary emergency framework was passed in November 2022 by the European Commission to accelerate permitting processes and deployment of renewable energy as a response to the energy crisis. Member states have agreed that the permit-granting processes would not exceed three months and that grid connection permitting processes are also not to exceed three months. This is a temporary regulation and is expected to last one year, though it does highlight that in order to enable scale up of solar PV capacity at a quickened pace, permitting processes, particularly grid permission, will need to be streamlined by grid operators particularly as the region prepares for the switch to 100% renewables in the long term.

Country	Clean Energy Ambition	Solar Capacity target
European Union (EU)	At least 32% Renewable Energy Share in energy mix (RES) by 2030*	320 GW by 2025; 600 GW by 2030**
Spain	160 GW of total installed renewable capacity by 2030, 74% RES by 2030 and 100% by 2050	30 GW solar by 2030
Greece	80% RES by 2030, 28 GW + 7 GW storage	Previous NECP aimed for 19 GW renewables by 2030 of which 7.66 GW was solar; this has now increased
The Netherlands	100% clean power by 2030; 97% RES by 2030	Net zero by 2050
Portugal	80% RES by 2026	6.6 GW by 2025; 9 GW by 2030
Germany	80% RES by 2030 and 100% by 2035	22 GW solar PV additional capacity per year to reach 215 GW by 2030 over ground and rooftop installations
Romania	30.7% RES by 2030 (looking to increase)	3.7 GW of solar PV capacity
Italy	55% RES by 2030	50 GW solar PV by 2030
Poland	Climate neutrality by 2050, EU's RED targets: 32% RES in final consumption by 2030	5-7 GW of solar PV by 2030, 10-16 GW by 2040
Ireland	80 % RES by 2030 (was increased from 70% in 2021)	1.5-2.5 GW by 2030 (increased from 0.4 GW in CAP19)
France	EU's RED target of 32% in final consumption and 40% RES in electricity production, 38% RES for heating consumption by 2030. Aiming to reach up to 100 GW of installed renewable power by 2030.	Small scale solar ambitions
Denmark	100% renewable production by 2050. NECP indicates a 55% share of renewable energy in gross final consumption of energy by 2030	Quadruple solar capacity by 2030 though a specific capacity value has not been specified
Macedonia	46% RES by 2025 ~1.5 GW by 2025	400 MW in rooftop PV by 2040
Albania	42% RES by 2030	Previously set target of 490 MW solar PV by 2020; projects between 280 and 770 MW until 2030
Bosnia-Herzegovina	RED target	N/A
Hungary	Energy Strategy indicates country will reach 20% RES in primary energy band (not binding target); though is targeting at least 32% RES (EU target) by 2030	6.5 GW by 2030, 12 GW by 2040

Table 3.1.1: *Summary of Clean Energy Ambitions and/or Solar Targets in Europe*

** REPowerEU plan proposes to amend target to 40% RES by 2030; final target to be announced in April 2023*

*** Capacity targets also include commercial and residential and REPowerEU also proposed to ramp solar target to 740 GW by 2030*

Europe's supply chain capacity appears to also be an issue – China dominates the global solar PV supply chain (See Section 4. Key Contractors) and Europe almost entirely relies on Chinese imports for the supply of solar PV panels as shown in Figure 3.4. Specialised Chinese companies provide the entire solar PV value chain for example polysilicon and solar modules which has enabled the cost of solar PV to reduce with the levelised cost of energy (LCOE) – (measures the cost of solar PV inclusive of CAPEX and OPEX) to fall around 80% between 2010 and 2019 according to IRENA. Europe has benefitted from these falling solar PV costs however the recent Ukraine conflict has brought to light the risk of relying on majority imports for energy, making it particularly sensitive to future solar PV supply chain risks. Other factors including forced labour concerns in component production has also highlighted ESG issues that European customers are increasingly worried by.

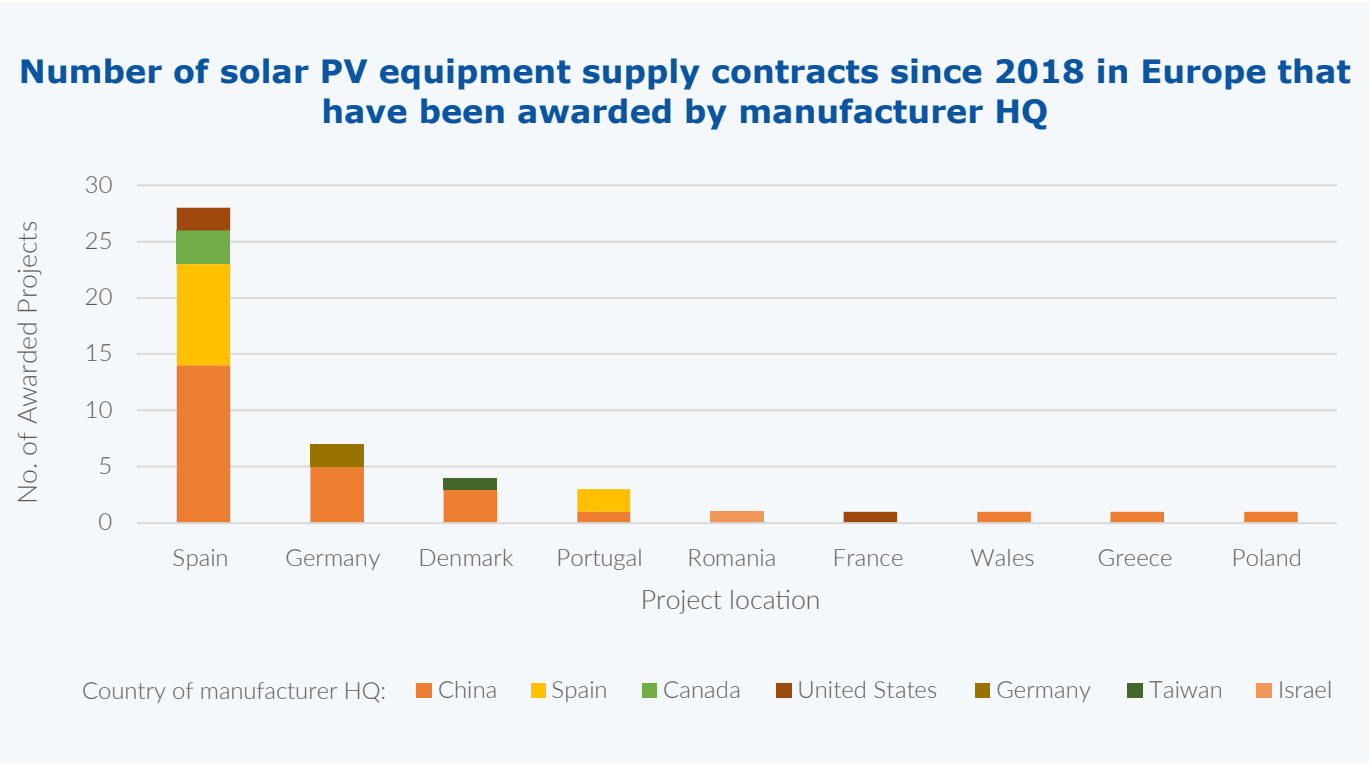


Figure 3.1.4: *Number of solar PV equipment supply contracts since 2018 in Europe that have been awarded by manufacturer HQ. Source: EICDataStream*

Because of these challenges, the EU launched the Solar Photovoltaic Industry Alliance in December 2022 to diversify supplies of solar PV products and increased its manufacturing capacity target from 20 GW to 30 GW a year of PV manufacturing across the supply chain by 2025.

European manufacturing

Some European companies are beginning to expand their solar PV capabilities within manufacturing. Enel Green Power is building 3Sun, a 3GW manufacturing facility in Italy, to produce modules and cells. The facility is part of the wider TANGO project – (iTaliAN pv Giga factOry) and is set to become Europe's largest PV module factory. The facility has a total investment of over €600 million of which over €100 million was received from the EU's Innovation Fund with the intention for the factory to be a catalyst in the relaunch of Europe's solar PV value chain. Elsewhere, Swiss company Meyer Burger are aiming to build a 4.2 GW manufacturing facility by 2025. Increased manufacturing in Europe will reduce the reliance on Chinese imports. As Figure 3.1.4 demonstrates, we are already seeing this in Spain where an increasing number of Spanish suppliers are being awarded contracts for solar PV projects, since 2018.

If the region is successful in overcoming current challenges, it has the potential to be a global leader in solar PV alongside the likes of the USA and India. That being said we will likely see a greater number of solar projects come online towards the end of the decade to meet targets set for 2030.

Figure 3.1.5 shows the top operators in the region who are planning and developing projects in the region and Figure 3.1.6 is a geographical summary of some projects by major players in Europe. Iberdrola Renewables, a subsidiary of Spanish utility Iberdrola, is leading in both the number of projects that have been announced and capacity; with over 4 GW of solar PV in the development pipeline across Spain, France, and Portugal. The company aims to install up to 8 GW of solar PV between 2023 and 2025 and is estimated to be spending over USD$3 billion in CAPEX by 2025, according to EICDataStream. The company has recently commissioned the 590 MW Francisco Pizarro project which is the largest PV plant in Europe and largest plant Iberdrola is bringing online to date. The renewable power generated from the plant will mitigate 150,000 tonnes of CO2 emissions per year. Lightsource BP are also a major player in Europe. The JV between BP and Lightsource is aiming for 25 GW of solar PV by 2025 and currently has over 1.6 GW of solar PV in the pipeline in European countries (outside of the UK) including Spain, Italy, and Portugal.

Other international major players include Endesa, Engie, and Enel Green Power who together are planning to install almost 7 GW of solar PV across Spain, Portugal, Romania, Germany, and France.

Floating Solar PV in Europe

There is a growing trend across Europe in floating solar PV and international player, Voltalia is developing a floating plant in Portugal. In Greece, PPC is a major player and is planning to bring over 1 GW of solar PV online by 2025. Much like other developers in Greece, PPC is looking into floating solar PV and is currently developing a floating solar PV complex on the artificial Polyfytos lake in the northern region of the country. The company is also leading Greece's effort to phase coal out of the national energy mix – this seemed achievable before Russia's invasion of Ukraine. These efforts have not been now dampened to allow lignite-fired power plants to replace gas flows with soaring gas prices. Elswehere, Germany company profine Energy has entered into a letter of intent to develop an up to 1.5 GW floating solar farm in Bulgaria. The company is a joint venture between engineering services provider Wirth Gruppe and PVC profiles manufacturer profine Group.

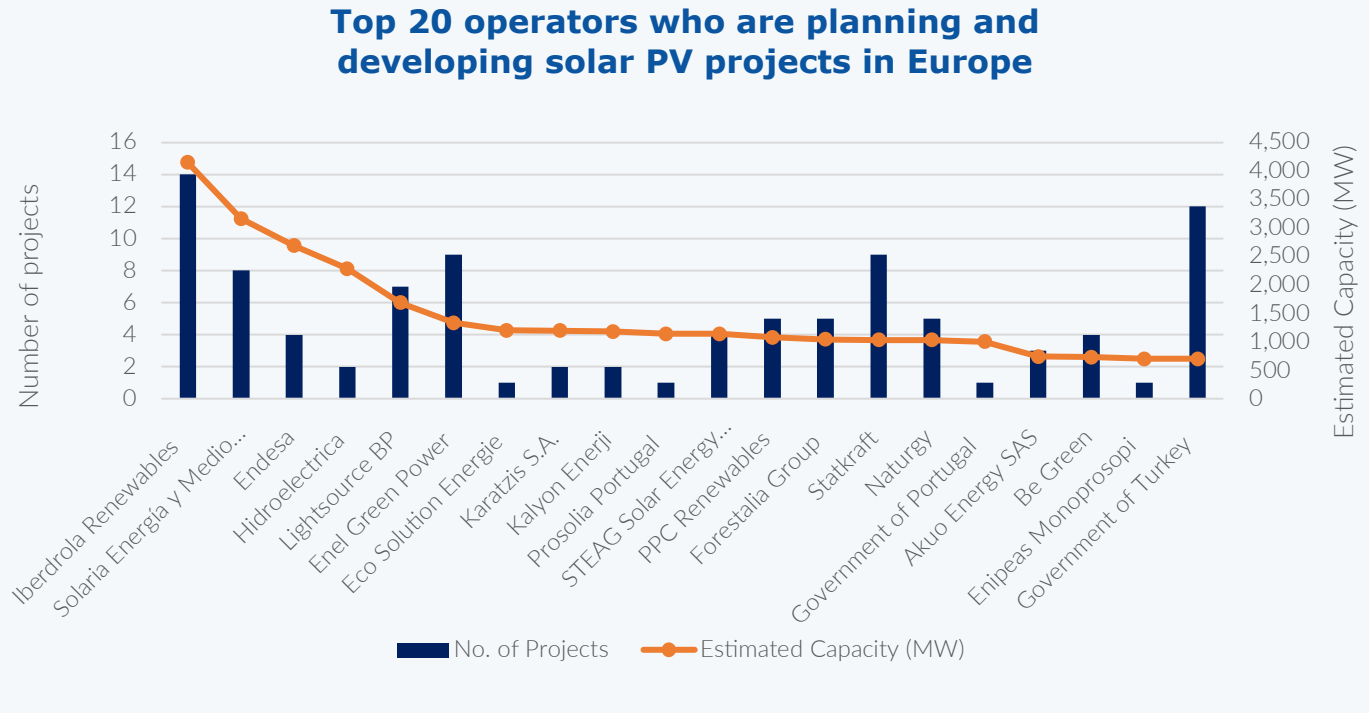


Figure 3.1.5.: Top 20 operators who are planning and developing solar PV projects in Europe.
Source: EICDataStream

Hydrogen and Solar PV in Europe

In France, Engie are developing approximately 2 GW of solar PV capacity by 2030 to assist in their hydrogen ambitions. The plants are to power green hydrogen electrolysers including for the country's first commercial scale hydrogen project, HyGreen Provence. In collaboration with the Durance, Luberon, Verdon urban area (DLVA), Air Liquide and its subsidiary Hydrogen Company, Engie proposed HyGreen Provence as a local development to decarbonise the region. Similarly, German-owned BayWa r.e. are also planning a solar PV project in France in collaboration with French green hydrogen producer, Lhyfe SA which has the potential to power a green hydrogen project that has yet to be announced.

Key European projects

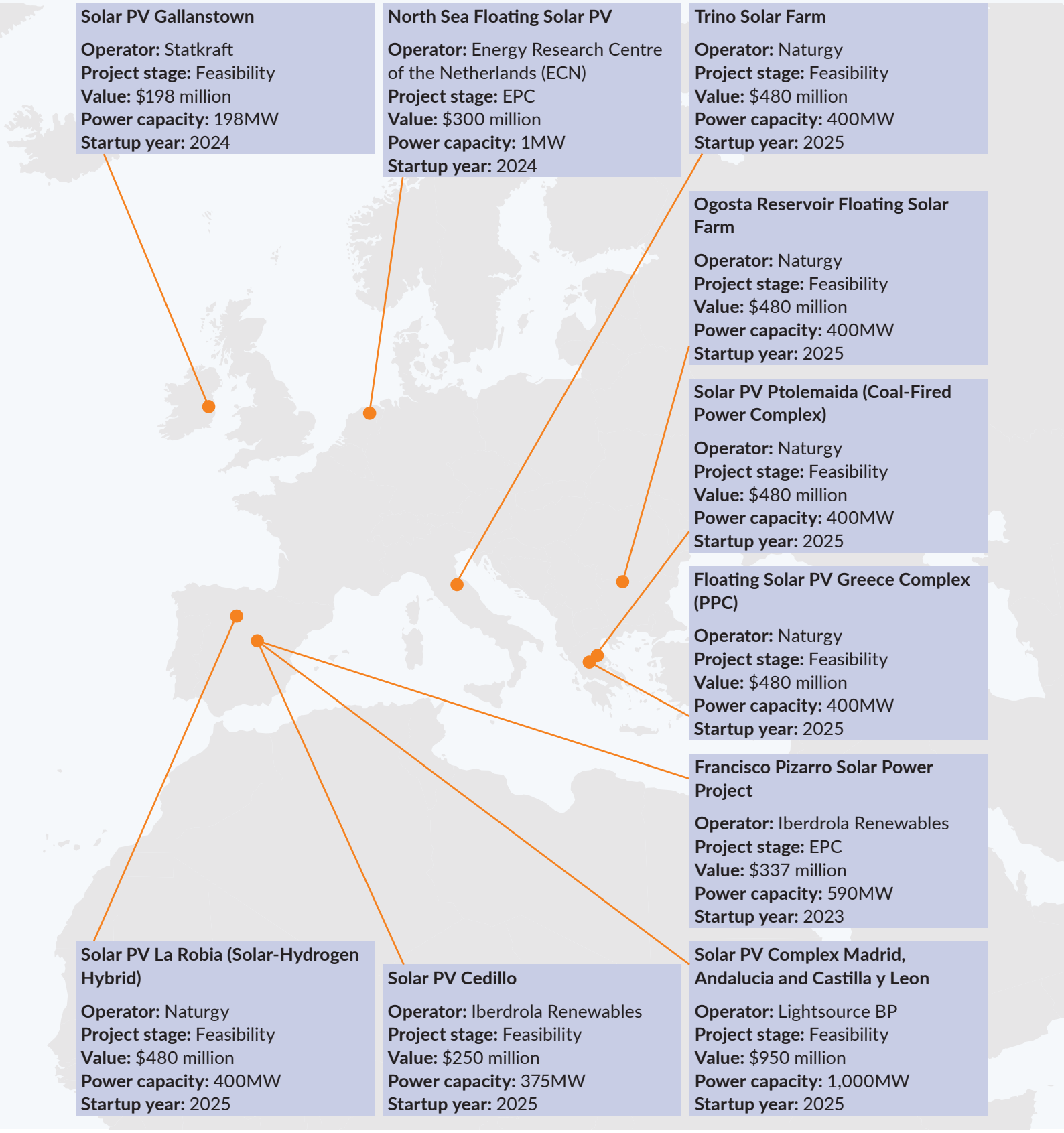


Figure 3.1.6.: *Geographical summary of key projects in Europe.*

Source: EICDataStream

3.1.1 Spain

According to the World Bank's Global Photovoltaic Power Potential study, Spain has a theoretical potential of 4.575 kWh/m2 and ranks 140 out of 183 countries analysed, in terms of irradiation (more specifically Global Horizontal Irradiation). This irradiation is on par with countries like Mozambique and Brazil, making Spain amongst the highest irradiating countries in Europe. Spain has been adopting solar PV greater volumes over the last decade and according to EICDataStream and EICAssetMap, the country's operational solar PV capacity has grown beyond 8 GW over the past decade. But it is since 2018 that we have seen an accelerated pace in projects being announced, with over 26 GW of solar PV potentially coming online by the end of 2025, according to EICDataStream.

Much of this ambition to install large capacities of solar PV can be attributed to Spain's renewable targets. The country is planning for 160 GW of renewable capacity by 2030 – which would increase Spain's renewable energy share (RES) to 74% by 2030 and has a long-term goal of 100% RES in their power mix by 2050. More specifically, the Spanish government aims to install 22 GW of wind, 30 GW of solar PV, 5 GW of CSP, 3.5 GW of pumped hydro storage and 800 MW of biomass between 2020 and 2030. Additionally, the country is currently planning to phase out conventional and fossil power sources – coal power by 2025, oil-fired power plants by 2030, and nuclear power by 2035.

Local governments for provinces such as the Basque Country and Catalonia have also made individual solar PV commitments. For example, the Government of Catalonia is targeting 12 GW of renewable energy by 2030 – 7 GW of solar and 5 GW of wind – 62 GW by 2050 and carbon neutrality by 2050. The Government for the Basque Country has made a UN Compact and committed to develop 30 MW to 250 MW of solar PV capacity (equating to 30 to 50 new installations) with a total investment of €24 to 200 million by 2030.

United Nations Global Compact

A voluntary initiative based on company and country commitments to implement the United Nation's sustainability principles. A 'UN Compact' is a commitment by companies and stakeholder to meet the UN goals.

Spain has implemented policy which will help reach the targets set. The Integrated National Energy and Climate Plan 2021-2030 (INECP) and the Climate Change and Energy Transition Act (CCET) require a deployment of around 60 GW of renewable capacity (wind and solar PV) as well as 6 GW of storage to be put into operation. The CCET Act was passed to establish the foundations and mechanisms required to achieve the targets set in the INECP 2021-2030. In July 2021, the European Council also approved of Spain's Recovery, Transformation and Resilience Plan (RTRP) which provides financing for many initiatives to deploy renewables and electrify the economy. According to EICDataStream, an estimated CAPEX of over USD$31 billion is to be spent to bring wind and solar projects online by the end of 2025, with a CAPEX of over USD$24 billion alone predicted for solar PV installations. However, the Spanish government predicts that more than €240 billion will be required to meet the INECP 2021-2030 targets and expects that 80% of this investment will be from the private sector. It already appears that the government is assisting in attracting greater private investment to the solar PV sector through incentives.

Why the ramp up in capacity?

It could almost be considered a scramble to procure new renewable capacity as Spain considers the likelihood of achieving its mid to long term targets. A moratorium was issued in 2012 in a previous administration which was implemented in 2014 and stopped installation of new renewable capacity. This resulted in Spain missing interim annual targets that were expected to contribute to reaching 20% RES by 2020. The moratorium ended in 2016 when auctions for 8.7 GW of additional renewable capacity were launched as a way to utilise the 2013 Electricity Act which entitles new renewable installations to financial support under an incentive mechanism, Spain's Specific Remuneration Regime. Additionally due to the emergency caused by hiking international prices for energy particularly gas, Spain's Royal Decree-Law 6/2022 was passed in March 2022 which, until the end of 2024, would fast-track environmental approval of new wind plants of less than 75 MW generation capacity and new solar parks up to 150 MW capacity. The Law also provided regulations for floating PV plants, as a way to support the advancement of technology in the sector in future. We can therefore expect to see a greater number of these projects being announced over the next couple of years as a result.

The INECP aims to incorporate both auction mechanisms and PPAs to procure solar PV capacity. Already, long term, fixed-price PPAs are common in both PV and wind markets in Spain but following the political turmoil as result of Russia's invasion of Ukraine and unprecedented energy price volatility there is greater demand for shorter-term and baseload-type PPAs. Corporate PPAs and agreements between large consumers and developers are likely to continue being the main mechanism to incentivise renewable investment in Spain.

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Aside from installing solar PV to electrify the economy, Spain's green hydrogen goals are also a contributing factor in the scale-up of capacity. In 2021 the Spanish government published its hydrogen roadmap which includes objectives for 2030 and 2050 to ensure that green hydrogen contributed to its climate neutrality goals. Along with an initial investment of USD$1.56 billion to be spent over three years, the government plans to achieve an installed capacity of at least 4 GW in electrolysers by 2030. The country's established renewables sector makes Spain well placed to be a green hydrogen exporter.

Challenges do remain for the solar market in Spain, however. Spain's renewable market is growing much faster than its storage market which led to the country applying solar PV curtailment for the first time in 2022. In April 2022 power generation exceeded demand so the grid operator Red Eléctrica de España (REE) instructed some producers to stop production and a large amount of renewable energy was discarded. If the storage market was as advanced as the renewable market, this curtailment may have been prevented. Hydrogen generation may assist in avoiding curtailment with excess solar-generated power being utilised to power electrolysers in the mid to long term.

3.1.2 Greece

According to EICDataStream, Greece is planning to develop over 7 GW of solar PV capacity to bring online by 2025. Solar PV is amongst the most widely adopted renewable generating technologies in Greece as the country moves to phase out coal. Many projects are planned to be developed at decommissioned lignite fields or to power operational coal plants.

Greece's National Energy Climate Plan (NECP) presents a detailed roadmap to achieve the country's energy and climate goals by 2030 and net zero by 2050. The Plan aims to increase RES share from 20% to approximately 61% between 2020 and 2030 – which equates to approximately 10 GW of renewable energy capacity. This share was increased in June 2022, as Greece passed a renewables law targeting 15 GW of new capacity to contribute to the country's 2030 goals and to increase its RES to 35% of the energy mix and 70% of the power mix. The law also stipulates:

- That licensing processing time will reduce from 5 years to 14 months
- Energy storage capacity will increase to at least 3.5 GW by 2030
- Grid infrastructure will be improved to accommodate new renewable capacity
- Promotion of floating solar PV which allows for the construction of pilot plants with a capacity of 0.5–1 MW
- Small scale solar is also encouraged with support for the construction of 200,000 small PV systems which would translate to 2 GW of renewable electricity capacity

In September 2022, Greece launched a 1 GW solar and wind energy tender via the Regulatory Authority for Energy (RAE). Bidding was aimed to start at €54/MWh to attract 180 MW of solar capacity to compete for selection. The lowest PV price reached was €46/MWh with over 370 MW of solar PV capacity being awarded out of a total awarded renewable capacity of almost 540 MW. PPC (Public Power Corp) Renewables emerged as a winner in the tender (investment plan to reach goal of 1.5 GW of renewable installed capacity by 2023 and 5 GW by 2027) – with four projects with total capacity of 250 MW. EDF's Greek unit, Heliothema Energy also won 33 MW of capacity to be spread across four projects.

So far, the reduction in the licencing processing time still seems unrealistic as the most recent auction rounds failed to procure 1 GW (though this will be rolled over to the next tender) of capacity of renewables as not enough projects had gathered the necessary licences required to participate in the tender. This may be a consequence of the lack of grid capacity in Greece and the lack of digitisation of licencing processes. But the likely reason for lack of bids is the high starting price for bids; low tariffs are not working well due to both the effects of inflation and also short-term increases in the costs of solar equipment.

Solar financing in Greece

The European Bank for Reconstruction and Development (EBRD) support RES projects in Greece via the InvestEU and REACT-EU programmes from an investment fund totalling almost €90 billion. The Recovery and Resilience Facility (RRF) is also another financial vehicle under the EU which Greece can access for support in solar development. The Greek RRF expects to provide €6 billion of EU grants towards RES investments with more funding from EU loans. EBRD since 2015 has invested over €2 billion in investments in Greece to support sustainable infrastructure. Significant regional investment into Greece's solar PV market and streamlining of licencing processes will likely support the expansion of solar capacity over the next decade in Greece.

3.1.3 Ireland

With its first grid connected solar PV farm coming into operation in May 2022, and over 5.5 GW of solar capacity in development that could come online by the end of 2025, Ireland is considered to be an emerging solar PV market, according to EICDataStream. The country has huge ambition in renewables. Under the Renewable Electricity Support Scheme (RESS) which was established in 2020; the government aims to increase Ireland's renewable energy share of its electricity system to 80% by 2030 and to reduce GHG emissions by 51% by 2030. The RESS provides support on projects and is part of the Programme for Government and the Climate Action Plan 2021. Concerns over energy security supply have also been voiced which could potentially increase ambitions further. Following Russia's invasion of Ukraine, the Irish Solar Energy Association (ISEA) as called for greater national ambition and to increase the solar capacity target to 6 GW by 2030 from 2.5 GW as set in the Climate Action Plan of 2021.

The main mechanism for solar capacity procurement is via the RESS auctions. The first auction, RESS 1, was held in 2020 and many lessons have been learned from it; many of the projects awarded in this round are now not going ahead. Supply chain issues and inexperience in the sector have played a role, but the high costs associated with initial development of solar have also contributed too. Commercial rates in Ireland are higher compared to other European countries, and the costs of transportation of electricity generated as well as operation and security of grid are significant. Ireland also recognises that there will be increased competition from other European countries, due to recent announcements around increasing solar ambitions. This means that in the short-term Ireland will have to compete for limited resources and skilled workers.

RESS auctions are delivered by the Department of Environment, Climate and Communications (DECC) with support from the Commission for Regulation of Utilities (CRU), and EirGrid who are the Transmission System Operator (TSO). The most recent round, RESS 2, saw a renewable strike price of €97.87/MWh for all capacities with almost 1.2 GW in utility scale solar capacity alone being awarded. This is a significant improvement from the results of the first RESS round which awarded only 400 MW of large and utility solar capacity at a strike price of €72.92/MWh (incl. community scale). This increase in strike price is, however, attributed to a sharp increase in electricity costs in Ireland as a result of volatile global energy prices; the rise in electricity costs highlighted the need for diversification of Ireland's mix. The huge amount of solar capacity awarded in this recent auction indicates that growth of the grid-connected solar PV market will be significant over the next few decades as Ireland works to meet its climate and energy targets.

Though not covered in this report, rooftop solar is heavily supported in Ireland. In October 2022, the government removed barriers to allow greater adoption for residential and commercial scale solar – planning permission for these types of solar is no longer required. Ireland is also a part of the EU's Solar Rooftops initiative and aims to deploy almost 400 MW of rooftop and commercial solar capacity alone, so we can predict significant and continued growth in rooftop and commercial solar.

3.1.4 Analyst Opinion

Europe has shown itself to be one of the largest markets in the world and is expected to make significant progress with an increasing annual installed capacity. With plenty of policies and support schemes put in place in major markets such as Portugal and Spain to the emerging markets like Greece and Ireland we have seen huge players such as Iberdrola and Enel Green Power take advantage of this and invest heavily into each country. With larger markets continuously pushing for more solar the smaller markets are motivated to follow, in particular the Eastern European countries such as Albania and Kosovo. We find that most of the contracted work comes from the local region, most European companies are able to win those opportunities regarding EPC and BOO, for OEM supply, like most regions, often contract Chinese companies due to the cost effectiveness of such equipment. As EICDataStream only tracks utility scale solar projects one shouldn't underestimate residential solar. In markets such as Germany and the Netherlands which don't have a significant utility scale solar market, residential solar plays a huge role in overall installed capacity and thus contributions towards net zero targets. Overall, activity in Europe suggests that there shouldn't be any outstanding challenges for each market to reach their targets. Europe offers plentiful opportunities for the solar sector to thrive.

Nabil Ahmed, Energy Analyst

3.2 Commonwealth of Independent States (CIS)

Due to Russia's invasion of Ukraine, analyses of Russia and Belarus will be omitted from this report. The countries that have been analysed include Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, and Uzbekistan, where applicable. According to EICDataStream, over 12.7 GW of renewable energy capacity could be developed by the end of 2025 across the region, with 40% of total capacity being solar PV. A growing market with little regulation has attracted foreign investment with Uzbekistan attracting the most investment so far. The country is leading the region with over 3.5 GW of solar PV capacity in planning or under development over 11 projects. Kazakhstan is also an emerging market with an estimated CAPEX spend of USD$425 million to develop just over 370 MW of solar PV capacity by 2024 and ever since the launch of its 2020 renewable energy auctions, is ambitiously increasing its renewable energy share. Elsewhere, Armenia is making market reforms to assist in ensuring and diversifying its energy supply and has set a target of 1 GW solar PV capacity by 2030.

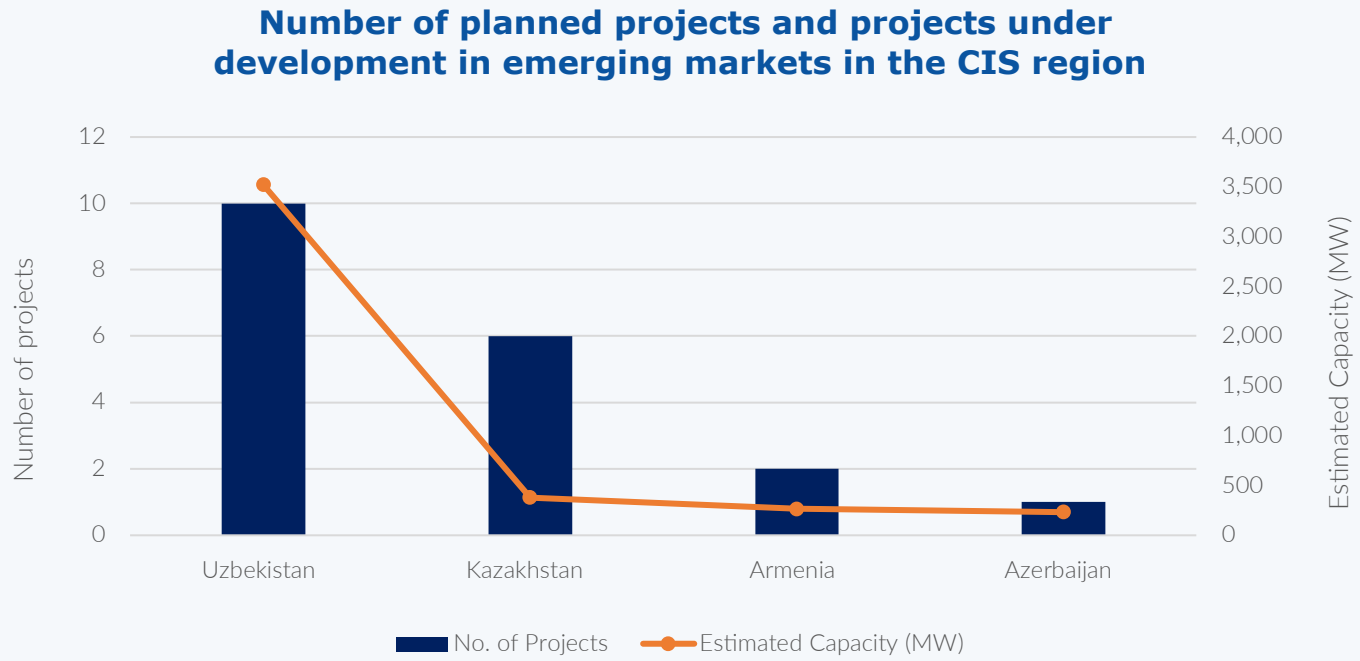

Figure 3.2.1: *Number of planned projects and projects under development in emerging markets in the CIS region.*
Source: EICDataStream

Country	Clean Energy Ambition	Solar Capacity target
Uzbekistan	12 GW renewable energy capacity by 2030; 25% RES by 2025 and 30% RES by 2030	4 GW by 2026 and another 5 GW by 2030
Kazakhstan	6% RES by 2025, 15% by 2030 and at least 50% by 2050	N/A
Armenia	Government expects solar capacity to increase to account for at least 15% of power generation by 2030	100 MW by 2024 and 1 GW solar PV capacity by 2030
Azerbaijan	30% RES by 2030	N/A
Kyrgyzstan	10% RES by 2040	700 MW by 2030
Tajikistan	10% RES by 2030	N/A

Table 3.2.1: *Summary of Clean Energy Ambitions and/or Solar Targets in the CIS region*

A growing trend of international support and investment can be observed in the region as investors such as the World Bank Group, USAID, and European Bank for Renewable Development (EBRD) have recognised the potential for solar PV as a viable renewable energy source. Countries such as Kazakhstan and Uzbekistan are mostly reliant on aging fossil fuel plants particularly coal – many governments in the region have therefore understood that reform of their respective energy profiles must be conducted. Lenders and programmes such as the International Finance Corporation (IFC) and USAID have supported in developing renewable auction mechanisms, enabling financing as well as helping to develop and implement national clean energy strategies.

Auction	Period	Awards
500 MW solar PV tender with assistance from the International Finance Corporation (IFC)	July 2022 – October 2022	Voltalia – 100 MW – USD$0.03/kWh Masdar – 250 MW – USD$0.03/kWh GD Power/PowerChina – 150 MW – USD$0.05/kWh
200 MW solar PV tender with assistance of the Asian Development Bank (ADB)	February 2022 – May 2022	Masdar – 457 MW – USD$0.02/kWh

Table 3.2.2: *Summary of recent auction results in Uzbekistan*

Uzbekistan – a case study

Uzbekistan has two operational solar PV plants, Total Eren's 100 MW Tutly Park development and Masdar's 100 MW Nur Navoi Plant which was built via the Scaling Solar Programme. However, the number of announcements in Uzbekistan has significantly increased since 2017 following Uzbekistan joining the World Bank's Scaling Solar Programme. USAID has, as part of the Programme, assisted Uzbekistan since 2017 with studies and planning to transform the country's energy system. The outcome of the support led to the Government of Uzbekistan adopting a law on renewable energy in 2019 and also set up subsidies for energy users to encourage the move to clean energy sources. A target to reach 25% of renewable energy share (incl. solar, wind, hydro) by 2030 has been set; this has recently been brought forward to 2026 and would bring around 12 GW renewable capacity online, of which 7 GW will be solar and wind and a further 2.9 GW hydropower. Uzbekistan also announced that it will support the goal to be carbon neutral by 2050, another incentive to increase its renewable capacity.

The country has also recently seen growth in demand for electricity, despite economic slowdowns related to the pandemic. However, the demand growth in projects is much greater than the actual demand for power; this has led to the Ministry of Energy increasing its 2030 renewable power capacity target to 12 GW. Instead, the Government plans to increase the share of renewables in the long term planned energy mix; recent low tariffs realised in latest PV tenders, as demonstrated in Table 3.2.2, have implied the competitive market can further grow, which helps the Ministry of Energy to decide on cost structure of tariffs for consumers.

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International investors are increasingly collaborating with the Government of Uzbekistan to announce tenders for capacities up to 2 GW of solar energy projects, demonstrating a real drive for solar PV development in this emerging market. USAID has supported Uzbekistan with technical assistance and training to dispatchers as well as large sums of investments. The solar PV market in Uzbekistan has adopted a public-private partnership (PPP) structure as a preferred method of attracting foreign investment to develop the sector. The Ministry of Investments and Foreign Trade, the Ministry of Energy and the PPP Development State Agency are working on the modernisation of Uzbekistan's energy sector. Power Purchase Agreements (PPAs) are the chosen mechanism for solar power trading in the country however tariff policy is still under development with a new tariff policy reaching approval with the aim to be implemented by 2030. Government-owned company, National Electric Networks of Uzbekistan, signed PPAs with the awarded bidders for a period between 20 and 25 years and acts as the offtaker, whilst the Ministry of Foreign Investments and Trade enters into a government support agreement. Projects are then usually under an IPP basis using a design, build, finance, own, operate, maintain structure, or put simply, a BOO. You will observe in this report, that this is often the preferred method of solar capacity development.

Figure 3.2.2 is a summary of planned capacity additions by operators in the CIS region. Across the region, Masdar are proving to be a major player ever since the Abu Dhabi-based company signed a PPA for the Nur Navoi plant in 2019, just as Uzbekistan began developing renewables. The company chose Uzbekistan as a strategic location for solar development due to Uzbekistan's renewable ambitions and the investments many international financial institutions are making into the renewables sector. Masdar has several projects in the works.

Elsewhere in the region, Masdar has also signed cooperation agreements with Kazakhstan and Azerbaijan to develop clean and renewable energy projects. Most recently in June 2022, the company signed two implementation agreements with the Ministry of Energy: one for the development of 1 GW of onshore wind capacity and 1 GW of solar PV, and another integrating offshore wind and green hydrogen projects with capacities up to 2 GW. The agreements will strengthen the grid network in Azerbaijan and enable the country to become a renewable energy export market, as well as enable domestic decarbonisation too. Masdar's penetration of the solar PV market in the CIS region is part of their strategy to meet their own target of 100 GW of renewable capacity by 2030; according to EICDataStream, Masdar have almost 1.5 GW of renewable capacity in the pipeline – indicating they have a long way to go to meet their target.

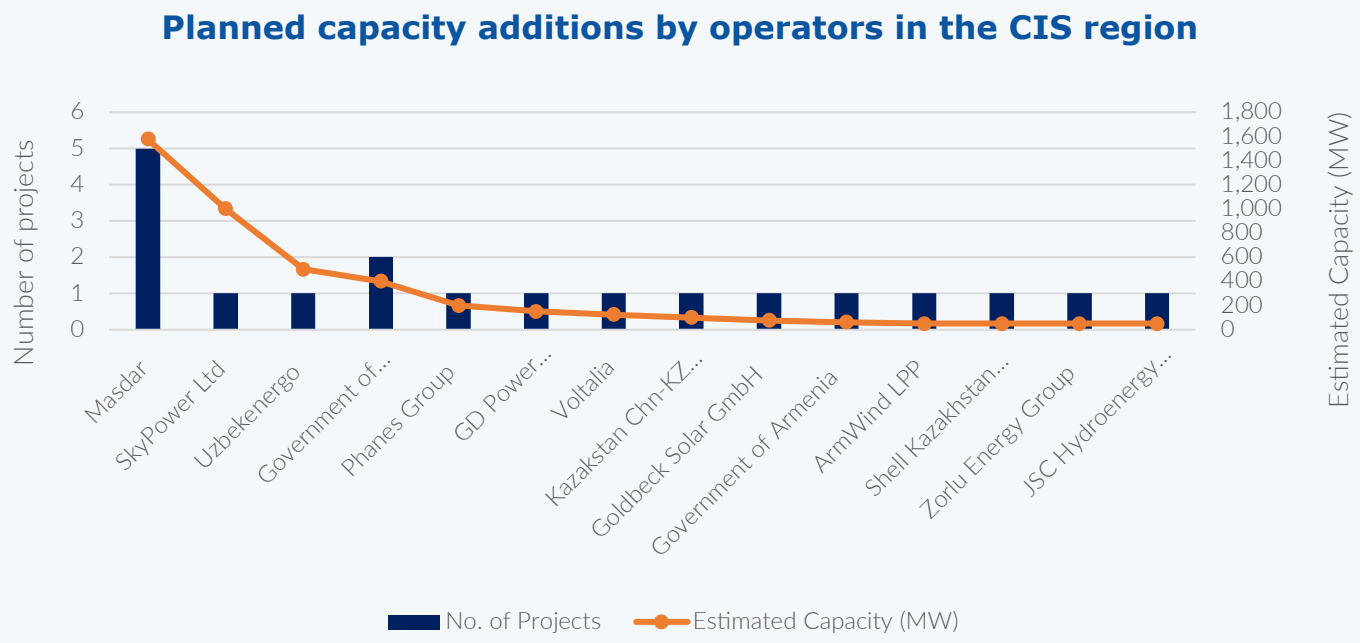

Figure 3.2.2: *Planned capacity additions by operators in the CIS region.*

Source: EICDataStream

Scaling Solar in Uzbekistan

As mentioned, the World Bank Group's Scaling Solar Programme is being implemented in Uzbekistan which is the first country outside of Africa to join it. Under the programme, the 100 MW Nur Navoi project in Uzbekistan was developed with a winning bid of USD$0.027/kWh in LCOE. The IFC, a World Bank company, has continued to work to provide advisory services for policies and tenders in the region. Most recently, the IFC advised the Uzbekistan government on a PPP to develop 1 GW of solar – likely with an international developer like Masdar.

Saudi Arabia's ACWA Power has also expressed their intention to bid on in future tenders in Uzbekistan and most recently, although unsuccessful, submitted a bid in the 2022 500 MW solar PV auction. Additionally, in August 2022, ACWA Power signed three energy agreements with Uzbekistan's Ministry of Energy totalling USD$12 billion to diversify the country's energy mix, including wind, green hydrogen, gas-to-power, and renewable energy developments in the country starting in 2023. The agreements make Uzbekistan ACWA's second largest country for investment and is a move towards generating a pledged 120 GW of electricity over the next 10 years.

As can be noted from the previously discussed developers there is a growing trend of Middle Eastern players exploring opportunities in the CIS region; the renewable energy auctions being pushed by international development banks in the region are the likely reason. The auctions implemented tend to be of a similar structure to those in the MENA region for solar PV projects which perhaps makes it easier for Middle Eastern companies to navigate and penetrate the emerging CIS market. Moreover, the market and regulatory immaturity of the CIS region makes it easier for international and major investors to take on the high risk of projects at this present time and develop capacity. That being said, as the market matures it is likely that more defined policies and regulatory frameworks will allow for smaller players to enter the market.

Key CIS projects

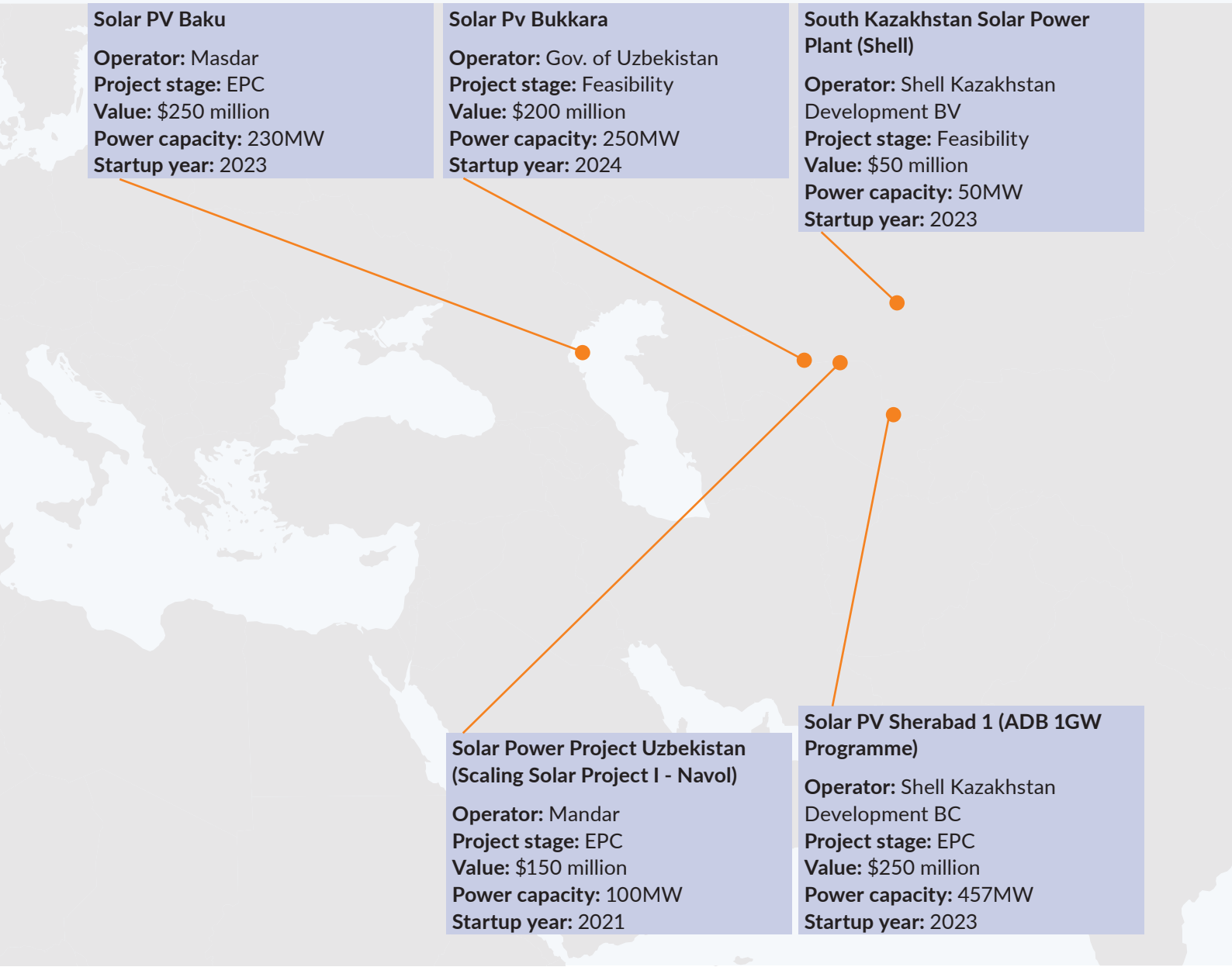

Figure 3.2.3 *Summary of key planned and operational projects across the CIS region*

Source: EICDataStream

3.2.1 Analyst Opinion

Within the CIS region most of the activity is present in Kazakhstan and Uzbekistan and that is most likely where we expect it to remain in the upcoming years. With current affairs regarding Russia, there is push for renewable energy to reduce reliance on oil and gas and thus have seen a growing interest for the implementation of policies and subsidies. Furthermore, we are seeing more developers getting involved via PPAs and foreign investment into the market. There is an increase presence of major players entering the region such as Masdar who have successfully won bids from various government tenders such as in Uzbekistan and are also planning to develop the first large capacity solar farms in Turkmenistan and Kyrgyzstan and will act as either the EPC or BOO contractors, furthermore we find that equipment will come from companies in China such as Jinko Solar. With a lot of the projects on EICDataStream in the early stages of development, it is difficult to predict the progression of the solar market as a whole within the upcoming years, with most of those at large capacities (50MW-250MW) and given the market isn't mature, a lot of time, planning and introduction of policies is required in order to bring these solar projects and more to operation and reach their targets.

Nabil Ahmed, Energy Analyst

3.3 Sub-Saharan Africa (SSA)

According to EICDataStream, the Sub-Saharan African region is expected to bring online over 24 GW of solar PV capacity by the end of 2025. With increasing urbanisation, population growth and economic development, electricity demand has grown exponentially, forcing governments in the region to improve access to affordable energy. Despite the region's potential, deployment of solar PV has been slow because of multiple barriers including:

- Lack of transmission and distribution infrastructure

- Lack of competition, with many projects not being competitively tendered which has delayed reaching lower CAPEX for smaller scale projects and has led to high transaction costs that increase tariffs for units of power

- Political risks and long development cycles which cause increased equity and debt costs, driving up tariffs

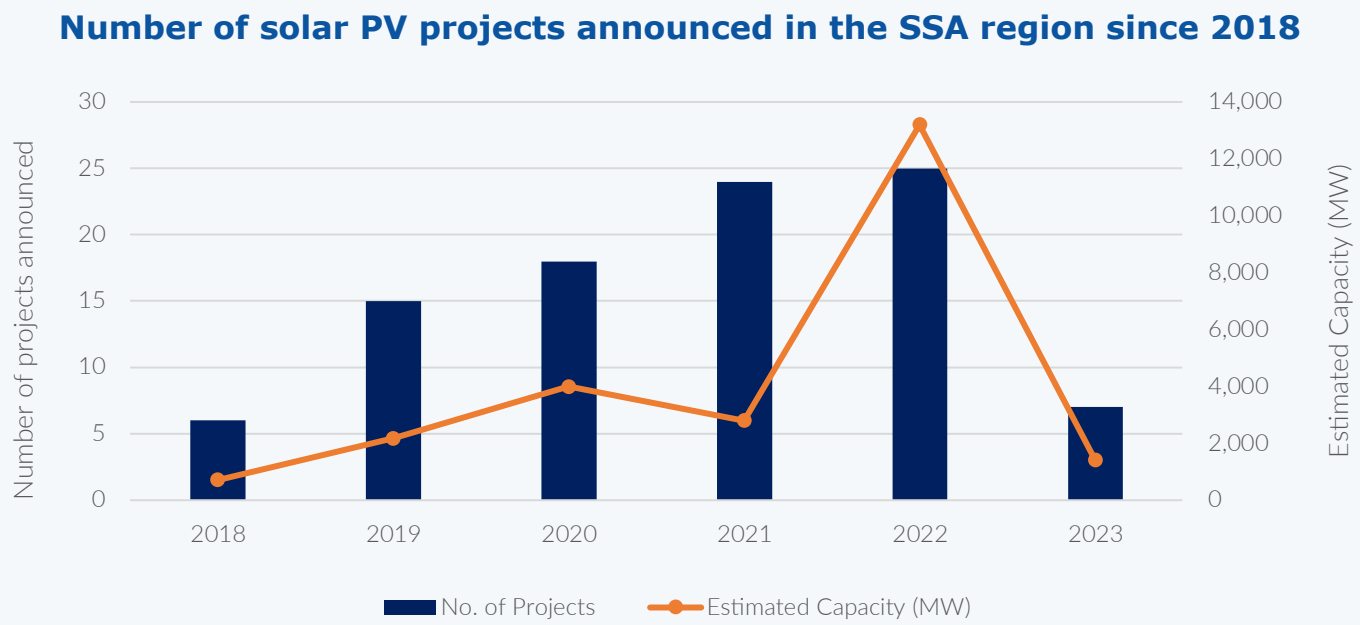

Figure 3.3.1: *Number of solar PV projects announced in the SSA region since 2018.*

Source: EICDataStream

Solar energy system costs are falling globally, which makes the adoption of solar technology in SSA an attractive option. Many utility-scale projects in emerging markets with high solar potential such as Zimbabwe, Zambia, Democratic Republic of Congo, Namibia, and South Africa are being announced. World Bank Group's IFC-led Scaling Solar Programme and USAID are assisting many emerging markets in SSA to develop tender processes and deploy solar PV in Zambia, Senegal, Madagascar, Cote D'Ivoire and Togo. Not only solar PV, but the onshore wind market is growing in the region too, as this resource is also attractive to foreign investment. According to Linklaters, in the period of 2011-2020, over USD$34.7 billion was invested in the renewables sector, of which over USD$20 billion was invested in solar alone from investors in France, the UK, the US, Italy, and Spain.

Leading in investment, Nigeria could spend an estimated USD$6 billion across two projects with a total capacity of 5.8 GW by 2028. The largest of these is the 5.6 GW Kebbi Solar Plant. Africa's biggest oil producer is looking for alternative power sources as the cost of diesel has soared with rising global oil prices and despite local financing being difficult to access, foreign investment has been attracted to both Nigeria and also across the region. Solar potential in the region is vast as observed in Figure 3.3.4, which makes it an attractive prospect for investment into solar power. In terms of projects that are predicted to come online by 2025, a greater number of emerging markets are being observed. Namibia is leading in planned capacity addition, whereas in South Africa more smaller capacity utility-scale projects are being planned. Elsewhere, Zambia mostly relies on hydropower as an energy source, however with increasing droughts in eastern and southern Africa, Zambia faces lower dam levels resulting in lower electricity production during the dry season. As a result of this, Zambia has aimed to deploy 500 MW of solar PV by 2023 to ease chronic power shortages and is increasing efforts to achieve this target.

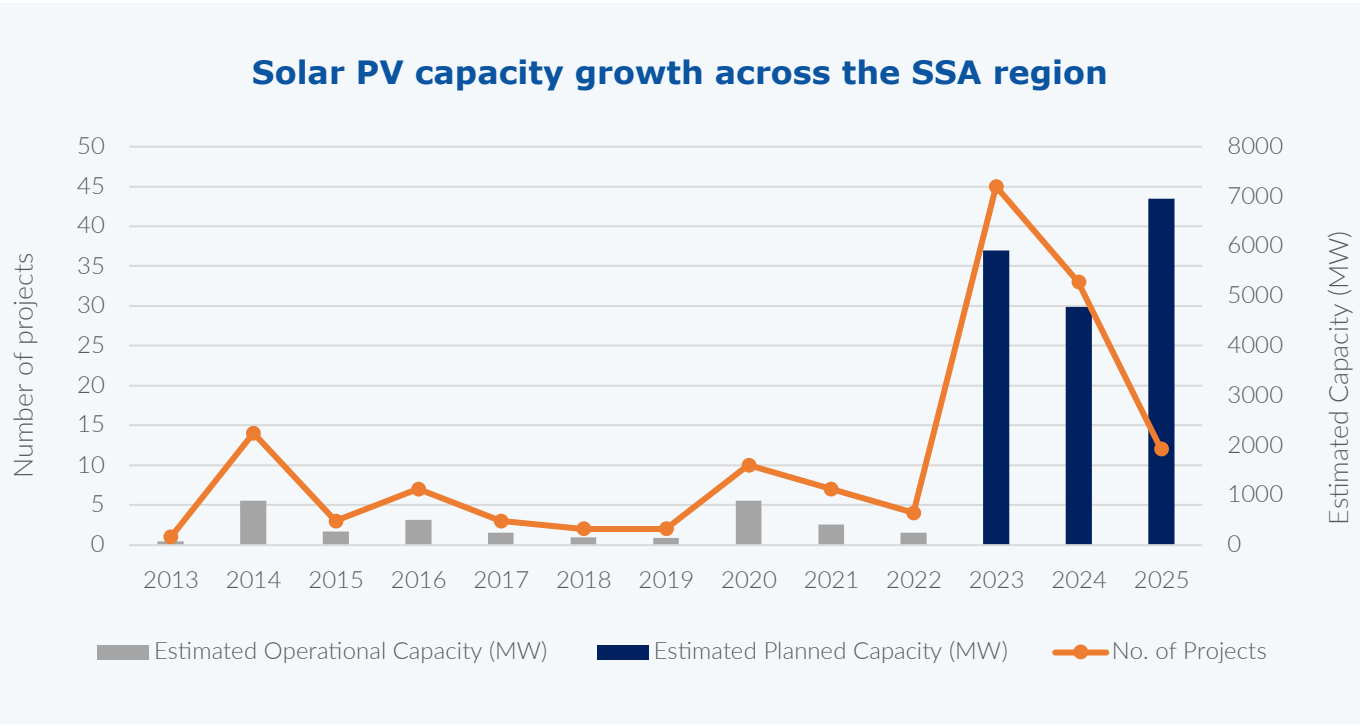

Figure 3.3.2: *Solar PV capacity growth across the SSA region.*

Source: EICAssetMap and EICDataStream

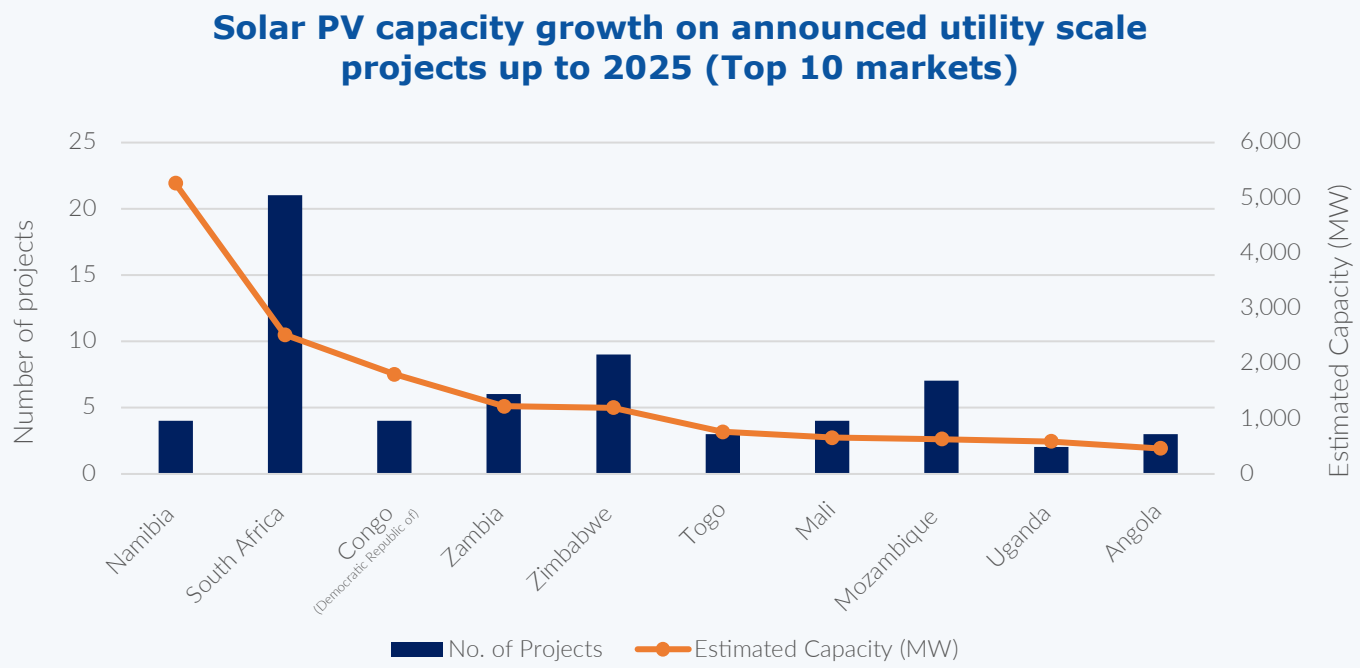

Figure 3.3.3 *Solar PV capacity growth on announced utility scale projects up to 2025 (Top 10 markets).*
Source: EICDataStream

IFC's Scaling Solar Programme

International investment to increase solar deployment, the Scaling Solar Programme was established to support governments to tender grid-connected solar projects to the private sector at competitive tariffs with the aim for deployment within two years of the Programmes engagement. Support is provided in the project's inception through to construction and operation. It is an attractive programme for project developers who are hoping to penetrate the IPP business model in its infancy in the region. However, delays in project work and procurement processes have led to the Programme delivering capacity slowly, as evident by the progress of many projects in EICDataStream.

Figure 3.3.4 shows the top developers in the region and Figure 3.3.5 is a geographical summary of some projects by major players in the SSA region. Mainstream Renewable Power leads by number of projects, with six projects in planning or under development in South Africa for a total capacity of 450 MW by 2024. The data shows that many governments are also moving developments forward. For example, the Government of Botswana in collaboration with Namibia and the World Economic Forum's (WEF) Global Future Council on Energy are developing a 5 GW 'mega' solar project as part of USAID's Power Africa who had signed a Memorandum of Understanding MoU in April 2021 with both governments. Much of the financing will be delivered by IFC and the African Development Bank via the Africa Renewable Energy Initiative, with collaboration with the New Partnership for Africa's Development, IRENA and Power for Africa. The first phase of the project will focus on the competitive procurement of 300-500 MW of solar power in both countries to make way for procurement of capacity in neighbouring countries once transmission and distribution infrastructure is constructed.

As many projects in the region are operated by governments, build-own-operate (BOO) contracts are the norm. BOO contracts have been awarded to foreign developers including Total Energies, ACWA Power, Amea Power, and Enel Green Power who will develop solar projects in Mozambique, Ethiopia, and Mali. With more and more Sub-Saharan African countries targeting climate goals, it's likely that this will attract more foreign investment, and international developers to bid for BOO or EPC contracts in the region over the next decade.

Alongside solar, the battery storage market in the region is also being realised with foreign investment as the main driver. For example, Norwegian company, Scatec, was awarded a contract to construct three Kenhardt co-located projects in South Africa with a total capacity of 540 MW of solar PV capacity and 225 MW/1,140 MWh of battery storage after reaching financial close. The first-of-its-kind project was tendered under the Risk Mitigation Power Producer Procurement Programme (RMIPPPP) and will provide 150 MW of dispatchable power under a 20-year PPA. For the developer, this will be its largest investment and it will hold 51% equity with the other 49% equity belonging to local Black Economic Empowerment partner, H1 Holdings. Other co-located solar PV and battery projects are being planned in the region with smaller scale battery projects in Mozambique and South Sudan expected to come online over the next five years.

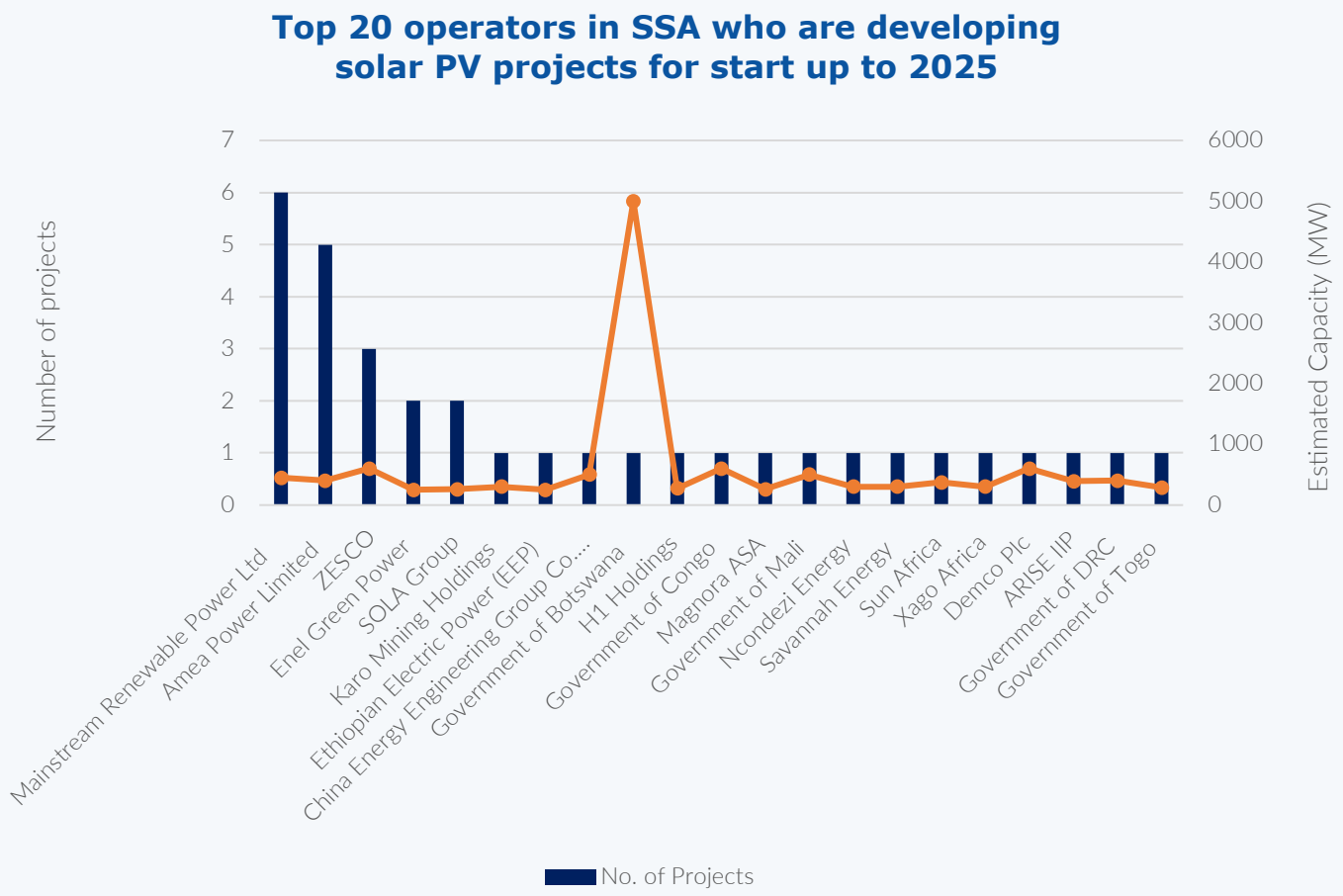

Figure 3.3.4: *Top 20 operators in SSA who are developing solar PV projects for start up to 2025.*

Source: EICDataStream

Geographical summary of key projects in SSA

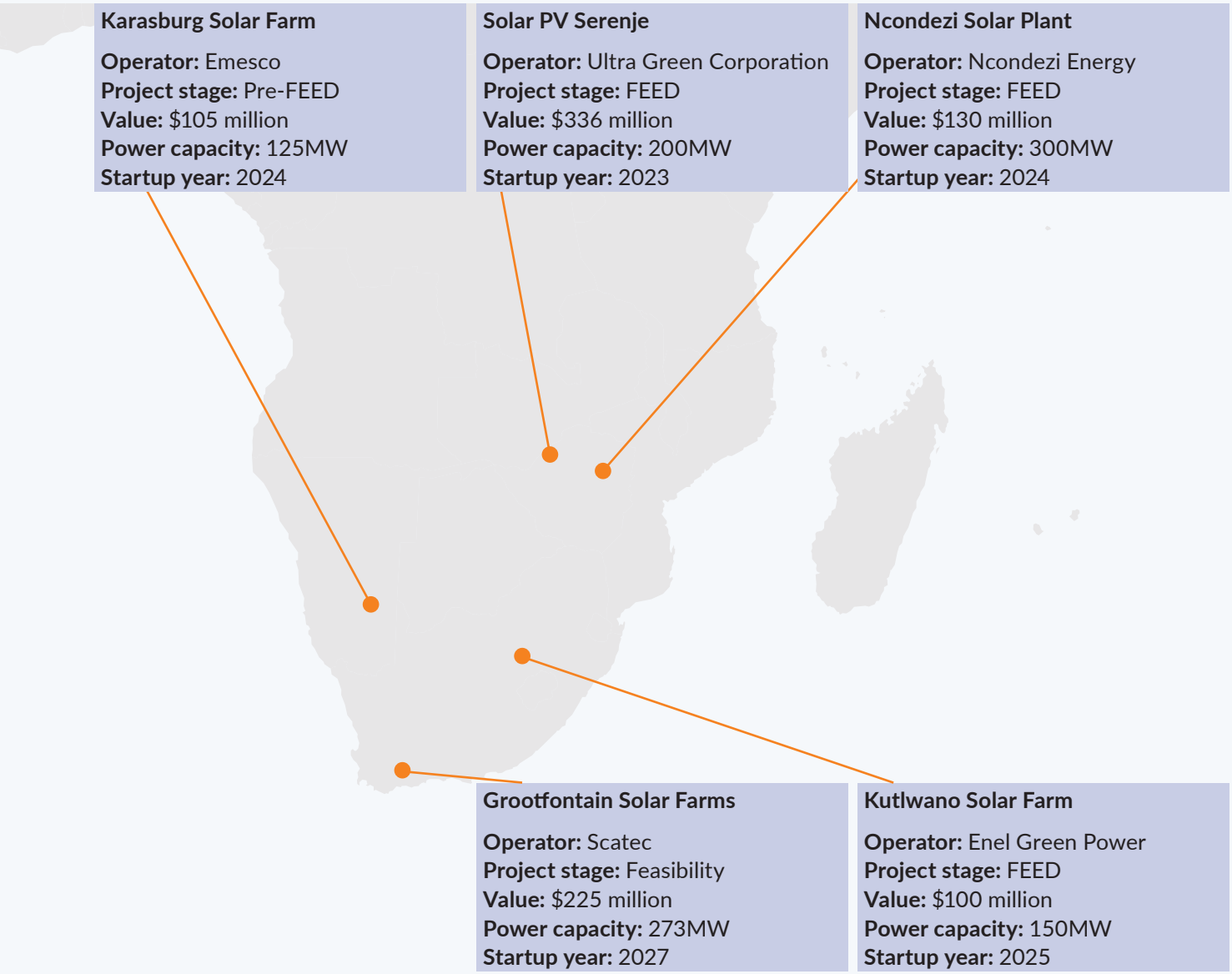

Figure 3.3.5: Geographical summary of key projects in SSA.

Source: EICDataStream

3.3.1 Namibia

According to the World Bank's Global Photovoltaic Power Potential study, Namibia has a theoretical potential of 6.405 kWh/m2 and ranks 2 out of 183 countries analysed, in terms of irradiation and ranks 1 in practical potential at 5.379 kWh/m2. Despite this potential, Namibia is a net importer of energy from surrounding countries including South Africa, Zambia, and Zimbabwe to meet the country's shortfall in domestic energy generation. Namibia's Ministry of Mines and Energy has predicted that imports could drop by 20% by 2024 if solar capacity is rolled out more widely. According to EICDataStream, over 5 GW of capacity is expected to come online by 2025 with an estimated CAPEX spend of almost USD$4 billion.

With commitments and targets being made to a future green economy, dating back to 2004, Namibia is attracting foreign investment to economically advance via clean energy. As part of its updated National Determined Contributions (NDCs) to the UNFCCC in 2021, Namibia committed to reducing its greenhouse gas emissions (GHGs) by 2030 and has been implementing renewable energy as part of its policy and programme.

The role of the Ministry

The Ministry of Mines and Energy promotes renewable energy and efficiency and aims to promote frameworks for these via the following methods:

- Namibian Renewable Energy Programme (NAMREP) Phase 1 (2004-2007) and Phase 2 (2007-2010) which was cofounded by Global Energy Facility (GEF) and supported by UN Development Programme (UNDP)

- Namibia's National Renewable Energy Policy (2017) has 25 core policy statements to meet the following objectives to make:

  - Making Renewable Energy a Vehicle for Expanded Access to Affordable Electricity in Namibia
  - Confirming the Commitment of Namibia's Government to Renewable Energy
  - Boosting Investor Confidence in the Growth of Renewable Energy in Namibia
  - Creating an Enabling Environment for Renewable Energy Development in Namibia
  - Accelerating Renewable Energy Sector Growth and Enhancing Value Chains in the Sector
  - Enabling Greater Participation of Namibians in the Renewable Energy Sector

Namibia's National Renewable Energy Policy aims to support emerging technologies that assist Namibia to meet their emission targets and replace higher emission technologies with cleaner and low-cost ones. As part of the country's NDC, it is predicted that increased renewable energy capacity will allow for a 30% reduction equivalent in the quantity of electricity imported in 2018 with the addition of 0.8 TWh or 800 GWh in new renewable energy generation of which 330 MW of solar PV capacity per year is added by 2030. Much like other countries Namibia has also implemented competitive procurement programmes with tenders to procure 300-500 MW of solar capacity growing in popularity. The benefits from this push for solar will likely be seen in the 2030s as local supply chains develop and the LCOE becomes more desirable.

In terms of financing, there are three main methods of funding mechanism to promote renewable energy capacity as outlined in Table 3.3.1.

Financing mechanism	Administrative body	Description
National Energy Fund	Ministry of Mines and Energy (MME)	Established under the Petroleum Products and Energy Act of 1990, the fund includes financing for research and development of new technology and to improve energy infrastructure, security of supply, affordability via funding of energy projects and subsidisation of energy prices.
Solar Revolving Fund	MME	Established in 1997 to stimulate demand for utilisation of solar in rural area especially, offgrid areas. The Fund is part of the Namibia's Off-Grid Energisation Master Plan for Namibia (OGEMP)
Sustainable Use of Natural Resources and Energy Finance Fund (SUNREF)	Agence Française de Développement (AFD, French Development Agency)	3-year programme development by AfD to mobilise commercial Namibian banks to finance investments into green technologies. Loans and green bonds issues by, FNB Namibia, Bank Windhoek and Nedbank who as part of SUNREF, invested €15 million in green projects in Namibia.

Table 3.3.1: Summary of financing mechanisms to promote renewables and solar energy in Namibia

Namibia's green hydrogen ambition

A major incentive for Namibia to pursue solar PV is the country's ambition to incorporate green hydrogen; with such a high solar potential, this presents an opportunity for Namibia to sell to markets of demand, particularly many countries in Europe who are keen to decarbonise with hydrogen. Namibia also boasts port infrastructure in Luderitz and Walvis Bay which again indicates that green hydrogen export can be a viable future market.

3.3.2 South Africa

The solar PV market in South Africa is seeing a lot of activity as the country pursues decarbonisation and a net zero by 2050 target. By 2025, the country is estimated to bring over 2.5 GW of solar PV online with an estimated CAPEX spend of almost USD$2.5 billion. Much of this incentive is a consequence of the country's ambition to reduce its dependence on its state-owned utility, Eskom, who supplies power primarily by coal and is Africa's largest GHG emitter. Over the last decade, Eskom has been facing financial and operational issues – more recently the utility has begun to consider adding renewables to its plant portfolio. The South African government has issued tax incentives since 2016 via the South African Revenue Service to encourage developers to pursue solar. However, companies have been slow to adopt grid connected PV systems due to lack of promotion from the government as well as lack of market signals. For example, Eskom until recently, were not pursuing renewables.

South Africa's REIPP

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) was established in 2010 and has resulted in more than 6GW of renewable capacity to be allocated to bidders in South Africa. The Programme saw significant growth in the 2010s but less growth in the 2020s but has allowed private sector to investment in renewables and gas in a move away from coal. The government has also considered opening a request for proposals for battery storage as a short-term solution to lack of grid capacity. The most recent round – Bid Window 6 (BW6) – saw 860 MW out of a total of 1GW of solar PV capacity being allocated to five bidders which are summarised in Table 3.3.2. At the time of writing, February 2022, a sixth project has also been identified as eligible to be allocated capacity though a decision is yet to be made between the government and bidder, which would potentially increase capacity to 1GW in allocated capacity. PPAs were also signed with successful bidder for the fifth round which saw 13 projects with capacities of 75 MW being awarded resulting in a total capacity of 975 MW of solar PV capacity being allocated.

Project	Capacity	Operator	Strike Price
Kutlwano Solar PP	150 MW	Enel Green Power (Under its subsidiary Kutlwano Solar PP RF Pty Ltd)	USD$0.027/kWh
Boitumelo Solar PP	150 MW	Boitumelo Solar PP RF Pty Ltd	USD$0.027/kWh
Doornhoek PV	120 MW	Amea Power (Under its subsidiary Doornhoek PV Pty Ltd.)	USD$0.032/kWh
Virginia Solar Park	240 MW	Ursa Energy Pty Ltd	USD$0.029/kWh
Good Hope Solar Park	200 MW	Antlia Energy Pty Ltd	USD$0.029/kWh

Table 3.3.2: *Summary of projects that have won bids in the most recent REIPPPP round. Note: Some companies have been identified as subsidiaries where it available to public knowledge.*

Ambitions for solar PV capacity are also evident in South Africa's 10-year energy strategy, namely the Integrated Resource Plan 2019 which aims to deploy 6 GW of PV by 2030. This would increase PV installed capacity from 3% of total electricity supply it is at currently, to 11% by 2030. Natural gas, solar and wind are the main focus of the plan however a further 1.5 GW of new coal generation capacity is being planned to come online by 2030. This would make coal still account for 43% of South Africa's generation capacity in 2030. For South Africa to decarbonise meaningfully, coal will need to be phased out. The government is in negotiations with international investors to pioneer a just transition. At COP27 in November 2022 five G20 members – France, Germany, the UK, the US, and the EU – committed to contribute to a USD$8.5 billion investment under the Just Energy Transition Partnership. The purpose of the partnership is to repurpose old coal power plants and invest in grid infrastructure and power sources to the grid, which will likely be generated by solar and wind farms to be distributed to cities and heavy industry.

Many of the projects being announced in South Africa over the last couple of years tend to be small scale or less than 100 MW. This may be a result of the Electricity Regulation Act (ERA) which has since been amended to raise the licensing threshold for embedded (small scale) generation projects from 1 MW to 100 MW. This has allowed smaller developers and companies to adopt solar resulting in greater penetration of the technology. Therefore, it appears there is potential for the expansion of South Africa's solar PV market. Further promotion, investment from international developers and more defined frameworks, are key to this expansion.

3.3.3 Zambia

According to EICDataStream, a CAPEX of over USD$1.5 billion is estimated to bring over 1.2 GW of solar PV capacity online by 2024, making it one of the region's emerging markets. In 2006, Zambia released its Vision 2030 (later updated in 2015 in the lead up to the Paris Agreement) which aims to reduce expensive regional power imports and exposure to fuel prices. To do this, Zambia plans to increase renewable alternative sources of energy and to reduce the share of fuel from wood (biomass) by 40% by 2030. Later the country's, National Energy Policy, which was adopted in 2008, aimed to remove barriers to the development of renewable energy capacity in Zambia, indicating clear ambitions to adopt renewable energy. Further promotion, development and deployment of renewables was to be achieved by establishing frameworks in R&D as well as a commitment to providing financial instruments to stimulate growth on renewables was intended.

However, it was not until the mid-2010s where this movement in establishing financial frameworks began. The country had joined the Scaling Solar Programme in 2015 led by the World Bank's IFC with the aim to drive urgent development and installation of at least 600 MW of solar power in a bid to mitigate severe power cuts of 2015 and 2016 following the privatisation of the energy sector and sell-off of coal-fired power plants. Under the Programme, Zambia launched its first competitive tender round to procure solar PV. Round 1 aimed to sign contracts for two utility scale power plants at 50 MW of capacity each. The winning bidders were to be contracted under a PPA with the government and were responsible for financing, construction, and O&M of the plants for 25 years. This first round attracted 48 power developers, seven of whom bid the lowest solar power tariffs; at the time, the winning bids were USD$0.06/kWh- the lowest solar tariff seen in the region at the time. The solar plants have been in operation since 2019 – NEON and First Solar's Bagweulu 54 MW plant and Enel's 34 MW plant (which had won the bid to develop at US$0.08/kWh).

Zambia Electricity Supply Corporation (ZESCO) is the administrative body responsible for launching tenders for development and construction for capacities of 50 MW PV plants with the most recent tender being launched in August 2022. It appears 'little and often' in capacity and frequency is the approach Zambia is taking to achieve its capacity targets. This may be due to the push for mini grids to become the main transmission and distribution mechanism to be adopted in SSA; Zambia is a large country with its population quite spread out which negates the effectiveness of a centralised system.

3.3.4 Analyst Opinion

The Sub-Saharan African region has been one of the most difficult regions to implement solar farms making the sector as a whole under-developed and the weakest market despite having the most potential. The region therefore requires a lot of investment alongside support schemes to nurture it, which is what we are seeing more of in recent years. An example is the Desert to Power scheme with an objective of providing 10GW to the Sahel region of Africa by 2030 which recently saw the Global Energy Alliance for People and Planet announce USD $35 million in support of Sustainable Energy for Africa (SEFA) under the initiative. In Mozambique, the African Development Bank recently announced a USD$2.5 million grant from SEFA to support the development of renewable energy which includes a feasibility study for a floating solar farm. Regarding the contracted work for EPC or OEM we see international companies winning the majority such as EPC being done by Middle Eastern AMEA and France's Voltalia with OEM being supplied by Chinese companies like JA Solar and Sungrow Power Supply and we expect this to continue. We are seeing many emerging markets such as Namibia and South Africa well as other countries, who we expect to be the some of the leaders of the region within the next decade, to gain an increasing amount of investment coming from outside the region, and with solar systems in general becoming increasingly cost-effective (as solar being the cheapest form of renewable energy) we expect this to catalyse the push for solar in the entire region creating a sustainable market.

Nabil Ahmed, Energy Analyst

3.4 Middle East & North Africa (MENA)

According to EICDataStream, over 38 GW of solar PV capacity is currently proposed for development between now and 2025, in the Middle East and North Africa region. Most countries in MENA have significant solar irradiation; all MENA countries were observed ranking in the top 50 countries for greatest global horizontal irradiation (GHI) and practical PV potential (PVOUT) in the World Bank Group's 2020 Global PV Potential Study. Saudi Arabia is leading the region in terms of capacity and number of projects and is planning to bring almost 10 GW of solar PV capacity online by 2025. A CAPEX of around USD$38 billion is estimated to be spent on solar PV projects across the region, which is over 60% of the estimated total CAPEX spend for all renewable projects in the pipeline in MENA. That being said, over USD$77 billion in CAPEX is estimated to be invested in conventional power including nuclear until 2025; solar PV investment is at the moment less than 50% of this, demonstrating how the region still has a long way to go in its energy transition

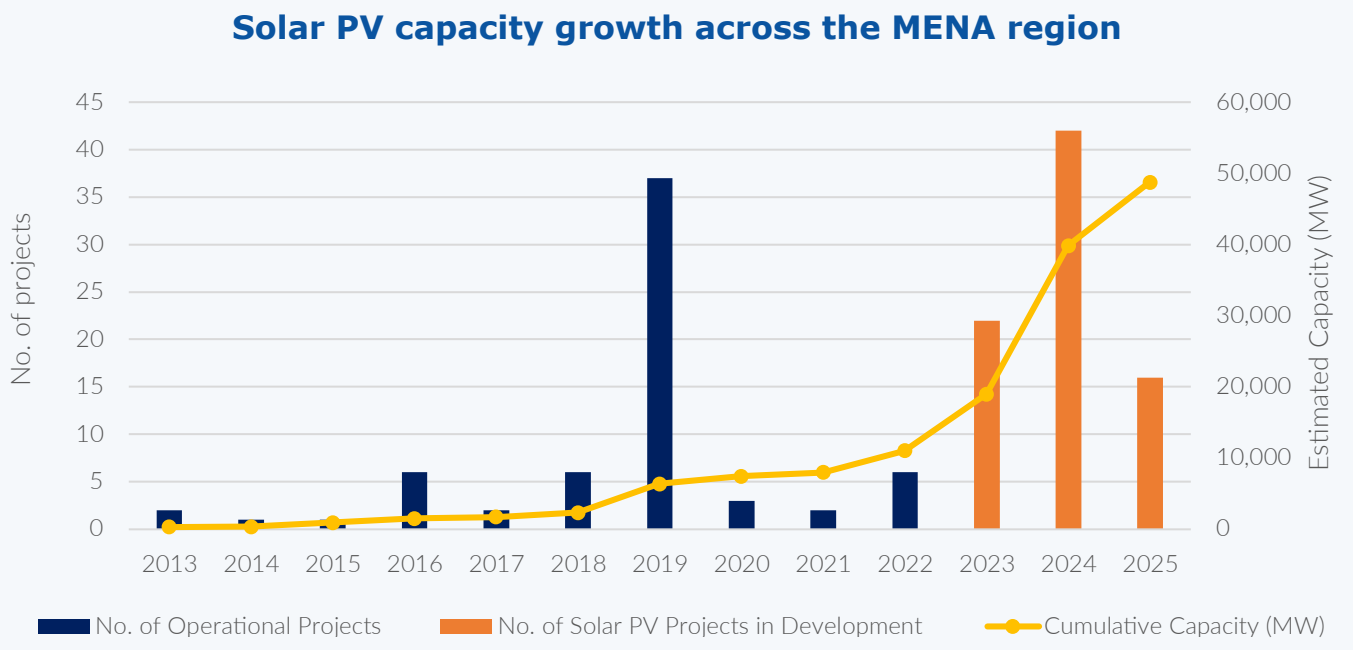

Figure 3.4.1: Solar PV capacity growth across the MENA region.

Source: EICAssetMap and EICDataStream

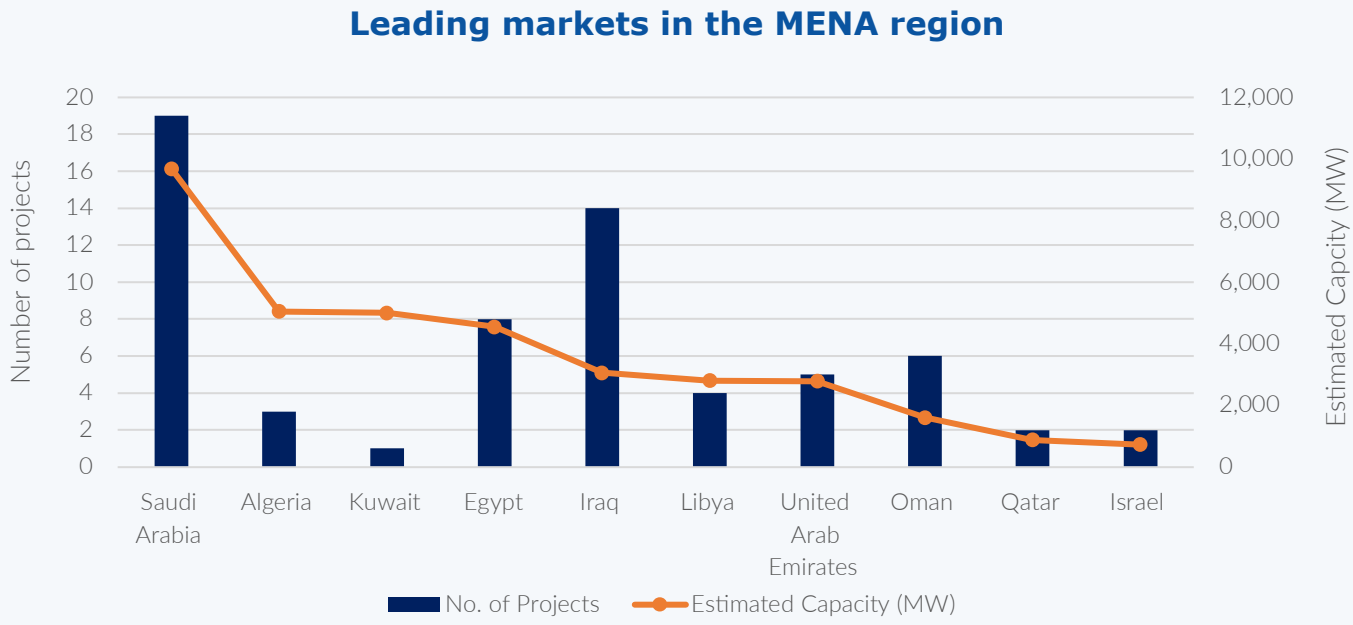

Figure 3.4.2: Leading markets in the MENA region.

Source: EICDataStream

Cost of solar in MENA

Currently, though, several countries in the region are amongst global growing markets in renewable any development. The auction mechanisms that many countries in the MENA region have delivered on the trend of world-record solar prices as many proposed solar developments are large capacity utility scale projects meaning that the economies of scale have been reached quicker in the region compared to other regions. Some of the records broken in the region since 2019 are listed below:

- Saudi Arabia: April 2021 – 600 MW Faisalia Solar PV USD$0.0104 /kwh – which broke the number 1 record for solar PV
- Saudi Arabia: April 2021 – 1.5GW Sudair Solar PV USD$0.0124 /kwh – which broke the number 2 record for solar PV
- UAE: April 2020 – 2 GW Al Dhafra Solar PV USD$0.135 /kwh – which broke the number 1 record for solar PV

Collectively, many MENA countries perceive renewable development as an opportunity to decarbonise industry, expand the energy sector value chain, and incorporate new technologies. Some countries like Morocco are going even further with solar development on a social level encouraging a local industry through skill expansion and creating new jobs. Generating energy from solar and other renewables also benefits key oil and gas markets in the region who can export more O&G to import markets in both Europe and Africa, rather than use oil and gas for power, whilst reducing their own emission intensity. With COP27 hosted in Egypt in November 2022, and COP28 to be hosted in the UAE in 2023, the MENA region's climate emissions and achievements have and will continue to be under global scrutiny, as well as offering the region an opportunity to become a climate action leader. Diversification of energy systems is also desired by major local operators who have ambitions to grow beyond fossil fuels in the long run which has created a huge pipeline for green hydrogen projects in the region. Since the pandemic began, various collaborations in the forms of MoUs have been announced between energy companies in MENA and global energy majors for production of green hydrogen using solar PV as the main powering source, thus incentivising solar PV development. Additionally, the global price for batteries is assisting in building a business case for energy storage with projects being announced in Jordan, Morocco, Saudi Arabia, Oman, and Israel.

Country	Clean Energy Ambition	Solar Capacity target
Algeria	22GW of renewable capacity by 2030	15GW of solar by 2035
Kuwait	15% RES by 2035	N/A
Egypt	42% of RES in electricity by 2035	N/A
Morocco	52% RES in installed capacity of clean energy by 2030; 10.5GW in renewable capacity	~2GW by 2030 of solar PV and CSp
Saudi Arabia	50% RES by 2030; 60GW renewable capacity	27.3GW by 2023; 40GW solar PV by 2030

Table 3.4.1: *Summary of Clean Energy Ambitions and/or Solar Targets in MENA*

Morocco

With a renewable target of 10.5GW by 2030, Morocco is aiming for 20% of this capacity to be from solar (including both PV and CSP), 20% for wind and 12% from hydropower. Currently, a CAPEX of almost USD$8billion is estimated to be needed to bring online eight solar PV projects in Morocco by the end of 2027. A further USD$800 million in CAPEX is estimated to be spent for the hybrid NOOR Midelt 1 PV and CSP project which has an expected start-up in 2023 which is currently being constructed by Spanish engineering and industrial construction group, TSK. Morocco is also home to the world's largest concentrated solar power plant, the Noor Ouarzazate which has a capacity of 580 MW and came into operation in 2020. Morocco is currently evaluating the technology types that it has adopted over the last decade, in particular, PV and CSP with battery energy storage systems (BESS) to govern what technology types will be used in the future to achieve capacity targets. Further regulatory reform is expected; there is an absence of clear frameworks required for commercial and industrial (C&I) offtakers to access electricity from low voltage grid and there is no specific regulatory frameworks for independent production of solar power. Power trading between producers and suppliers does not yet exist in Morocco as the liberalisation of the market is not yet fully advanced. Electricity is traded, however, via PPAs between IPPs and government under the renewable energy law (Law 13-09) or PPAs between ONEE or MASEN under a build, own, operate, and transfer (BOOT) model.

Green Hydrogen in the MENA region

Due to its high renewable energy potential and geographical location between Europe and Africa, the country plans to use the Power-to-X concept to be a leader of green fuels production. In 2020, Morocco and Germany signed a cooperation for green hydrogen development and in March 2021, a national green hydrogen cluster, GreenH2, was announced to promote cooperation between national and international partners. The purpose of the cluster is also to prepare the regulatory framework for the hydrogen industry in Morocco to support the development of a new emerging industry. Green hydrogen agreements are becoming more and more popular with Morocco particularly with European neighbours.

Kuwait

Amongst the top ten oil producing nations, Kuwait is heavily dependent on oil-export revenues. Shifting supply and demand trends as a result of global politics has initiated oil-price volatility and market uncertainty for many oil-producers. New energy strategies as a result are being implemented to ensure economic development by reducing fossil fuel dependency and to diversify energy mixes. According to EICDataStream, approximately USD$6.7 billion is estimated to be invested in the two mega solar PV projects planned in Kuwait by 2026. Rather than smaller scale projects, the emerging market expects to, as idealised in the Kuwait Vision for 2035, to announce multi-packs of mega size projects to achieve its 15% renewable energy share target by 2030. The projects are government-led by organisations such as the Kuwait Authority for Partnership Projects (KAPP) and the Ministry of Electricity and Water (MEW) and are expected to issue EPC packages for the projects with assistance from consultancies, following many delays particularly for the 3GW Al Dibdibah Solar plant as part of Phase 2 of the Al Shagaya Renewable Energy Complex.

Despite its solar potential, the MENA region generally faces major challenges in increasing this capacity. Physical challenges include a lack of sufficient grid infrastructure to transport renewable power to highest demand as well as a lack of utility-scale storage for the capacity generated. The region is also recovering from reduced energy demand caused by the pandemic whilst power generation is at overcapacity and current regulatory frameworks aren't incentivising investment as much as they should. Like many other regions, if framework and guidance for corporate power purchase agreements were implemented, this would assist in solar PV development further.

Figure 3.4.3 highlights major players in the MENA region whist Figure 3.4.4 is a geographical summary of key projects. Saudi's Renewable Energy Project Development Office (REPDO) are seemingly the leading operator in the region in terms of number of developments with ten planned projects in the pipeline at a capacity of over 4.6GW. It is worth noting that projects in Saudi Arabia are often developed on a Build Own Operate (BOO) model – REPDO are responsible for running the licensing programmes where developers such as ACWA Power, EDF Energy and Masdar are awarded BOO contracts. Tendering BOO contracts for solar PV projects is likely part of the strategy to meet the NREP targets including to encourage public-private partnerships and to allow private investment in renewable energy. Across the region, ACWA Power are the named operator for seven projects with a total planned capacity of 3.3 GW and have also been awarded sixteen BOO contracts over the last five years, either independently or in a joint venture, for planned or now operational solar PV projects.

The Kuwait Authority for Partnership Projects (KAPP) is leading in the region in terms of largest capacity development; 8 GW of solar PV is expected to be constructed over two projects. The 3 GW Al Dibdibah Solar Plant as part of Phase 2 for the Al Shagaya Renewable Energy Complex is currently in feasibility stage with expected start up by 2026. The project is part of the Shagaya Renewable Energy Master Plan which the Kuwait Institute for Scientific Research (KISR) originally proposed a 70 MW demonstration facility. The second phase consists of a plant expansion to 1.5 GW and a further 2 GW in the third phase; though phases 2 and 3 were merged in September 2022. These phases will be offered to investors on a Build, Operate, Transfer (BOT) model. The BOO and BOT model is a growing trend for the procurement of renewables across the region with 26 BOO or BOT/OT contracts being awarded for projects up to 2025 in MENA, according to EICDataStream. Many of these contracts also seem to encourage foreign investment with international companies such as Scatec Power and Voltalia being awarded BOO contracts for the Borj Bourguiba Solar PV project as well as Phase of the Ain Beni Mathar of the Noor PV II Project.

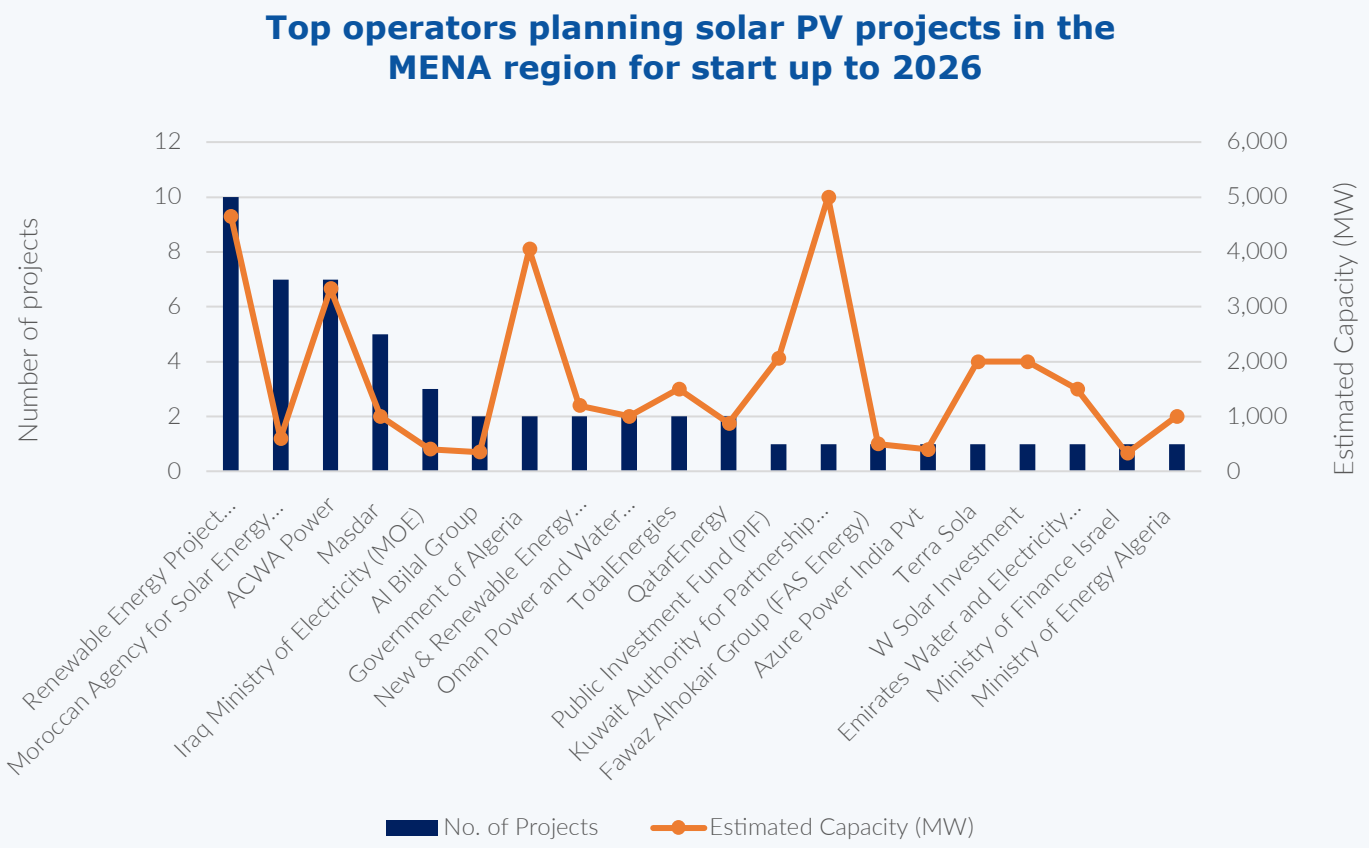

Figure 3.4.3: *Top operators planning solar PV projects in the MENA region for start up to 2026.*

Source: EICDataStream

In Morocco, private project developers are supported by the Moroccan Agency for Sustainable Energy (MASEN) who are responsible for permitting, tendering of projects and financial aspects including securing state guarantee of investment. This role was previously carried out by the Office National de l'Electricité et de l'Eau potable (ONEE - Morocco's National Electricity and Drinking Water Company), however MASEN continued the programme developed by ONEE to install 500 MW solar power capacity by 2020. MASEN are currently operators for seven solar PV projects with a capacity just under 600 MW which, similarly to KAPP and REPDO are developing the projects under an IPP model and award BOO contracts to developers. Xlinks is also a significant player in the region, particularly as they announced the 7 GW Sahara Desert Solar PV project in 2022 for startup in 2027. Amongst the largest projects in the region and in collaboration with the UK's Octopus Energy, Xlinks plan to construct the plant over approximately 200 km2 in the Sahara Desert in Morocco, which will also be connected to a 5GW/20 GWh storage system. The purpose of the project is to export the power generated to the UK exclusively via 3,800km of HVDC undersea cables, which could potentially contribute to solar PV becoming a major export commodity for Morocco.

Geographical summary of key projects in the MENA region

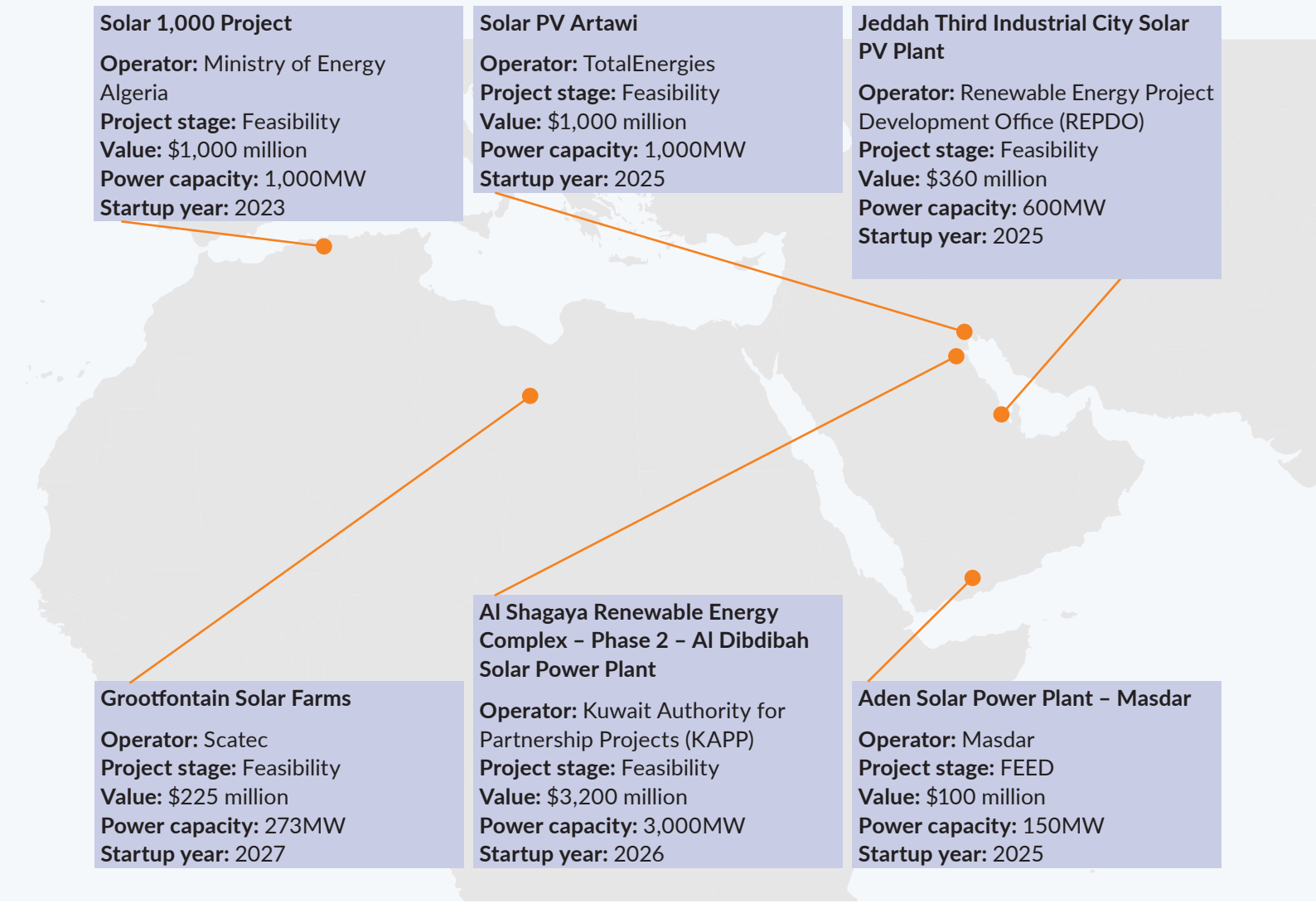

Figure 3.4.4: Geographical summary of key projects in the MENA region.

Source: EICDataStream

3.4.1 Saudi Arabia

According to EICDataStream, Saudi Arabia is planning to bring almost 10GW of utility-scale solar PV projects online by 2026. In 2016, Saudi Arabia released the Vision 2030 which acknowledged that in order to achieve its target of 60GW of renewable energy by 2030, a competitive renewable energy sector would need to be established. However, it appears unlikely that this target will be met. Under Vision 2030 and the King Salman Renewable Energy Initiative, the National Renewable Energy Program (NREP) was established to maximise the potential of renewable energy in Saudi Arabia. It is via this programme that pre-developed projects are tendered.

NREP targets

- Short term (2021-2023): Increase local content, established LCOE price baseline, kickstart supply chain
- Medium term (2024-2025): Become globally competitive, established local content and LCOE, set up solar and wind clusters
- Long term (2028 onwards): Become a Renewable Energy Industrialisation Hub, established local content and LCOE, exporter of renewable energy supply chain

In 2021, a renewable energy target of 50% was announced and the other 50% of power would be supplied by natural gas rather than oil as part of the Saudi Green Initiative. According to EICDataStream, just almost 12GW of renewable energy capacity is estimated to come online by 2025, so Saudi Arabia will need to ramp up capacity to meet its target. Another incentive for the country to support renewable deployment is their pledge for net zero emissions by 2060 and a government investment of more than USD$180 billion was announced at the end of 2021. Saudi Arabia's Renewable Energy Project Development Office (REPDO), who were established to oversee the NREP, plan to lead in development of 30% of the targeted renewable energy capacity via competitive auction tenders whilst the sovereign wealth fund, Public investment Fund (PIF), is expected to develop the remaining 70% via direct contract negotiation.

Of the 2030 renewable energy target, 40GW of solar PV capacity, 16GW of wind capacity and almost 2.7GW of concentrated solar power (CSP) capacity will be required to be developed. An interim target of 27.3 GW by 2023 was announced in 2019, an increase from the initial target 9.5GW capacity by 2023. Of the interim renewable energy target, 20GW of PV capacity, 7GW of wind capacity and 300MW CSP capacity is expected to be developed. According to EICDataStream, however, just over 3 GW of solar PV capacity is estimated to come online by the end of 2023; frameworks and regulations to incentivise solar PV have not been developed. The emphasis of solar in the REPDO programme and NREP shows promise of ambition in solar PV development, however.

A Privatisation Law established in 2021 increases the private sector's involvement in infrastructure projects whilst Saudi Arabia issued a green bond in October 2022 – the first of its kind on a sovereign wealth fund – to diversify the investor base and project funding sources. The cross-border city mega project, NEOM, which incorporates, solar PV, battery energy storage, green hydrogen production and transmission is aimed to play a key part in diversifying Saudi Arabia's economy. It is estimated to require 20 to 40GW of solar and wind projects alone to meet the power requirements which makes solar development over the next decade critical for Saudi Arabia.

3.4.1 Analyst Opinion

The goals set by countries such as the UAE, Saudi Arabia, Egypt and Oman will be the main driver to increase the share of renewable energy in the future, especially utility-scale solar. Companies and governments in the MENA region are willing to invest in solar due to the large open spaces available and the year-round availability of sunshine. As the MENA region is looking to become a major hydrogen exporting region, especially for green hydrogen, countries in the region will look to push on utility-scale solar projects as renewable energy is cheaper when compared to utilising fossil fuels. From the eyes of the analyst, solar activities in the region are highly active, with 57 contracts awarded between 2019 and 2022. These contracts include Engineering, Procurement, and Construction (EPC), subcontract, OEM supply, and installation contracts. The majority of projects awarded are from the UAE, Saudi Arabia, Morocco, and Egypt. most operators in the region tend to be state-owned such as Emirates Water and Electricity Company (EWEC), Dubai Electricity and Water Authority (DEWA), Renewable Energy Project Development Office (REPDO), and Moroccan Agency for Solar Energy (MASEN).

Wan Afiq & Faiz Halim, Energy Analysts

3.5 Asia Pacific (APAC)

According to EICDataStream, the APAC region offers the most solar PV investment opportunities globally, with rapid deployment of plants in developing countries like India who are looking to maintain dominance in the global market. According to EICDataStream, a CAPEX of almost USD$190 billion to 2025 is estimated, with both foreign and national investment contributions seen. This is set to rise as many countries in the region continue to make renewable energy commitments. Leading the region in terms of capacity and predicted investment is India with an estimated of CAPEX spend of over USD$108 billion to bring over 120 GW of solar PV capacity online by 2025, followed by Australia who are planning to develop almost 30 GW of solar PV capacity by 2025. Solar PV is the fastest growing energy source in Australia and is proving to be an emerging market in solar with approximately 10% of the country's electricity being generated by solar PV energy in the period of 2020-2021.

The APAC solar PV market is also showing evidence of diversifying to incorporate other clean technologies. Emerging markets in terms of large and utility scale solar PV include Malaysia and Indonesia amongst other south-east Asian countries who are beginning to invest in the floating solar PV market. Elsewhere co-location and hybridisation of solar PV with wind and energy storage is also a growing trend in the region. A push for solar PV as a source for green hydrogen production can be seen in Australia in particular. In general, APAC countries are looking to diversify their energy mixes regardless of whether the market is established or emerging. The energy transition is also directing national agendas across the region and is impacting many industries and markets. With an expected increase in energy demand over the next few decades, there is a need for alternative energy sources to be implemented quickly to aid decarbonisation.

Country	Clean Energy Ambition	Solar Capacity target
Association of Southeast Asian Nations (ASEAN)	23% RES by 2025	N/A
India	Net Zero target by 2070; 500 GW renewable energy capacity target by 2030	333 GW of solar PV to be added between 2022 and 2032
Indonesia	Net Zero target by 2060; 23% RES by 2025	~5 GW of solar PV capacity by 2030
Australia	Net Zero by 2050; 82% RES by 2030	N/A
Philippines	35% RES by 2030 and 50% by 2040; 15.3 GW of renewable capacity by 2030 and over 20 GW by 2040	2.3 GW of solar PV capacity by 2030
Malaysia	20% RES by 2025, 40% in renewable energy capacity by 2035; 18.4 GW of renewable energy capacity by 2040	4% solar PV in energy mix by 2040
Bangladesh	40 GW of renewable energy capacity by 2041	N/A
Vietnam	47% RES by 2030	45 GW in solar and wind capacity by 2030 (split unclear)
Singapore	Net Zero by 2050; 2 GW of solar PV and 30% of energy supply from low-carbon imports by 2035	At least 2 GW solar PV capacity by 2030
Thailand	Net Zero by 2065; at least 50% RES by 2050	15 GW of solar PV capacity by 2037
Pakistan	60% RES by 2030	13 GW of solar and wind capacity by 2030 (split unclear)
Japan	Net Zero by 2050; up to 38% RES by 2030	16% solar PV share of total generation by 2030
Taiwan	20% RES by 2025	20 GW of solar PV capacity by 2025; of which 8 GW of rooftop PV and 12 GW of ground mounts is targeted
New Zealand	50% of RES of total final energy consumption by 2035 and 100% renewable electricity by 2030	N/A

Table 3.5.1: *Summary of Clean Energy Ambitions and/or Solar Targets in APAC*

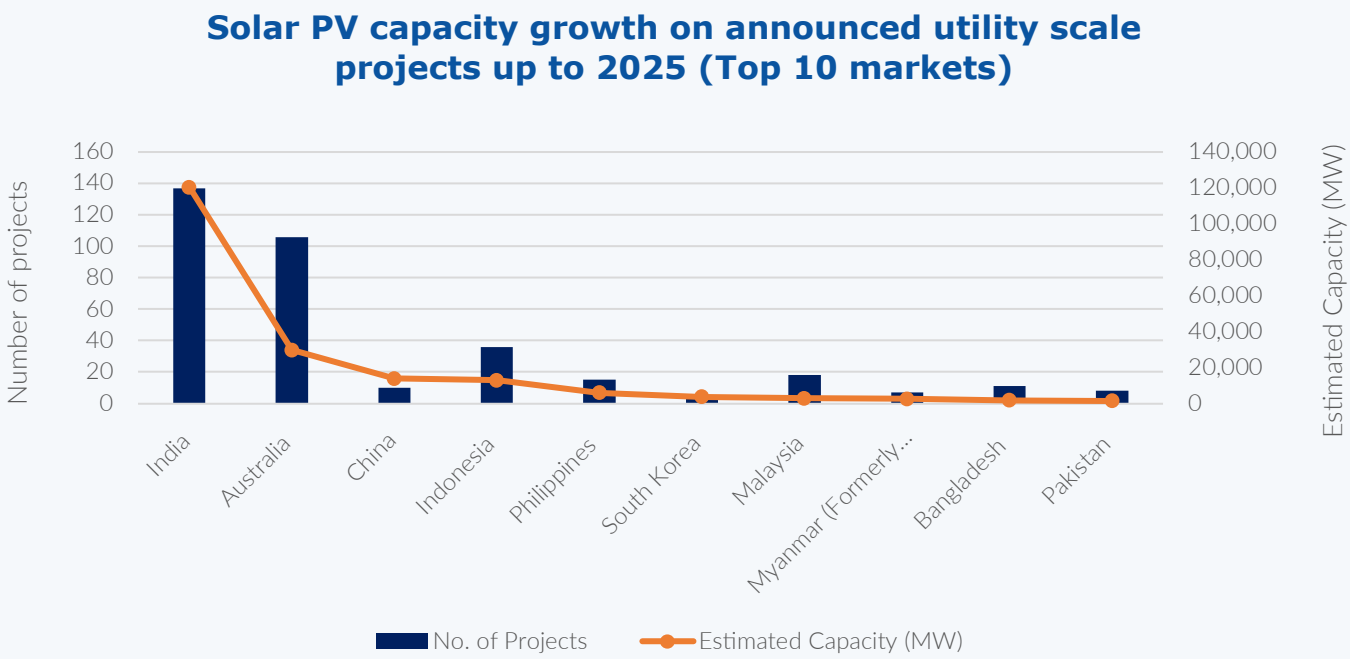

Figure 3.5.1: Solar PV capacity growth on announced utility scale projects up to 2025 (Top 10 markets).

Source: EICDataStream

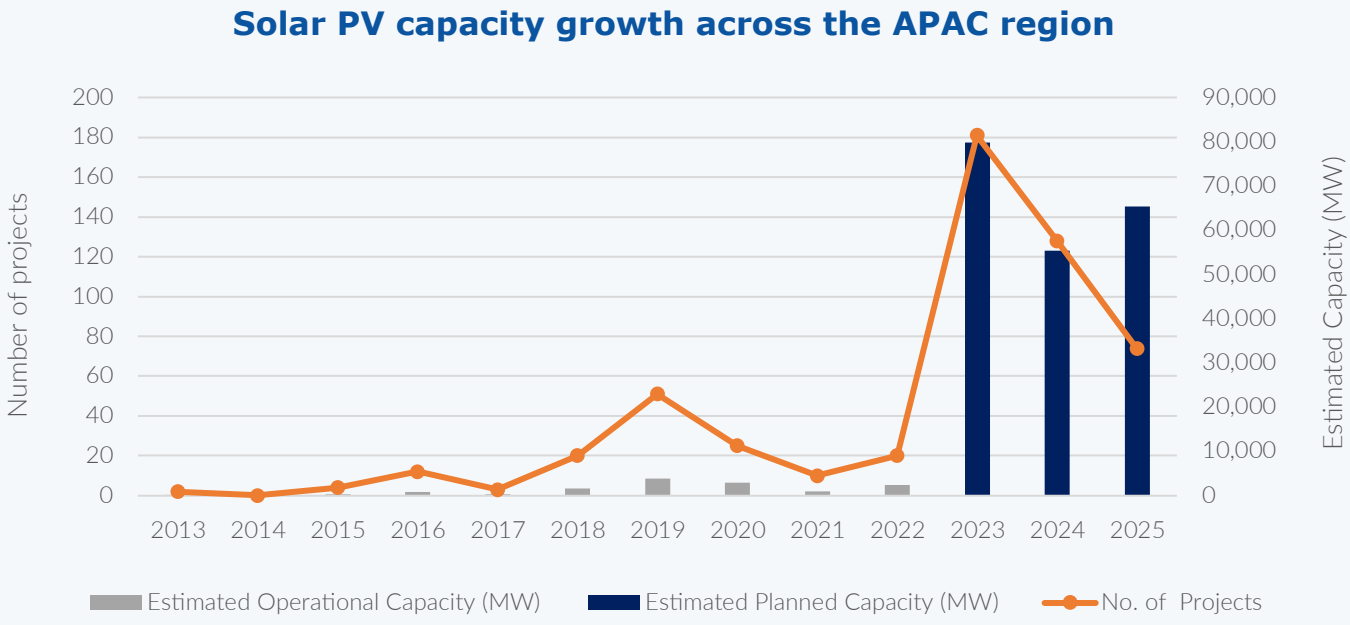

Figure 3.5.2: Solar PV capacity growth across the APAC region.

Source: EICAssetMap and EICDataStream

Floating Solar PV

Owing to the geography of the country, Vietnam, amongst other Southeast Asian countries, often has land limitations yet an abundance of water bodies. This feature is now being mitigated in the region with the development of floating solar PV (FPV) plants.

The 500 MW Dong Nai Floating Solar PV project is to be built in the Dong Nai province of Vietnam and is being developed by a Green Investment Group (GIG) owned company, Blueleaf Energy. The project is designed to have the capability to provide load-following and peaking power that would traditionally be provided by fossil fuel sources. A 200 MWh co-located battery energy storage system (BESS) is also planned as part of the floating solar project; this would certainly contribute to overcoming Vietnam's grid issues.

Elsewhere in the region, Indonesia is also emerging as a major FPV market. According to EICDataStream, almost 40% of all Indonesian solar PV projects in the pipeline are floating PV projects with a total capacity of almost 4 GW. As the world's largest coal exporter, Indonesia is pushing for renewables generation to meet growing electricity demand in the country; in 2020 the Indonesian Government set a target of 17 GW solar capacity by 2035. The Batam Floating Solar Project is one of the projects planned and is expected to come online by 2024. In July 2021, Singapore-based developer Sunseap signed a Memorandum of Understanding (MoU) with Badan Pengusahaan Batam (BP Batam) to build the FPV system with a co-located energy storage system at the Duriangkang Reservoir on Batam Island, Indonesia. With a capacity of 2.2 GW, it is the largest FPV system planned in the world, to date.

In India, the FPV market is also beginning to pick up pace. In 2017, Solar Energy Corporation of India (SECI) invited expressions of interest for 10 GW of floating solar power by 2022, to assess the feasibility of floating solar developments and has since issued tenders for various floating solar projects on Indian dams. In terms of operational capacity there are very few large-scale solar projects; the largest FPV plant was commissioned in March 2022 with a capacity of 25.3 MW. However, despite this, 8 GW of FPV capacity is expected to come online by 2026 according to EICDataStream. Increasing interest in India for FPV is largely due to the various water bodies available in the country. In India, ground-mounted solar plants occasionally suffer from performance degradation due to high operating temperatures; FPV benefits from the natural cooling effect offered by its location on water. Despite the country's potential, the government will need to set policies and supporting standards to enable FPV in India to contribute to the energy mix; FPV offers a new pathway for India to achieve its renewable energy ambitions as well as opening opportunities in domestic manufacturing.

Figure 3.5.3 shows the leading operators in the region who are planning solar PV projects to 2025 and Figure 3.5.4 is a geographical summary of some projects in the APAC region. Solar Energy Corporation of India (SECI) is the leading operator in the region with almost 28 planned projects in the pipeline with a total capacity over 29 GW for start up to 2025. It is worth noting, however, that the nature of the Indian solar market has skewed this data; SECI and other government bodies auction utility scale solar projects of at least 500MW – often termed as Ultra Mega Solar Power Project (or Park) – within a park on a build-own-operate (BOO) basis to developers such as Adani, Tata Power and ReNew Power, but the overall park is owned by the government.

In June 2021, NTPC increased their commitment to build 60 GW of renewable energy by 2032 from 32 GW and this has been agreed with the UN as seen in their UN Compact. In late 2021, NTPC also signed an MoU with Indian Oil to collaborate in renewable energy development as a means to support India's renewable energy ambitions and to reduce greenhouse gases (GHGs). According to EICDataStream, NTPC have over 18 GW in solar PV capacity for planned projects and projects under development – although, similarly to SECI, many of the projects are being developed on a BOO basis.

Adani Green Energy, the solar-specialised subsidiary of Adani Group, are a major player in India who have committed to the 1.5-degree pathway via the Science Based Targets initiative (SBTi). Just like Lightsource BP, Adani Group itself have also committed via their UN Compact to increase their portfolio of renewable projects to 25 GW by 2025 and to 45 GW by 2030. In late 2021, the Group further announced that they will invest over USD$50-70 billion in renewable energy over the next decade, of which 70% of planned CAPEX to 2030 would be dedicated to the energy transition. Investments towards the energy transition will include collaboration with potential partners for electrolyser manufacturing and backward integrations for component manufacturing to secure the supply chain for the solar PV and wind generation businesses within India, essentially contributing to the NSMM campaign (See 3.5.1 India).

According to EICDataStream, Adani has already announced a project pipeline of an estimated 17.5 GW in capacity, which shows good progress towards meeting their ambitions. Additionally, the company has committed via their UN Compact to provide reliable energy via hybrid projects and to increase their solar manufacturing capacity to 2 GW per year from 2022 onwards. Adani's involvement in the Gujarat Hybrid Renewable Energy Park includes a solar-wind hybrid plant with a capacity of 9.5 GW; again, which will contribute vastly to their ambitions.

Elsewhere in the region, Sunseap is also emerging as a major player and are operating multi megawatt projects in Singapore, Japan, Taiwan, Vietnam, and Cambodia. According to their 2020 Sustainability report, they intend to cut their GHG emissions by 25% by 2025 and are committed to increasing the recycling rate of raw materials used in production by 90% by 2025 with an additional aim of repurposing PV panels to become floating panels. The company is also planning a floating solar PV plant in Indonesia, the Batam Floating Solar Project on the Duriangkang Reservoir which is to have a production capacity of 2.2GW. This is vast increase in Sunseap's current operational capacity, especially as by the end of 2020, the company had just reached 300 MW in operational capacity. Reaching this scale of capacity has proved likely since Portuguese major, EDP Renewables (EDPR), acquired a 91% stake in Sunseap in November 2021. The acquisition is intended to combine EDPR's expertise in scale with Sunseap's regional knowledge which will allow EDPR to access the SE Asian market.

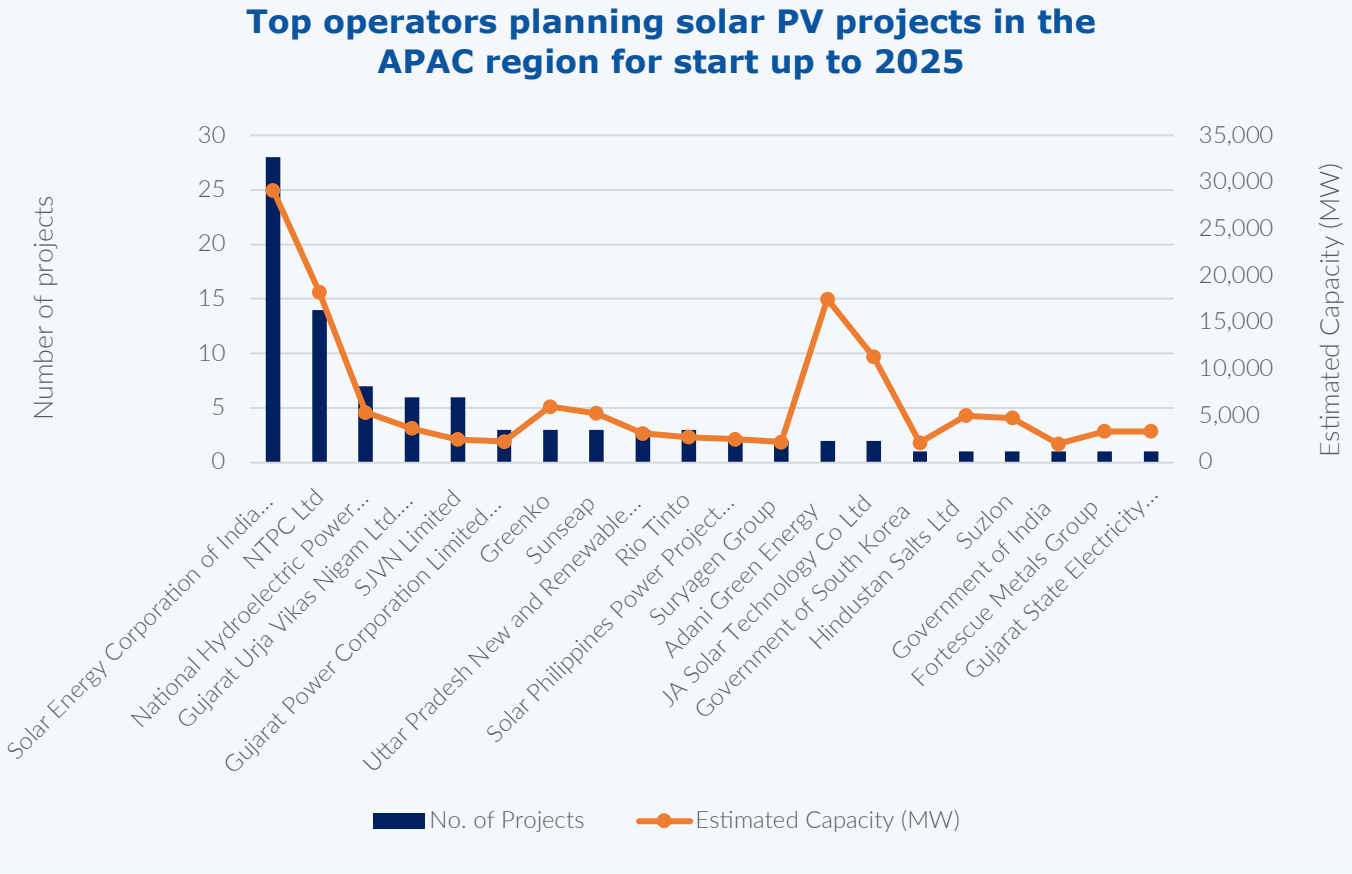

Figure 3.5.3: *Top operators planning solar PV projects in the APAC region for start up to 2025.*

Source: EICDataStream

Geographical summary of key projects in the APAC region

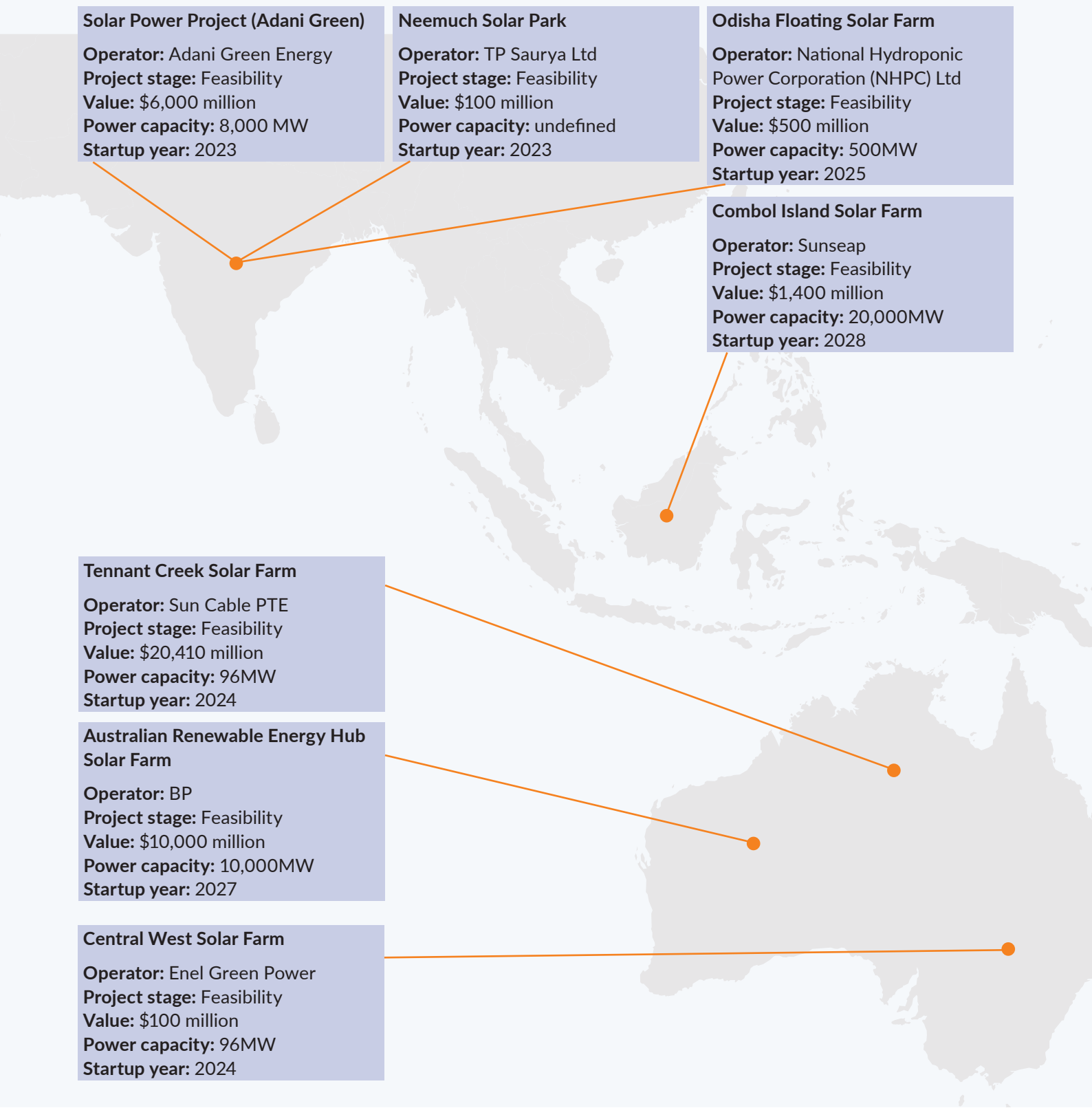

Figure 3.5.4: Geographical summary of key projects in the APAC region.

Source: EICDataStream

3.5.1 India

During negotiations around the Paris Climate Agreement, Prime Minister Narendra Modi launched a global solar alliance with 120 countries and in May 2017, construction commenced on India's first green energy corridor to promote the grid integration of renewable energy. Under the country's 2016 agreed National Determined Contributions (NDC), India set a goal of achieving a total installed renewable capacity of 175 GW by 2022, with solar PV making up 100 GW of this capacity goal. According to the Ministry of New and Renewable Energy in September 2022, the country was short of this ambition and had an actual installed renewables capacity of just over 118 GW. It had also underachieved its solar target with actual installed capacity reaching around 60 GW. According to the Climate Action Tracker, the growth of renewables is not fast enough for the Paris Agreement; to be compatible with the 1.5-degree Celsius limit, India would need to reach 55-79% renewable energy capacity by 2030, with a fully decarbonised power sector by 2050. That being said, net capacity additions between 2020 and 2022 alone totalled to 22.5 GW in solar PV, suggesting that the pandemic has not impacted India's commitment to solar energy expansion.

According to the World Bank's Global Photovoltaic Power Potential study, India has a theoretical potential of 5.098 kWh/m2 and ranks 104 out of 183 countries analysed, in terms of irradiation (more specifically Global Horizontal Irradiation). Much of the solar potential is in the north-western region and this potential has been harnessed as evident by the number and magnitude of solar projects in the pipeline for the states of Rajasthan, Gujarat, and Andra Pradesh; these states collectively have around 67 GW of solar PV capacity in pipeline to 2025, according EICDataStream. The state of Rajasthan is home to one of the largest solar PV plants in the world, the Bhadla Solar Park, which has a capacity of almost 2 GW. Developed in phases, NTPC Limited, one of India's major developers, auctioned around 400 MW of capacity in the first phase, prior to SECI auctioning the remaining in further phases – most recently an additional 500 MW is being planned at the park.

India, in a similar fashion to many Middle Eastern countries, has taken the approach of developing 'ultra-mega parks' of solar power so as to reduce project costs per MW, as well as to eradicate the grid capacity and transmission challenges associated with dispersed, smaller-scale projects. These large-scale auctions have contributed to India's relatively fast renewable energy development at rapidly decreasing costs. The LCOE has declined by approximately 60% between 2016 and 2021, according to IRENA, from USD$0.077/kWh to USD$0.028/kWh, due to the reduction in CAPEX costs. As part of India's Atmanirbhar Bharat or Self-reliant India campaign, a goods and services tax (GST) was implemented on renewable equipment as well a 40% and 25% Basic Custom Duty (BCD) on the import of solar modules and solar cells respectively, to encourage domestic production. Before it was issued, there were concerns that the cost of solar would increase, however recent auction results indicated that the cost had not increased dramatically. For example, in September 2022, Indian developer, Avaada Energy won 300 MW of solar PV capacity at a tariff rate of USD$0.035/kWh from a 500 MW solar project auction – Maharashtra State Electricity Distribution Co. (MSECL)'s Phase 8 auction.

Domestic manufacturing in India

To further increase domestic production capacity, the Indian Government also launched INR24,500 crores (~USD$320 million) in Production-Linked Incentives (PLI) for high-efficiency solar PV modules in November 2020, which has since been provided with a further INR19,500 crores (~USD$256 million), with the aim in making India a net exporter rather than net importer of solar equipment. The Incentive requires applicant manufacturers to set up a plant with a minimum capacity of 1 GW with a maximum set at 2 GW to produce solar modules with a minimum efficiency of 19.5%. In the budget for the current financial year (FY22/23), the government has said that they will give priority to "fully integrated manufacturing units from polysilicon to solar PV modules." The Indian Renewable Energy Development Agency (IREDA) announced the winning bidders for the oversubscribed May 2021 PLI tender which invited bids to set up 10 GW of high-efficiency solar module manufacturing capacities. Reliance New Energy Solar, Shirdi Sai Electricals, and Adani Infrastructure each bid to construct 4 GW of manufacturing capacity for which 2 GW will be subsidised with the PLI and their facilities will manufacture polysilicon, ingot-wafer, solar PV cells and modules.

With the objective to ensure the validity and reliability of solar PV manufacturers, in 2019, the Ministry of New & Renewable Energy (MNRE) issued the "Approved Models and Manufacturers of Solar Photovoltaic Modules Order" which provides a list of all manufacturers eligible for use in solar PV projects under government schemes, namely the Approved List of Models and Manufactures (ALMM) and renews this list annually. Despite the push in domestic manufacturing with mechanisms like the Basic Customs Duty (BCD) and PLI, the ALMM may hinder the solar supply chain in India as it generates difficulties for existing manufacturers who rely on various Chinese imported components to domestically manufacture solar PV panels. The impact of increasing the BCD will potentially push costs up for Indian manufacturers; negatively impacting India's supply chain, which may in turn slow down India's domestically produced solar ambitions.

State-level solar parks with capacities of 500 MW and above have become both a policy tool for the Indian government to reach overall renewable energy targets, as well as ensuring that states meet their renewable energy purchase obligations. The projects have enabled significant cost reductions, for example through shared project infrastructure. During the auctioning process for the Bhadla Solar Park in May 2017 bid prices reached INR2.44/kWh (USD$0.032/kWh), lower than the price for new super-critical coal plants in India and is amongst the lowest bids for solar power globally. Whilst solar irradiation levels are highest in Rajasthan, other projects have attained similar tariff bids, such as INR2.65/kWh (USD$0.035/kWh) for the Radhanesda Solar Power Park in Gujarat, and INR2.97/kWh (USD$0.039/kWh) for the Rewa Solar Power plant in Madhya Pradesh.

In 2011, SECI was set up by the Ministry of New and Renewable Energy (MNRE) to facilitate the implementation of government schemes and to achieve the country's ambitious solar development targets. One of the first major programmes to be launched was the Jawaharlal Nehru National Solar Mission (JNNSM), which was supported by the 2014-launched scheme for "Development of Solar Parks and Ultra Mega Solar Power Projects." JNNSM and the scheme had an initial target of 20 GW installed capacity by 2022 but this goal was reached ahead of schedule at the beginning of 2018. Since then, this target has increased to 100 GW of installed solar capacity by 2022 and at least 285 GW by 2030; unfortunately, as previously mentioned this was not achieved for 2022.

Figure 3.5.1.1. shows the trends of project announcements since 2018. Compared to the often-oversubscribed tenders issued by SECI in 2017 and 2018, a slowdown in the sector was observed with many tenders remaining undersubscribed since 2019. Delays to payments made by state-run distribution companies, delays in power-purchase agreement (PPA) signings, and mandatory tariff ceilings under auctions have been major factors in the decline of investors' interest. This trend of undersubscribed tenders as well as the impact of the pandemic on supply chain among other effects of the pandemic, has potentially hindered India's ambitions to achieve their 100 GW goal. Despite this, following the post-pandemic recovery and the rapidly decreasing costs of solar in that same period, solar has once again attracted developers to bid in auctions and sign PPAs which has resulted in an increased number of projects being announced since 2020.

It is expected that between 2023 and 2025, developers – particularly government producers known as CPSUs – will rush to meet project execution timelines and clear backlogs of projects following undersubscribed tenders, as indicated in Figure 3.5.1.2. In terms of policy changes, we will likely see a further push for subsidies for utility scale solar PV, especially with the increasing cost of solar imports, to facilitate growth in the sector. Over 10% of tendered Indian solar PV projects in the pipeline are expected to include domestic manufacturing, to combat import dependence on solar equipment – largely from China and to create market competition with Chinese manufacturers.

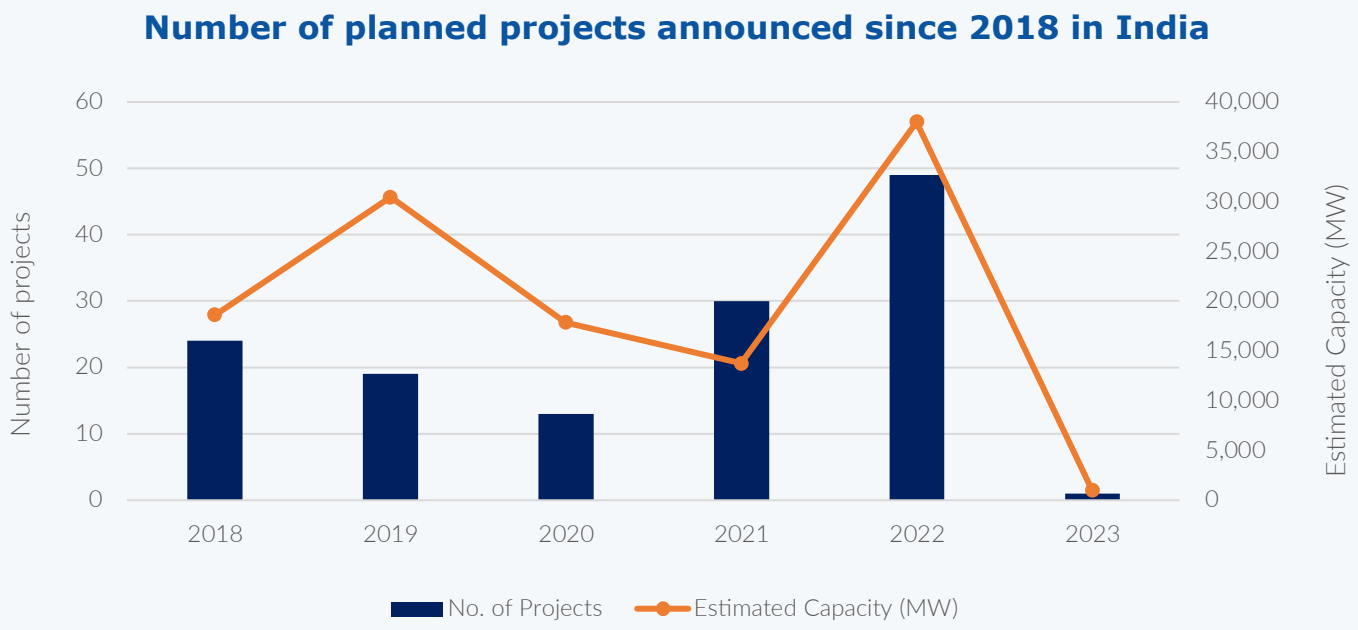

Figure 3.5.1.1: *Number of planned projects announced since 2018 in India.*

Source: EICDataStream

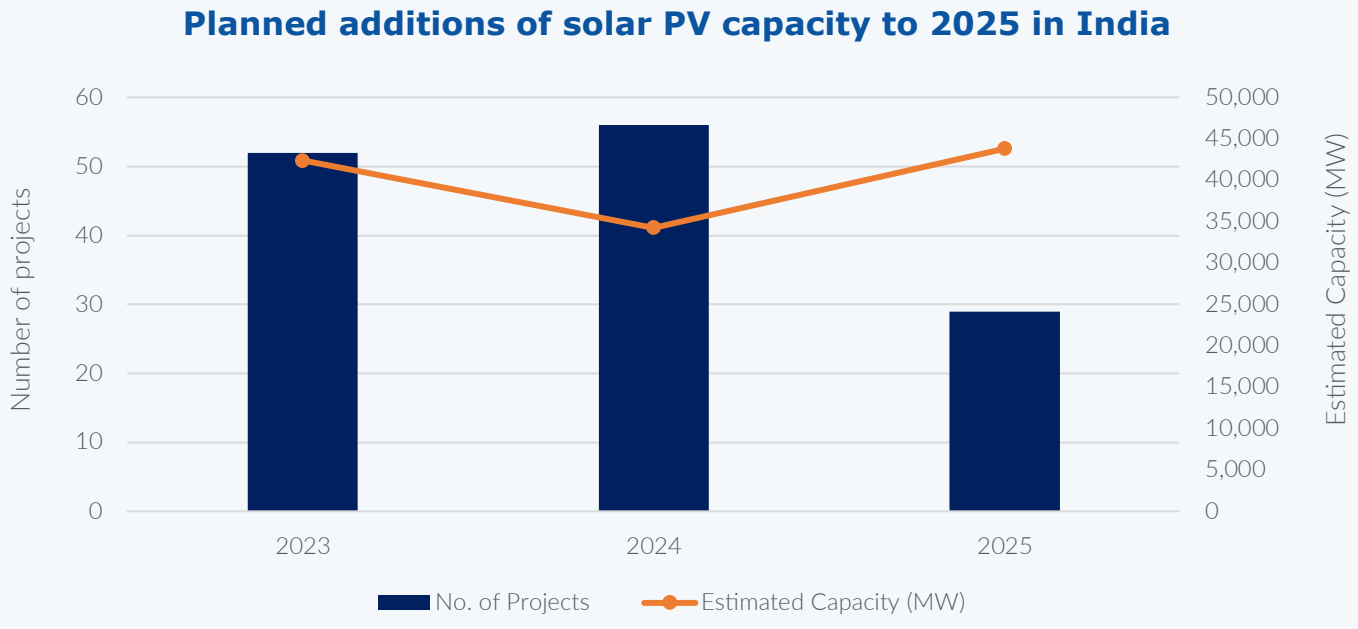

Figure 3.5.1.2: *Planned additions of solar PV capacity to 2025 in India.*

Source: EICDataStream

Diversifying the sector

Over the next decade the Indian government is planning to issue an increased number of hybrid renewable energy tenders particularly for the coupling of wind energy with solar. Variability in solar and wind generation has been a concern for many investors, especially considering these technologies are set to increasingly contribute to the global energy mix. The hybridisation of wind and solar is a solution that can reduce this variability due to their complementary natures in a united system; solar generation is greater during the day whilst wind generation can be greater at night. Hybridisation also increases overall renewable energy generation capacity which improves economies of scale, whilst also reducing transmission costs as hybrid projects can share transmission lines. Over 7.5% of Indian solar PV projects with estimated start-up by 2025 in EICDataStream are wind-solar hybrid projects demonstrating the beginnings of India's adoption of hybrid power.

Storage solutions for standalone solar projects as well as hybrid projects are increasing too, in India. Be it the coupling of pumped hydro power or battery energy storage systems (BESS), in EICDataStream we are seeing approximately 10% of projects in the pipeline incorporating storage systems with solar projects. With ambitious renewable energy capacity targets and an increasing penetration of variable renewable energy generation, we are observing an increasing number of tenders inviting bids from developers to incorporate storage components including grid-connected storage, to overcome supply and demand issues and grid stability challenges, particularly for hybrid projects too. A total of 4,000 MWh in pilot tenders for standalone energy storage is expected to be launched by the government.

Tata Power has already shown interest in coupling BESS with solar after being awarded a contract in 2021 to develop the 50 MW Ladakh Battery Energy Storage facility at the 50 MW solar plant that Tata Power is also developing and expected to come online in 2023. In government, SECI launched a 500 MW/1 GWh pilot tender in April 2022 for a standalone BESS project to connect to the Indian interstate transmission system (ISTS) and to assist in India's growing renewable energy capacity, which was awarded to the subsidiary of Indian utility, JSW Energy in August 2022. Elsewhere, state-owned power company, NTPC also issued a tender for a 500 MW/3,000 MWh storage system on a build-own-operate (BOO) basis in January 2022. Greenko won the lowest bid for the tender for a pumped hydro energy storage (PHES) plant in December 2022.

In India's transition to becoming a net exporter than importer of energy, hydrogen has been introduced as a viable fuel to assist in this transition. In early 2022, the government announced its first phase of the National Hydrogen Policy to promote green hydrogen production with the ambition to produce five million tonnes of green hydrogen per annum by 2030. This, in turn, would require increased wind and solar capacity to meet India's green hydrogen ambitions. The private sector is showing interest in supporting hydrogen ambitions with increased renewable capacity. For example, in July 2022, Indian developer Acme, announced plans to build a 5 GW solar PV plant which would power a 1.5 GW electrolyser to produce green hydrogen and 1.1 MT of ammonia.

3.5.2 Australia

As evident by the irradiation map in Figure 3.5.2.1, Australia has an abundance of solar energy potential; its latitude and dry climate are also beneficial for generating solar energy. According to EICAssetMap, the country currently has over 5 GW of operational solar capacity and according to EICDataStream, over USD$31 billion in estimated CAPEX spend to bring almost 30 GW in solar PV projects online by the end of 2025.

Solar potential in Australia

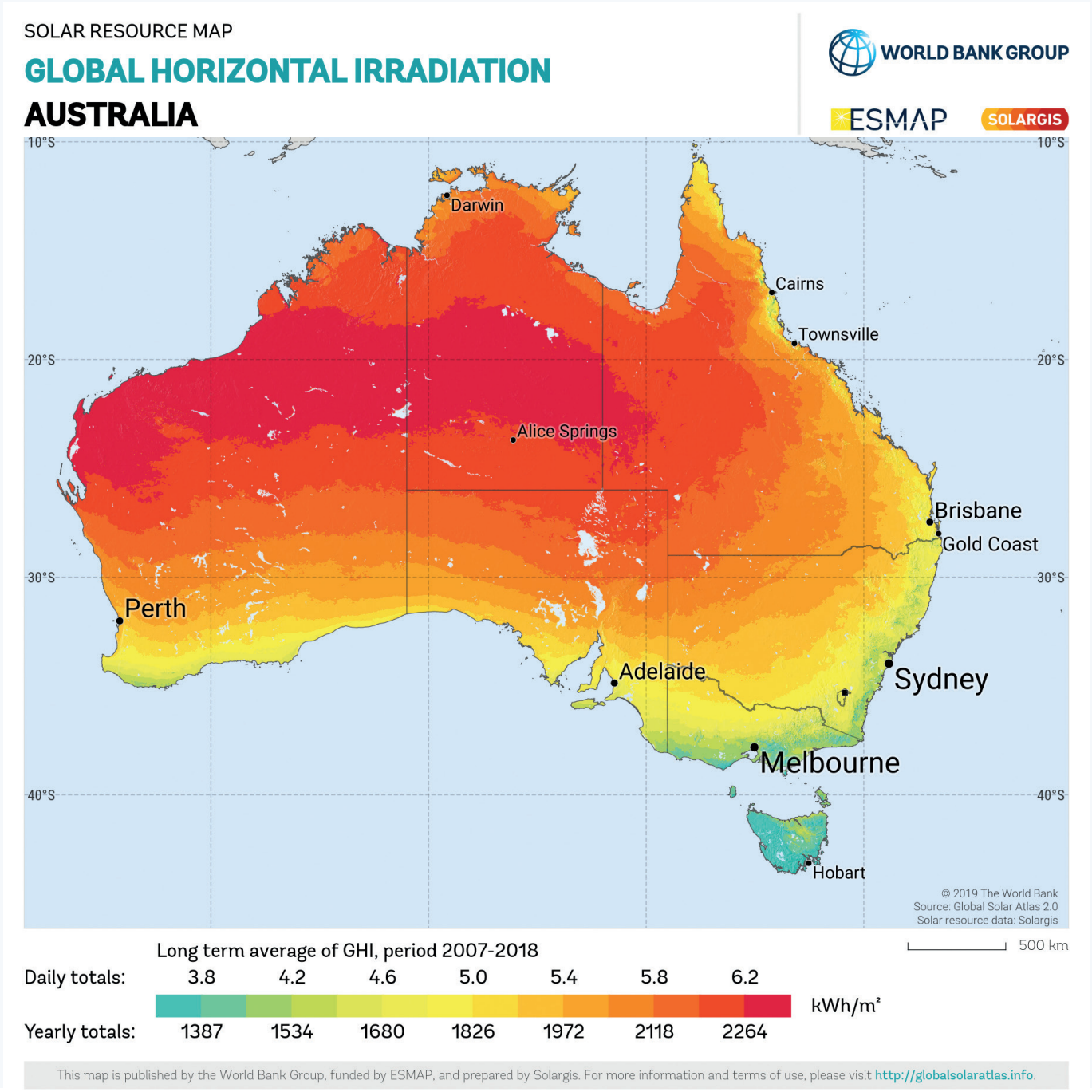

Figure 3.5.2.1: Solar potential in Australia. © 2020 The World Bank.

Source: Solar Gis

Australia has begun its transition into a low-carbon economy, however, it is still heavily reliant on coal which made up around 50% of the fuel mix in 2020 and is one of the country's leading exports. In June 2022, Australia was struggling with an energy crisis which led to blackouts across the Eastern states of the country. The crisis was triggered by a combination of events including the impact of the Ukraine crisis on global energy prices, ageing coal power plants, impacts of the pandemic on the coal plant workforce as well as high energy demand during Australia's winter season causing issues in supply and price spikes. This crisis highlighted how much Australia's east coast power system relied on coal power and further highlighted the need for the country to accelerate its renewable transition.

The Australian Renewable Energy Agency (ARENA) was established by the government in 2012 to improve the renewable energy market, in particular, to increase competitiveness of the technologies and therefore increase the supply of renewable energy. So far via ARENA, the government has invested almost AUS$8 billion (~USD$6 billion) into the Australian renewable energy industry. The Government has also invested AUS$2.5 billion through Australia's carbon offset scheme, the Emissions Reduction Fund, as well as a further AUS$2 billion for further abatement through the Climate Solutions Fund, to meet their Paris Agreement emissions targets. Australia has general emissions and renewable energy targets, for example, the Renewable Energy Target of reaching 50% renewable power generation by 2030, is complimented by the Emissions Reduction Fund to incentivise the uptake of renewable energy.

However, despite these investments, there is no specific national government policy to enable the scale-up of solar PV and therefore the market is mostly run by private companies and local governments who have made their own commitments and policies. Rather, ARENA supports innovation in solar technology to increase efficiencies and drive costs down. Australia's slow deployment of utility scale solar energy may be due to their technology-led approach and higher priority on residential solar, instead.

Australia-Singapore Low Emissions MoU

In 2020, Australia and Singapore signed an MoU to advance cooperation on low-emission technologies and solutions. This collaboration is intended to assist both country's ambitions in reducing emissions and are looking to prioritise clean technology sectors including hydrogen, carbon capture utilisation and storage (CCUS), and in renewable energy trading which they have already began work on. The Australian-ASEAN Transmission Line project by Sun Cable Pte is a 3800 km HVDC subsea link to supply clean power from solar energy and battery storage in the Northern Territory, Australia to Singapore to cover 15% of the country's energy demand (or 30 GW). The solar energy will be sourced from the 20 GW Tennant Creek Solar Farm, which is expected to be the largest solar farm in the world and is due to come online in 2028. The developer is looking to further expand the project by seeking opportunities in grid connectivity in Indonesia in order to facilitate renewables development. In March 2022, the Northern Territory (NT) government introduced the Solar Project (AustraliaAsia Power Link) (Special Provisions) Bill 2022 which would provide certainty that key commitments in the existing Project Development Agreement with Sun Cable would be met. The Bill aims to clarify and streamline existing processes, increase project certainty, and support Sun Cable to secure project financing, which the developer has had to raise capital for without government assistance.

Australia's Hydrogen Ambition

Green hydrogen is one of the Government's priority technologies for the ARENA, as outlined in the Technology Investment Roadmap, in order to help the country reach Net Zero emissions by 2050. In December 2019, the Australian Government released its National Hydrogen Strategy which will utilise renewable energy, particularly energy generated by solar PV for R&D, pilot, and full-scale projects to produce green hydrogen. The Strategy looks to facilitate the use of solar PV as a renewable energy source (RES) for domestic green hydrogen production and use via the integration of variable wind and solar generation into the electricity supply from the grid. Earlier that year, Western Australia had already released their Hydrogen Strategy which seeks to develop domestic green hydrogen production capabilities and benefits from high solar irradiance, which may assist in helping Australia become a global leader in green hydrogen exports.

3.5.3 Analyst Opinion

Over the last five years, it is no surprise that Asia Pacific experienced a rapid growth in the solar industry. Despite the impacts of the Covid-19 outbreak on the industry, significant progress has been made with completion of small, medium and mega scale projects in countries such as India, Australia and Vietnam. From the analyst's perspective, the growth of the solar industry in Asia Pacific is set to continue this upward trend over the coming years. Rapid development of solar plants in countries such as India and Australia will continue to maintain Asia Pacific's dominance in the global solar PV market. Moreover, the increasing need to reduce greenhouse gas (GHG) emissions, and net zero targets set by the Asia Pacific countries will further boost solar deployment in the region as countries shift from conventional power generation to renewables. It is also worth noting that emerging solar market in countries such as Indonesia and Japan are expected to show significant progress as both countries are expected to ramp up its solar deployment to meet the renewables target set by the governments. In terms of investment, the declining trend for fossil fuel power generation investments, together with the falling cost of renewables and stronger policy targets will provide advantages for an increase of investments to be made in the Asia Pacific's solar industry in the coming years. With all the factors combined, it is clear that Asia Pacific will be key destination for solar development as it offers big growth opportunities driven by the region's shift to cleaner energy solutions for the future.

Hirzi Izkander – Senior Energy Analyst

3.6 North America

North America utilises a great deal of renewable energy, from wind, solar, hydropower, and geothermal resources. With an estimated CAPEX spend of USD$107 billion on a solar PV pipeline of over 100 GW capacity by 2025, the region is on the way to being a global leader in solar energy, just second to India. The USA is the leading country in North America, with over 84 GW of solar capacity in the pipeline, followed by Mexico with a planned capacity of almost 9 GW. Solar potential in the region is fairly large, particularly in Mexico and the south of USA, where we are seeing more and more projects coming online.

Country	Clean Energy Ambition	Solar Capacity target
USA	100% decarbonised power sector by 2035 and net zero emissions economy by 2050; at least 25 GW of onshore renewable energy by 2025	30% of electricity generation by 2030 and 50 GW of annual solar manufacturing capacity by 2050
Mexico	35% of electricity supply from clean energy sources by 2024; add 30 GW in renewable energy capacity by 2030	To bring solar and wind capacity to 40 GW by 2030
Canada	100% net zero electricity system by 2035; 80% RES by 2050	N/A
Dominican Republic	25% RES in electricity generation by 2025 and 30% by 2030, and carbon neutral by 2050	N/A
Cuba	2 GW of clean energy capacity and 37% clean energy output by 2030	N/A
Panama	30% increase in renewable energy capacity by 2030	N/A
Puerto Rico	100% renewable energy by 2050	N/A
Trinidad & Tobago	30% RES by 2030	N/A
Barbados	100% renewable energy use and carbon neutrality by 2030	N/A
Guatemala	80% renewable energy by 2030	N/A
Jamaica	30% renewable energy by 2030	N/A

Table 3.6.1: *Summary of Clean Energy Ambitions and/or Solar Targets in North America.*

Compared to 2021, there was a noticeable slowdown in the number of projects being announced in 2022 in the USA, as the Uyghur Forced Labor Prevention Act (UFLPA) came into law in June 2022, which led to detention of solar module imports from China, thereby exacerbating supply chain challenges that the USA was already facing. In August 2022, the Inflation Reduction Act (IRA) was introduced with the aim to expand support for renewable energy over the next decade whilst also easing supply chain issues as it encourages the expansion of domestic manufacturing, shifting demand away from China. With this green light for renewable development as well as what is already being planned and under development, this could potentially bring the cumulative utility scale solar PV capacity in the USA to over 163 GW.

Solar potential in North America

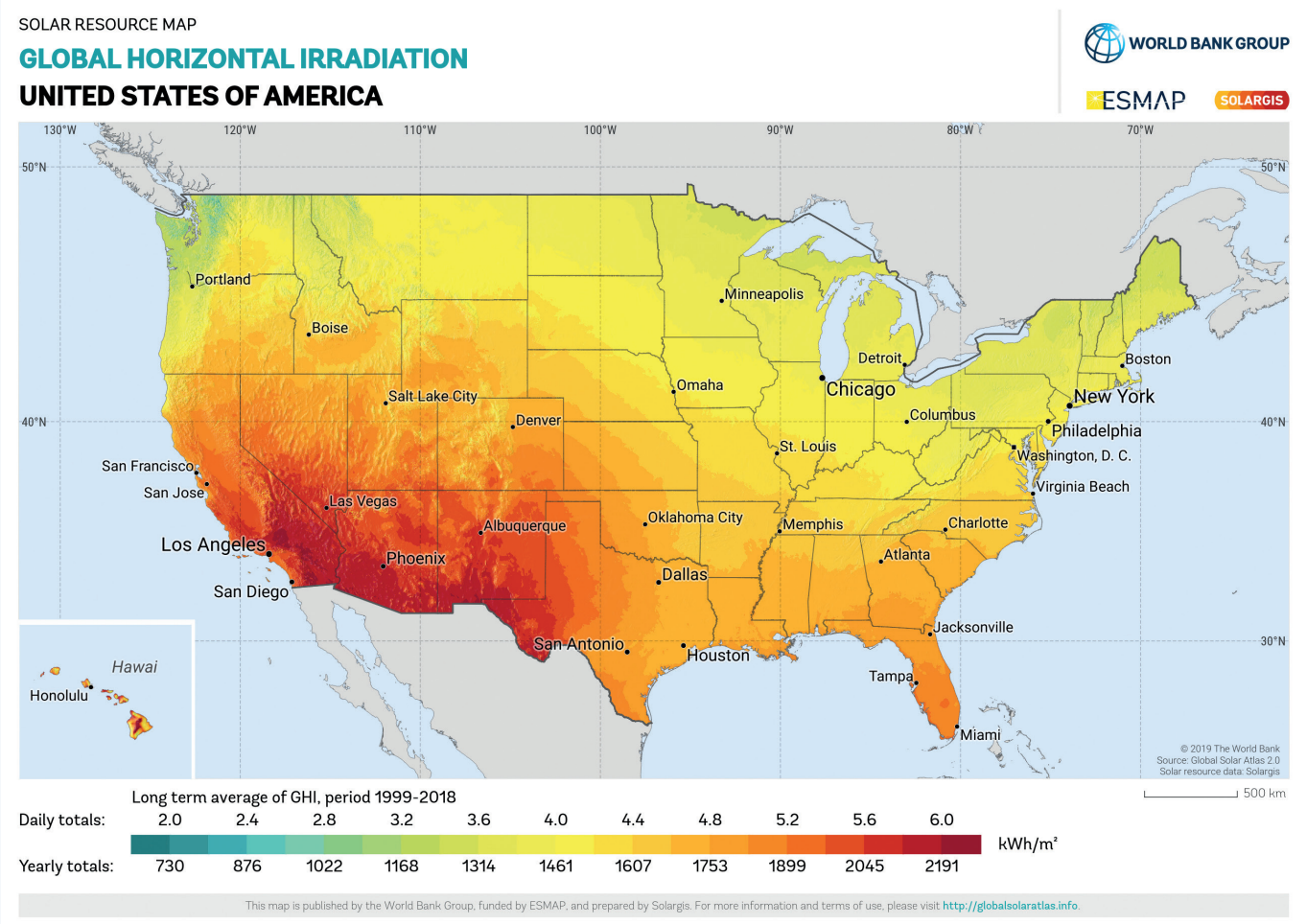

Figure 3.6.1: *Solar potential in North America © 2020 The World Bank.*
Source: Solar Gis

In contrast, controversial energy reforms have stalled many solar PV projects in Mexico, whilst government policies seem to continue to prioritise fossil fuels. Historically, Mexico's renewable auctions procured large capacities of solar capacity, however since 2019, the current administration under President Andrés Manuel López Obrador (AMLO) began lobbying for a new energy reform to reduce Mexico's dependence on private and often foreign investment. In 2021, the Electric Industry Law established a dispatch system that gave priority to CFE's operational plants. CFE's plants generate power from hydropower, natural gas, and nuclear so considering that most upcoming renewable projects in Mexico are privately owned, these would be dispatched last. These policy changes and resultant uncertainties have impacted the dynamics of the power market in Mexico for private companies and has affected confidence for future investments by foreign companies, leading to a drop in project announcements in 2022.

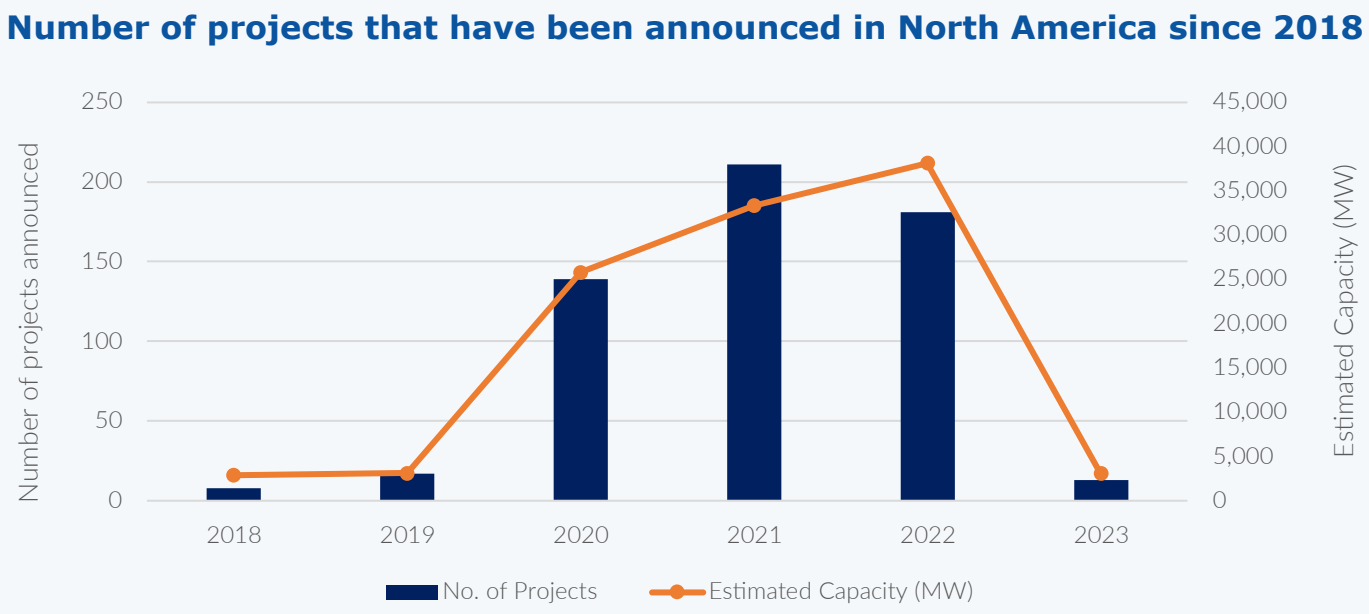

Figure 3.6.2: Number of projects that have been announced in North America since 2018.
Source: EICDataStream

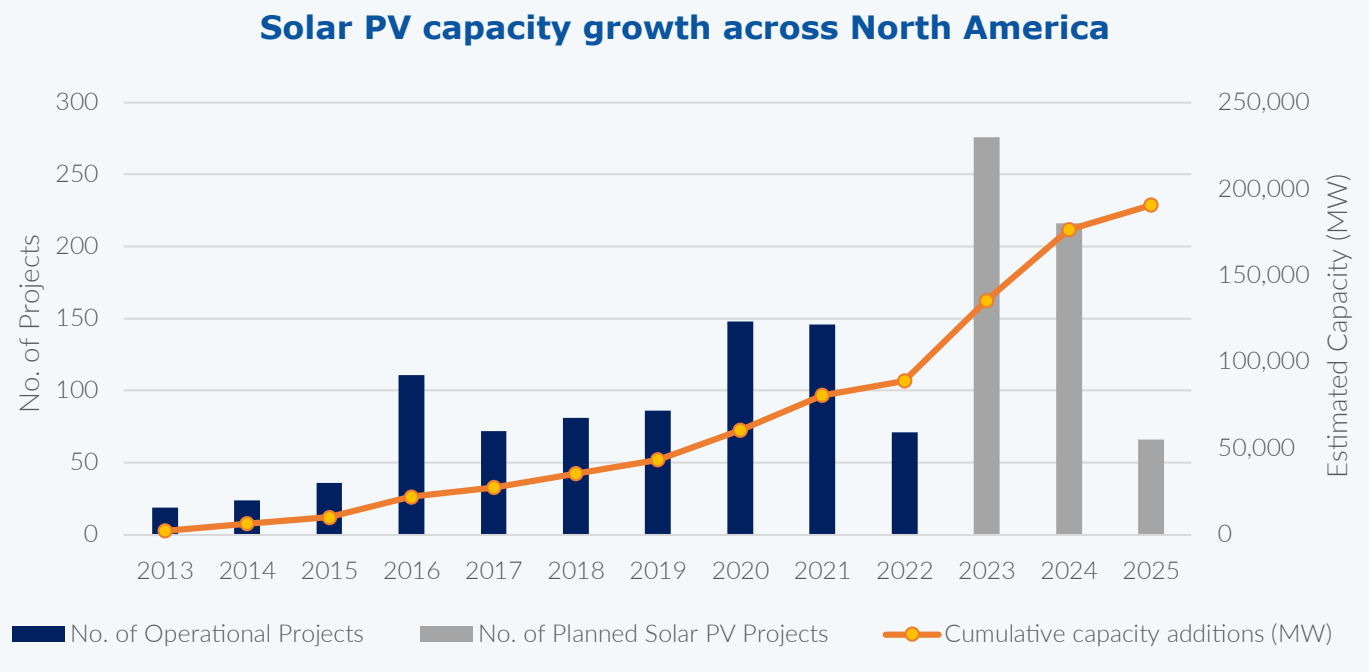

Figure 3.6.3: Solar PV capacity growth across North America.
Source: EICDataStream

Over 20% of projects announced since 2018 in Mexico have been put on hold as private developers have faced permitting delays and rejections at the commissioning stage as well as transmission restraints. Despite concerns in the private sector, Mexico's Development Program of the National Electrical System (PRODESEN) demonstrates ambitions for the development of renewable energy and suggests that the future market will likely develop solar PV via BOO contracts to private developers, whilst CFE remains as the operator. In June 2022, President AMLO announced agreements between Mexico and 17 US companies to develop wind and solar PV power along with a transmission system to export power to the US. The 17 companies were not disclosed however foreign investment from these companies is expected to bring online almost 2 GW of renewable energy, though a timeframe has not been specified. The most potential for foreign investment however is in small scale and distributed solar projects rather than utility-scale – small scale distributed generation projects continue to have shorter permit approval periods, whilst many utility scale projects are currently being rejected from generating and commissioning permits.

Mexico's Development Program of the National Electrical System (PRODESEN), 2022-2036

In June 2022, the Secretariat of Energy (SENER) published a plan addressing transmission and distribution, electricity generation and commercialisation of Mexico's national Electric System (SEN). Key actions:

- Development of CFE's power plants – mid-term focus on new combined cycle plants, and modernisation of hydroelectric plants
- Security of energy supply by coordinating different sources of generation of the CFE and private operators
- To increase power generation with clean and renewable energy sources to meet climate change and emissions reduction targets.

Due to the magnitude of development in the USA, Figure 3.6.4 shows the top operators who are planning PV projects for start-up to 2025 in a separate graph to major players across the region in Figure 3.6.5. Figure 3.6.6 is a geographical summary of key projects in the region.

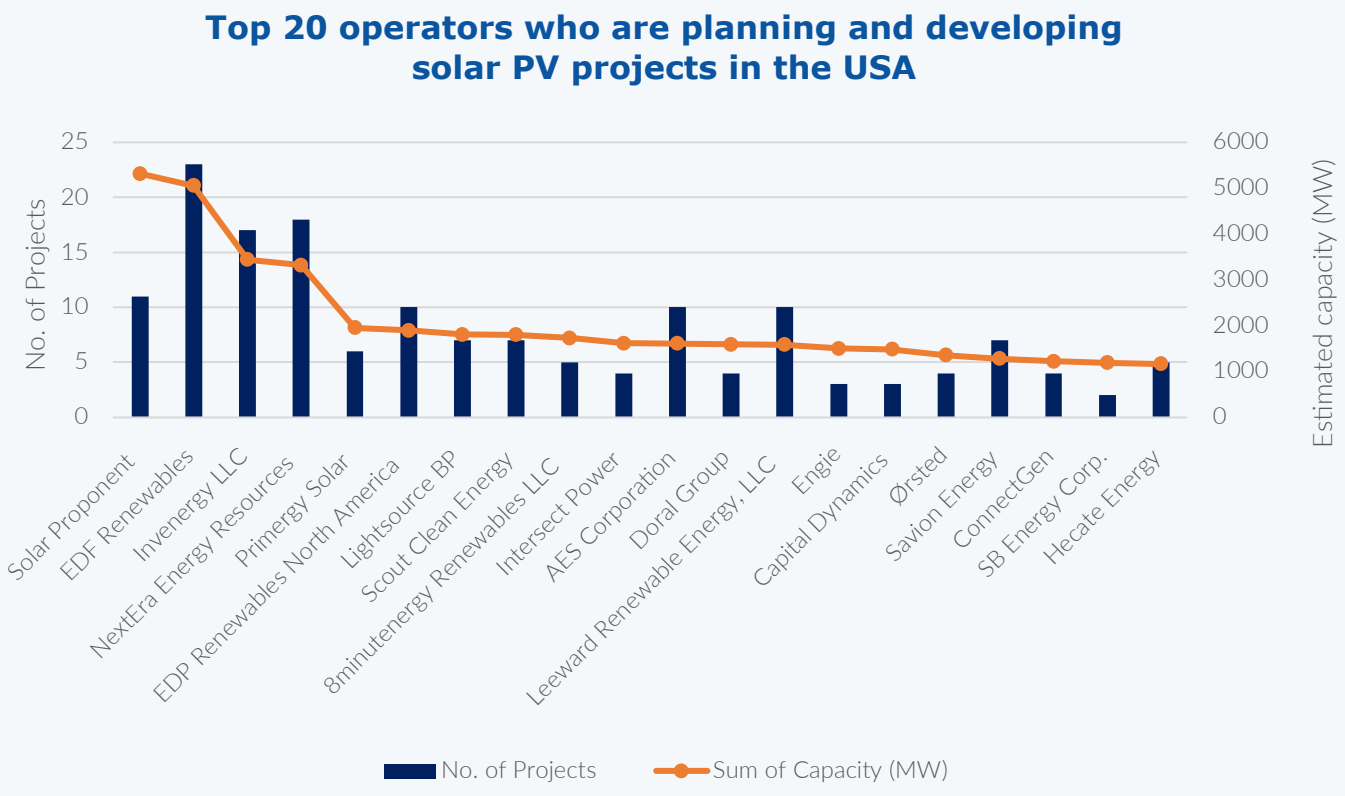

Figure 3.6.4: Top 20 operators who are planning and developing solar PV projects in the USA.

Source: EICDataStream

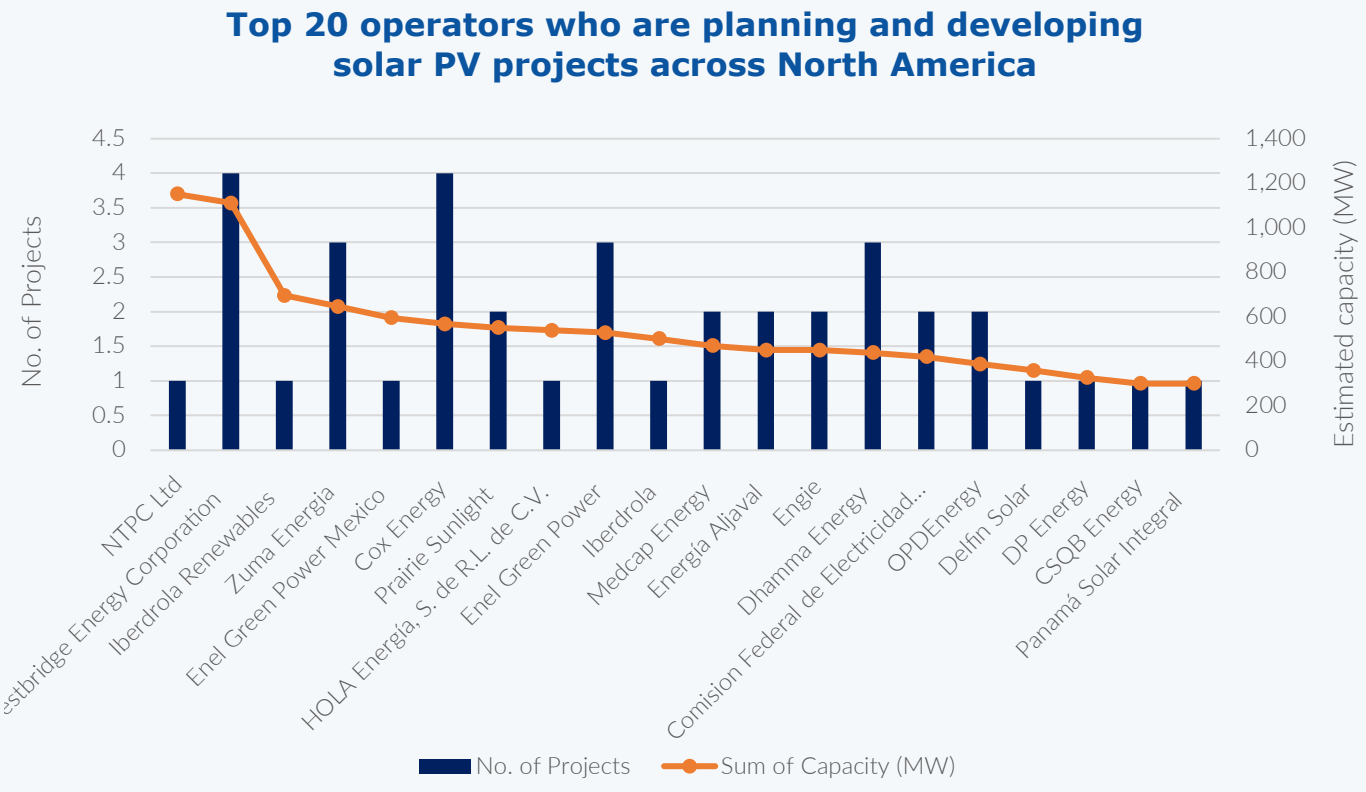

Figure 3.6.5: Top 20 operators who are planning and developing solar PV projects across North America.

Source: EICDataStream

Across the region, EDF Renewables is the leading developer with a total capacity of over 5.2 GW of planned in North America; of this total capacity 5 GW is to be developed in the USA with the remaining 200 MW planned to be developed in Canada and Mexico. The international developer is one of the most active developers in the USA with wind and solar hubs, particularly in California. Within the region, EDF has not made any commitments unlike its subsidiary in the UK; although companywide they aim to deliver renewable solutions to lead the energy transition. It also appears that they are delving into the storage market, especially in the USA. According to EICDataStream, all EDF battery energy storage projects in the US are to be co-located with their solar PV plants in development demonstrating a growing storage market in the US in line with government ambitions to incorporate storage with renewable energy sources.

Solar Proponent are a new player in the region, having formed in 2020 with the backing of USD$1.2 billion in capital by investment companies, EnCap Investments, Yorktown Partners, and Mercuria Energy. In 2022, the company announced plans to develop over 5 GW of utility-scale solar projects in Texas, USA for start-up by 2025. NextEra Energy Resources are another leading solar PV energy generator in the US and has over 6.5 GW of solar PV in operation, according to EICAssetMap. The company is planning and developing a further 3.5 GW of utility scale solar in the USA for start-up by 2025, according to EICDataStream. This push for solar PV is largely due to NextEra Energy's commitment in reducing their carbon dioxide emissions by 67% by 2025, compared to 2005.

In Mexico, state-owned CFE will invest an estimated USD$615 million to develop the 1 GW Puerto Peñasco Solar PV Park in phases for start-up by 2028. The original announcement, in July 2021, stated a USD$2 billion investment for the solar PV park which is part of the developer's modernisation plan – this drop in investment is likely due to CFE's priorities in hydropower. The plan largely focusses on modernising and expanding Mexico's hydropower assets and distribution system; CFE has only turned to solar recently after previously opposing 2013 energy reforms. The 1 GW solar PV park will assist in improving Mexico's energy security and will be linked to the grid system in Baja California via subsea transmission line to provide reliable electricity in the region.

Geographical summary of solar PV projects by major players in planning across North America

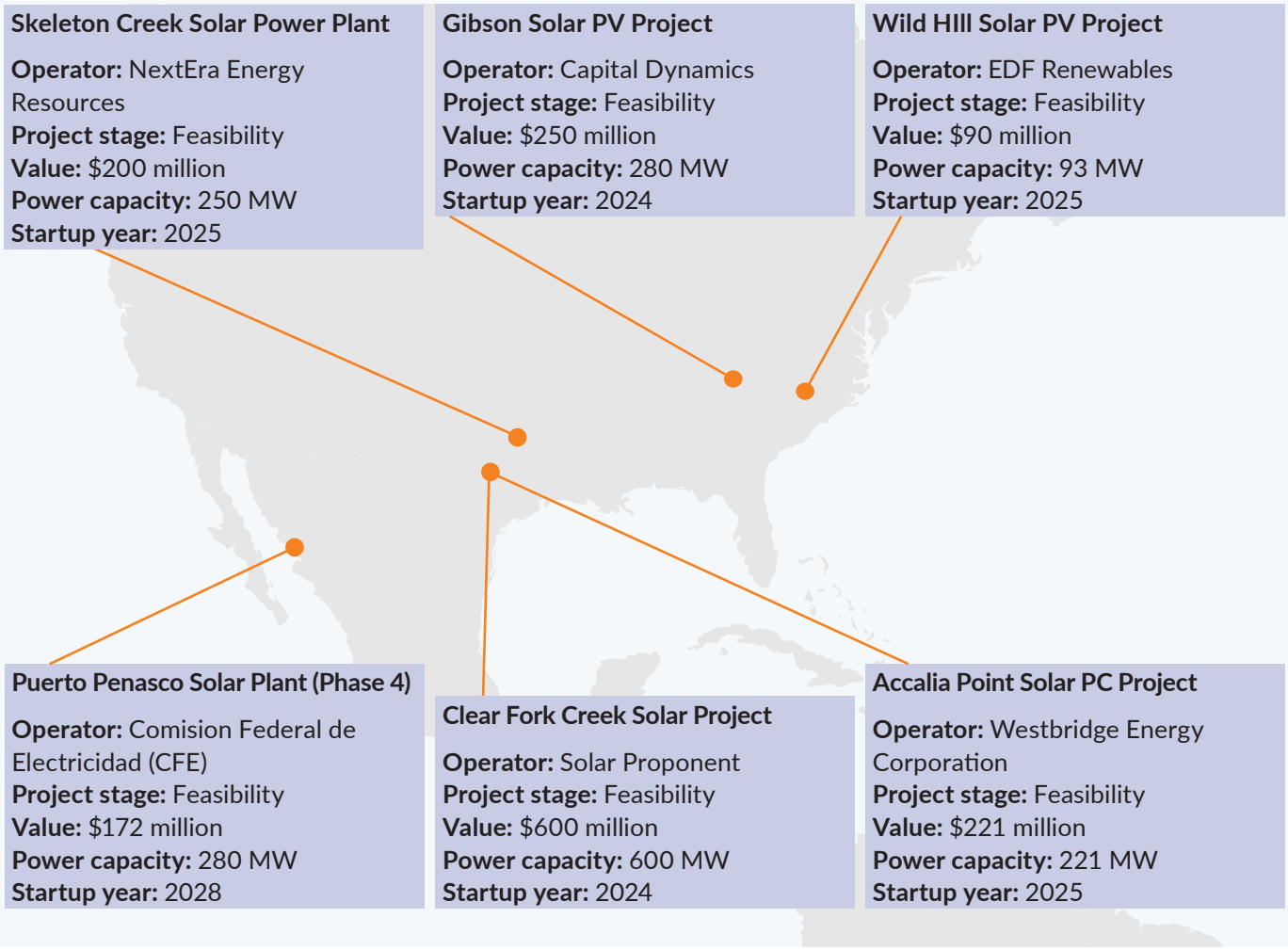

Figure 3.6.6: *Geographical summary of solar PV projects by major players in planning across North America.*
Source: EICDataStream

3.6.1 USA

Since the early 20th century, hydroelectric power generated huge capacities of renewable energy in the US; more recently we have observed a surge in growth in the form of wind and solar PV capacities. 2016 was the first year that the USA saw a huge increase in installed solar PV capacity. According to EICAssetMap, over 11 GW of utility scale solar PV came into operation in 2016, greater than both the installed capacity of 2014 and 2015 combined. It is likely that a rush in 2016 to obtain the 30% investment tax credit (ITC) (which was due to expire) was also a cause of this market contraction and therefore resulted in a depleted project pipeline by 2017. The ITC was later extended through 2019, but another lull in deployment momentum before a rush towards the end of 2019 was also observed for developers to obtain the full tax credit by the end of 2020.

Between 2017 and 2020, the number of projects coming online per year stalled. This was largely due to many utility-scale projects being put on hold or cancelled in 2017; according to EICDataStream, over 1.8 GW of project capacity was cancelled. The market contraction observed between 2017 and 2019 can be attributed to various factors including the uncertainty of import tariffs. In 2018, the Trump administration, as part of a trade war between the US and China, imposed Section 201 tariffs on PV modules and cells at 30% as well as on materials including steel (25% tariff) and aluminium (10% tariff). This policy received much opposition as it increased PV system costs despite the decline in global costs of cells and modules.

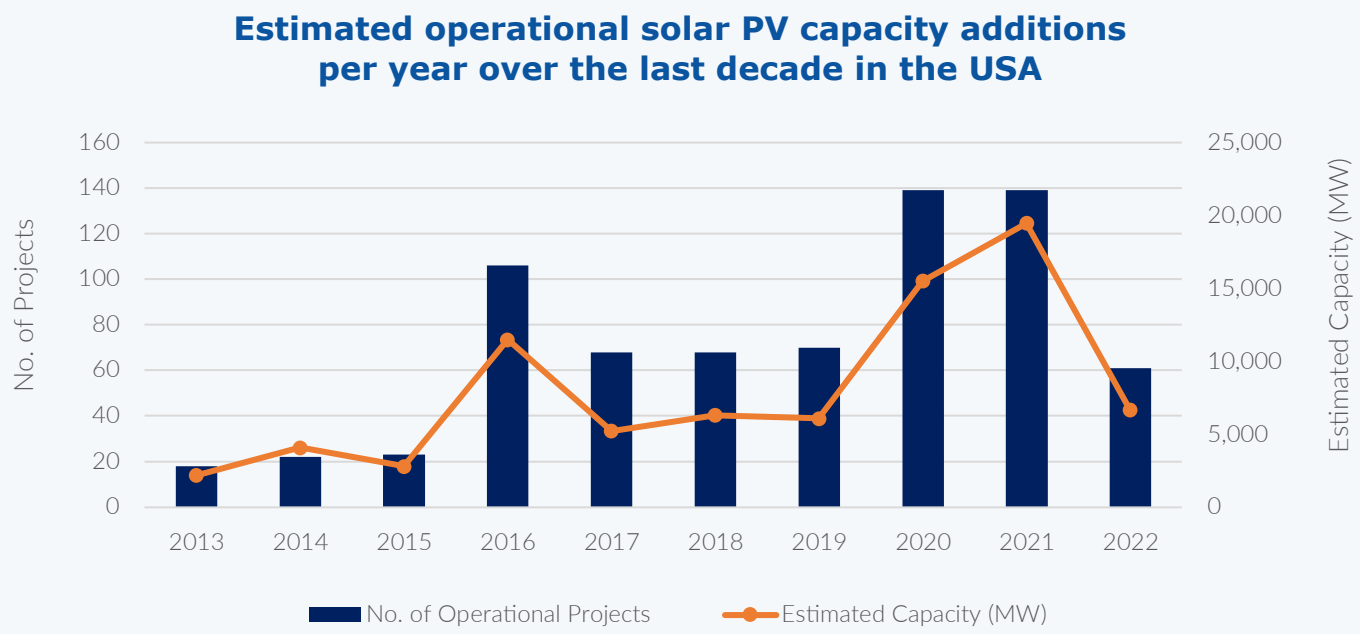

Figure 3.6.1.1: *Estimated operational solar PV capacity additions per year over the last decade in the USA.*
Source: EICAssetMap

Like India's method of promoting and procuring solar PV, the USA has also adopted a reverse auction approach. Sellers (in this case the plant developer) are invited to submit price bids where winning sellers are chosen by the buyer (in this case the utility company) based on lowest priced bids first. This way of procurement allows for the competitive market determine the price paid for solar and is attractive to policy makers. The developer is paid a price that is enough to bring the project online and protects against overpayment. As seen in India, however, there is a developer risk when auctions are undersubscribed and there is also no guarantee that the bid is successfully contracted.

Solar imports

Since 2020, many shipments of solar modules and panels have been detained by Customs and Border Protection (CBP) under Section 1307 of the Tariff Act. This section prohibits imports of merchandise that have been mined, produced or manufactured by forced labour and comes at a time in the US Government's effort against China's campaign of repression against Xinjiang Uyghur Muslims. CBP are specifically detaining silica-based products from Hoshine Silicon Industry Shanshan Co. amongst other companies who are linked to the campaign and operate in the Chinese region of Xinjiang. Solar modules from Tier 1 manufacturers such as LONGi and Trina Solar have already been detained and investigated to determine if they are connected to forced labour. In December 2021, President Biden signed the Ugyhur Forced Labour Prevention Act (UFLPA) and came into law in June 2022 which specifically prohibits products from the Xinjiang Uyghur Autonomous Region in China from entering US ports.

SETO

In 2007, the Energy Independence and Security Act established the Renewable Energy Innovation Manufacturing Partner Program to provide funding to support research and development in both manufacturing and infrastructure of renewable energy and the production and coordination of resources by the federal government, state government and private industry. The Department of Energy (DoE) Solar Energy Technologies Office (SETO) was set up to accelerate the deployment of solar technology to transition to net zero by 2050 via decarbonisation of the power sector by 2035. SETO promotes solar innovation by driving new solar products to market and soft cost reduction (via its Soft Costs program) as well as enabling solar to support and improve the resilience of the grid. The Office supports early-stage research and development (R&D) projects to drive down the costs of solar generated energy to improve efficiency and reduce manufacturing costs.

Solar PV is already amongst the cheapest forms of energy available in the US and SETO is continuing to drive costs down. In 2011, SETO launched the SunShot initiative to enable cost competitive solar PV without the use of subsidies. Via this initiative, cost targets were made; for example, SunShot had initially set a LCOE target of USD$0.06/kWh for utility scale solar PV to be met by 2020, down from USD$0.28/kWh. The target was met three years ahead of schedule in 2017, likely because of the surge in solar projects in 2016 announcements as demonstrated in Figure 3.6.1. SETO has also set more goals for 2030 to further cut the LCOE to USD$0.02/kWh for utility scale PV, whilst also intending to overcome grid integration challenges via the DoE's Grid Modernisaton Initiative and enable solar PV adoption by addressing market barriers.

Co-located Battery Storage

It could be argued that battery commercialisation over the last couple of years has been enabled by the co-location of battery energy storage systems (BESS) with solar PV developments. According to EICDataStream, over 65% of all US battery energy storage projects in planning or under development are associated with solar PV projects. With solar PV, as well as other renewables such as wind, generating energy at low marginal costs, the grid is beginning to be saturated with intermittent renewables which are reducing average electricity prices and therefore reducing the return on the generational asset. As a result, US developers are beginning to realise the benefits of BESS alongside solar PV assets to store electricity and later sell when there is increased demand. This in turn improves the profitability of the solar PV asset whilst also stabilising the grid.

Over the past few years, California has become a pioneer in a range of clean energy technologies in its energy transition. The state has harnessed its solar power and has also been the first state in the USA to introduce polices to drive decarbonisation and adoption of renewable energy. Despite its efforts, California has also faced the challenges of the energy transition quicker than other states. Home to the infamous 'duck curve,' California's supply and demand has had to be addressed. In 2013, the California Independent System Operator published the curve which shows the difference in electricity demand and the amount of solar energy generated throughout the day. When the sun is shining, solar supply is high and drops off as electricity demand peaks in the evening.

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Graph showing an example of the 'duck curve' during a spring day in California

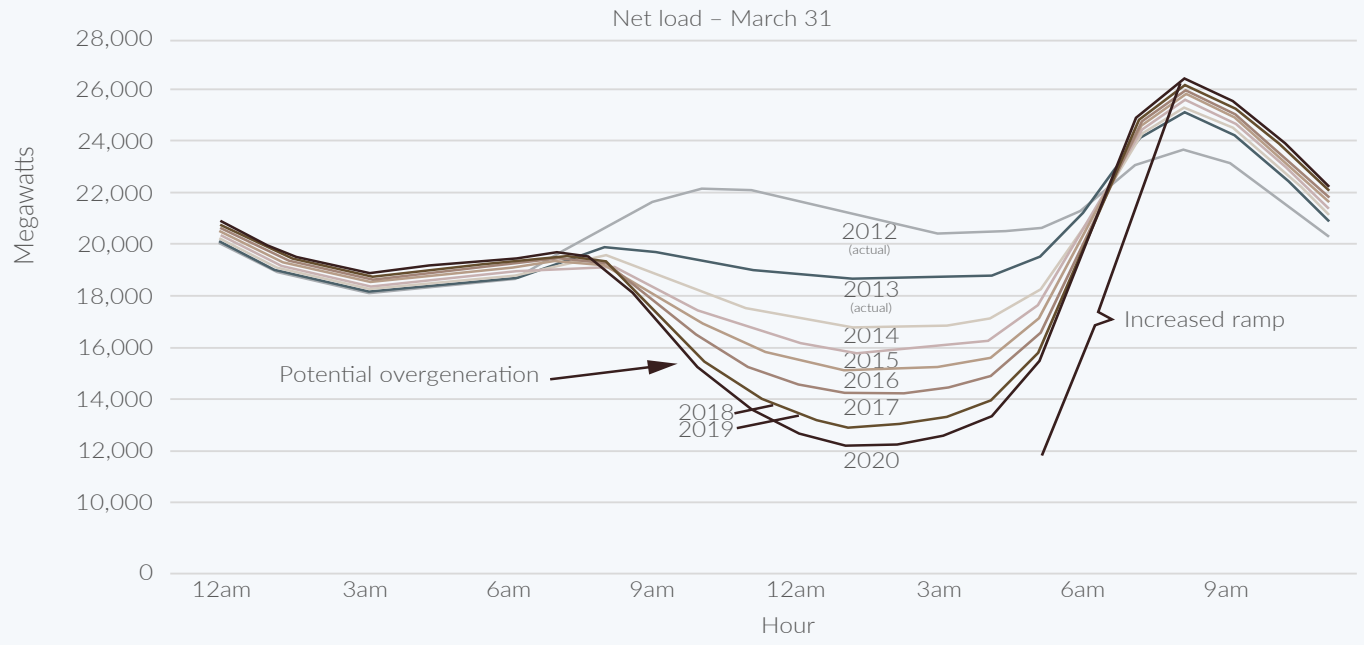

Figure 3.6.1.2: Graph showing an example of the 'duck curve' during a spring day in California.

Source: US Office of Energy Efficiency & Renewable Energy (2017)

Figure 3.6.1.2 is an example of a 24-hour period in California springtime where temperatures begin to cool and is very sunny, so demand for electricity is low as air-conditioning and heating is not quite required during the day, but other modes of sources are required to meet the demand when the sun goes down. The state as a result continued to rely on the flexibility of imports and gas plants to meet this demand. Another response to this demand is the use of batteries – co-locating BESS with solar PV plants are increasingly popular to developers who are building large scale solar PV in particular. According to EICDataStream, 107 out of 163 battery energy storage projects in the USA incorporate solar PV – over half of the BESS projects planned in California alone are co-located with solar PV, demonstrating BESS's significance in supporting the solar PV market and grid in the state.

3.6.2 Analyst Opinion

The world's second largest market for solar power generation, the US is poised to further expand its importance for the solar supply chain. The Energy Information Administration (EIA) expects solar power – including both utility-scale and distributed generation – to account for 51% of renewable energy generation in the US by 2050, up from the current 19%.

There is no doubt that the US$369bn Inflation Reduction Act (IRA) passed in 2022 will play a key role in this expansion: the IRA increases and extends fiscal benefits for new solar facilities, with production and investment tax credits now set at 30% (up from 26% in 2021). Tax benefits provide market certainty and are a great for opportunity for US and international developers, but opportunities around solar power are not limited to electricity generation. Clean hydrogen is experiencing major growth in the US and key players such as NextEra Energy are already exploring opportunities in this segment.

Looking at key players, AES, EDF, NextEra and Invenergy are the well-established developers with the most capital-intensive project portfolio. The US EPC market is varied, but future contracting activity in the solar EPC/BoP segment is likely to involve key contractors such as Burns & McDonnell, McCarthy Building Companies and Swinerton Renewable Energy.

Elsewhere in North America, Mexico's permitting delays created by the AMLO administration remain a challenge. The government's recent pledge to install an additional 20GW of renewable energy by 2030 invites scepticism, as the country's existing project pipeline is insufficient to achieve this goal. The country has immense potential and strong participation from international developers, however, which could unlock the country's solar PV potential should regulatory conditions change.

Pietro Ferreira, Senior Regional Analyst - Americas

3.7 South America

According to EICDataStream, an estimated CAPEX spend of USD$55 billion is predicted to bring around 70 GW of solar PV capacity in South America by 2025. This accounts for around 60% of total renewable capacity planned and under development for start up to 2025, including hydropower – a technology that currently provides more than half of the total electricity supply in South America. However, modernisation of ageing hydropower plants is needed and increased frequency of droughts in some areas caused by reduced water levels and therefore reduced power output, has led to many South American countries to seek power from alternative renewable power generating sources.

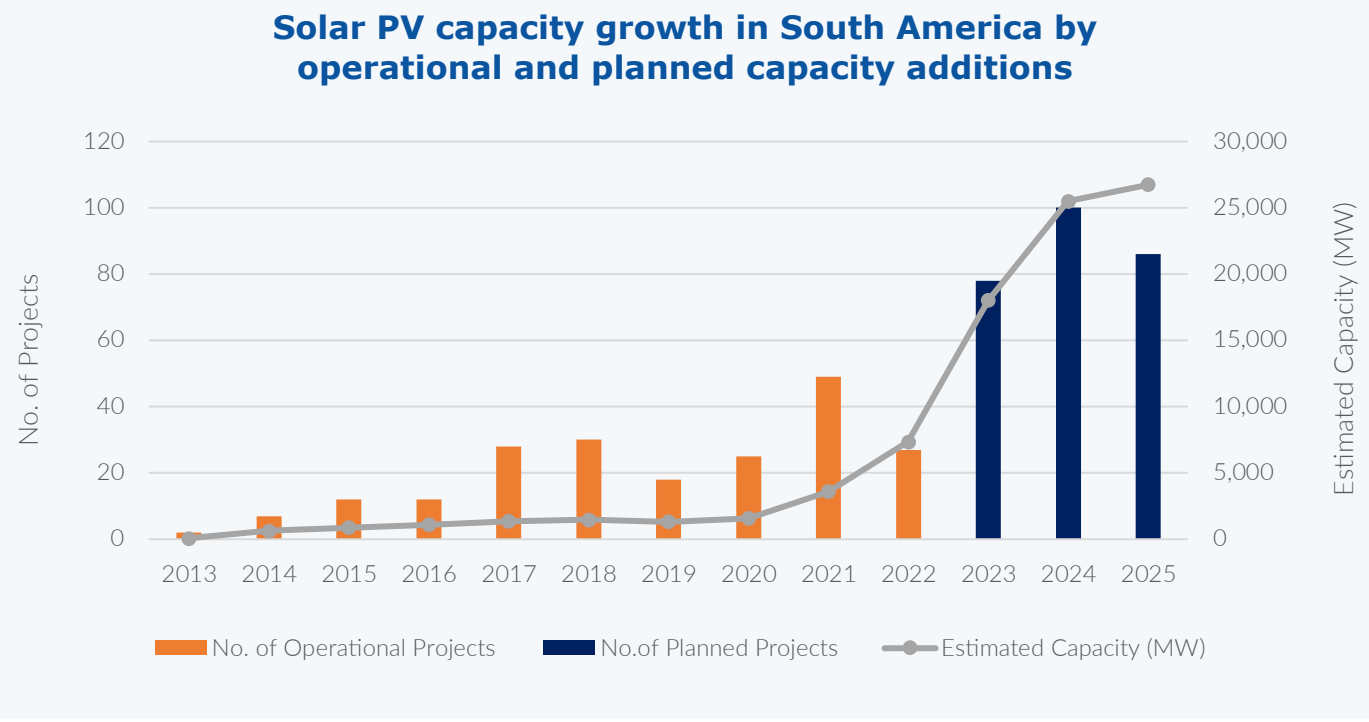

Figure 3.7.1: *Solar PV capacity growth in South America by operational and planned capacity additions.*
Source: EICAssetMap and EICDataStream

With successful renewable auctions procuring large PV capacity as well as the growing interest in corporate PPAs, South America has the potential to be a leading global market over the next decade. In particular, Brazil is amongst the top three countries in the world – behind India and the USA – in solar development with the potential for almost 40 GW of solar PV capacity to come online by 2025. Chile is planning almost 20 GW of solar PV capacity as the country harnesses the PV potential provided by the Atacama Desert which is amongst the top climate geographies in the world for solar potential. Elsewhere Colombia is an emerging market with over 10GW in planning and under development by 2025, as the country begins working towards its green hydrogen production ambitions.

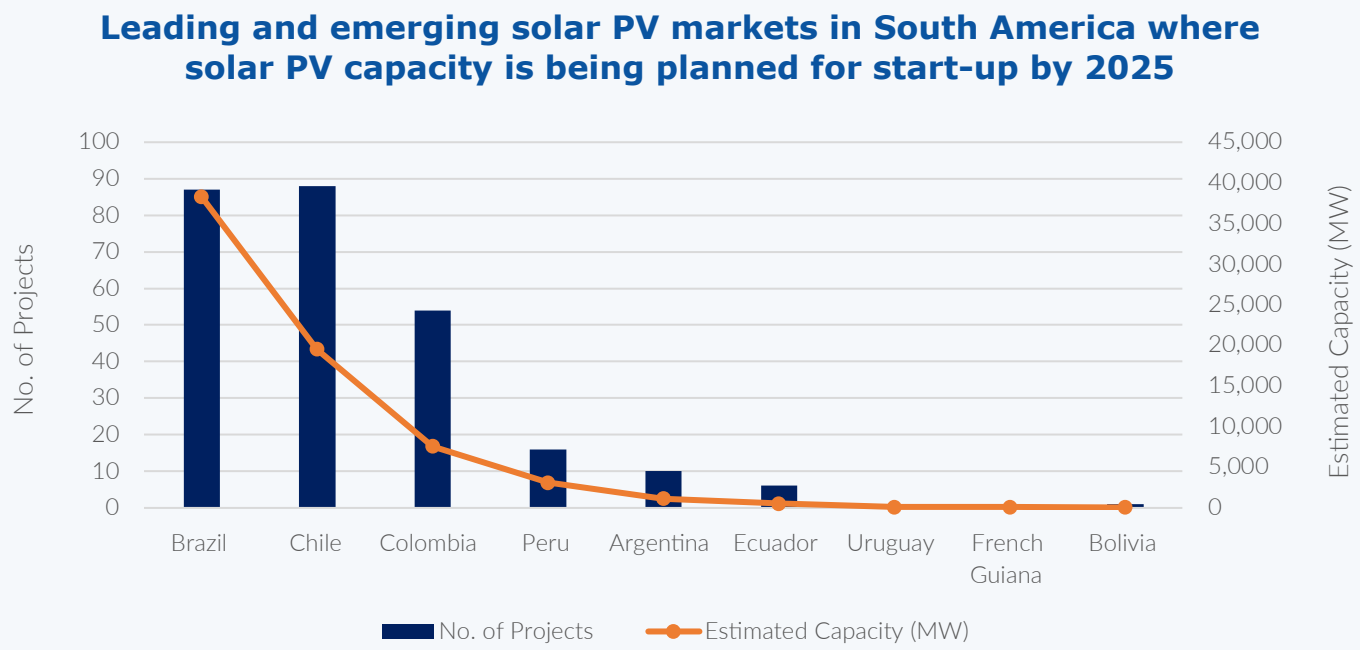

Figure 3.7.2: *Leading and emerging solar PV markets in South America where solar PV capacity is being planned for start-up by 2025.*
Source: EICDataStream

Developing policy in Colombia

USAID's Scaling Up Renewable Energy (SURE) project has assisted the country with the design and implementation of competitive auctions in order to support both the government and private sector partners. SURE also worked with Colombian policymakers to develop the regulatory framework to attract private investors. Colombia's third renewable energy auction was delivered in October 2021 and around 800 MW of solar PV capacity was allocated at an average price of USD$0.04/kWh. As well as support from USAID, the Colombian government also provides incentives to investors to develop solar PV and other renewable energies. Incentives include but are not limited to: annual income tax reductions and tariff exemptions. For example, individuals or entities who make investments into R&D, production, and consumption of renewable energy are eligible to an income tax reduction of up to 50% of the total investment value for 15 years after investment. Additionally, individuals or entities that import equipment, machinery and materials required for renewable energy projects are also eligible for a wave on import taxes.

Despite the plans and incentives, Colombia is struggling, much like other countries, with the supply chain bottlenecks that the pandemic caused. As a result, there are delays in the construction of transmission infrastructure near locations of large-scale renewable energy projects like solar and wind. This has resulted in uncertainty with some projects being at risk of missing their commissioning deadlines.

Policy	Summary
Generation Expansion Plan 2014–2028	Target of total renewable installed capacity of greater than 6 GW by 2028, with over half from non-hydropower
FENOGE (Fondo de Energías Renovables y Gestión Eficiente de la Energía)	Established in 2014 under a renewable energy law, FENOGUE is a fund to finance renewable energy plans and projects
National Energy Generation Plan 2015–2050	Short and long-term strategies and objectives for renewables in hydropower and other renewables like solar
Generation Transmission 2016–2030 Reference-Expansion Plan	Establishes guidelines for energy generation and transmission

Table 3.7.1: *Colombia's policies supporting solar PV development*

Country	Clean Energy Ambition	Solar Capacity target
REnewables in Latin America and the Caribbean (RELAC)*	70% RES of region's energy mix by 2030	N/A
Brazil	45% renewables in the energy mix by 2030; 23% renewables in the power supply by 2030	N/A
Chile	Carbon neutral by 2050; 20% RES by 2025 and 70% RES by 2030	N/A
Colombia	Carbon Neutral by 2030 and 70% RES by 2030, 4 GW of renewable energy capacity addition by 2030	N/A
Argentina	20% RES by 2025 and 70% RES by 2030	N/A
Peru	60% RES by 2025; 54% hydropower and 6% from other renewables.	N/A
Ecuador	1.44 GW of renewable energy capacity to be added to the grid between 2024 and 2028	490 MW solar capacity addition between 2024 and 2028
Bolivia	79% RES by 2030; increasing share of non-hydropower renewables to 19% by 2030	N/A
Suriname	25% RES by 2025, more than 35% RES by 2030	N/A
Paraguay	60% RES by 2030	N/A

Table 3.7.2: *Summary of Clean Energy Ambitions and/or Solar Targets in South America*

** RELAC consists of 15 countries who made the regional 2030 target in August 2022. Members include Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Peru, and Uruguay.*

Key drivers for solar PV development in South America include decarbonisation ambitions as well as the reduction in technology costs and the modular nature of solar. Despite this, the growth of the South American PV market is not without its challenges. Factors including the need for modernisation of transmission and distribution networks, supply chain bottlenecks, and increased regional debt as a consequence of the COVID-19 pandemic, have caused delays in projects and will likely continue to do for the next couple of years. That being said, renewables will continue to be developed, particularly due to the costs of energy from wind and solar sources being on par with that of fossil fuels.

Figure 3.7.3 shows the top 20 operators who are planning solar PV capacity in South America and Figure 3.7.4 is a geographical summary of key projects in the region. Brazilian company, Omega Energia are a new major player as they announced plans in 2022 to develop the one of the world's largest solar PV project - Kuara Solar PV Complex –at a capacity of 4.6 GW in Brazil. The operator intends to use the power generated from the plant at a green hydrogen facility proposed for Pecém Port.

The roles of energy storage and hydrogen in South America

Growth in the energy storage market in South America with the unprecedented scale up in renewable capacity is required – grid network instability is common across the region, so battery energy storage systems can potentially stabilise the grid whilst also supplying rural areas. Currently, however, the energy storage market is highly taxed, lacks regulatory frameworks and provides no subsidy therefore there is no incentive for end users. In the pipeline, the Parque Terra Energia Renovable Battery Storage Project is being developed by AES Andes for the Parque Terra Energia Renovable hybrid wind-solar project in Antofagasta. It is expected to be Latin America's largest battery storage system to date.

With international investment into projects in recent times, Brazil could well become one of the lowest cost global exporters of green hydrogen by 2030, competing with China, Australia and in South America, Chile. MoUs have been signed with many of the projects in the country and some projects have already specified their energy sources – largely from offshore wind and solar adjacent to the green hydrogen plants. We can expect PPAs from green hydrogen generators to further drive the Brazilian solar PV market within the next decade, if these projects come to fruition alongside the falling costs of solar PV.

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In September 2021, Colombia's Ministry of Mines and Energy outlined plans to achieve a target of 3 GW in electrolyser capacity for green hydrogen plants by 2030 and a vision for wide-scale adoption of fuel-cell vehicles. This scale of green hydrogen production will require a great deal of renewable power to generate hydrogen from water electrolysis. Then in April 2022, the Colombian government published a draft decree outlining regulations for the use and generation of hydrogen and in June 2022, some tax incentives for clean hydrogen projects were signed allowing blue and green hydrogen projects to be eligible for the same tax breaks as non-conventional renewable energy developments. These market signals indicate that Colombia is really backing green hydrogen as a future fuel so we can expect more renewable development through to 2030. The country has proven solar PV potential and so it is likely solar PV capacity will increase over the next decade to contribute to its end use as a power source for green hydrogen production.

Hydrogen may well also play a key part in providing energy storage for microgrids; batteries do provide the easiest way to store energy, but hydrogen storage is increasingly viable particularly with Brazil's hydrogen ambitions. Regulation for both battery storage and green hydrogen production is very slow, and we will likely not see this happen until the early to mid-2030s.

Enel Green Power are a major player across the region with over 3 GW of solar PV capacity planned and under development in Brazil, Chile, Colombia, and Peru, according to EICDataStream. The company is a major renewable developer – often referred to as a 'Renewable supermajor' alongside the likes of Iberdrola, NextEra, and Orsted – in the region with an installed capacity of approximately 15.3 GW. Enel has committed to reach net zero with a 100% renewable fleet of power plants by 2040 and to completely phase out their coal plants by 2027. Other intermediate global targets include reaching 65% solar and 34% wind capacity by 2024 and by the end of the decade are expecting to reach 154 GW of generating capacity from renewable sources.

Oil and gas companies are also looking at the South American solar PV market too, to assist them in reaching their net zero commitments. Via either acquisition of small developers, subsidiaries, or the development of large-scale solar PV plants, multinational utilities and majors such as BP, Shell and TotalEnergies are planning to develop over 4.5 GW of solar PV power across the region, according to EICDataStream. A significant project also includes the phased Antofogasta PV project in Chile was announced by Ibereólica in 2017, who are developing the 500MW plant with Spanish petrochemical company, Repsol and plan to bring the park online by 2025.

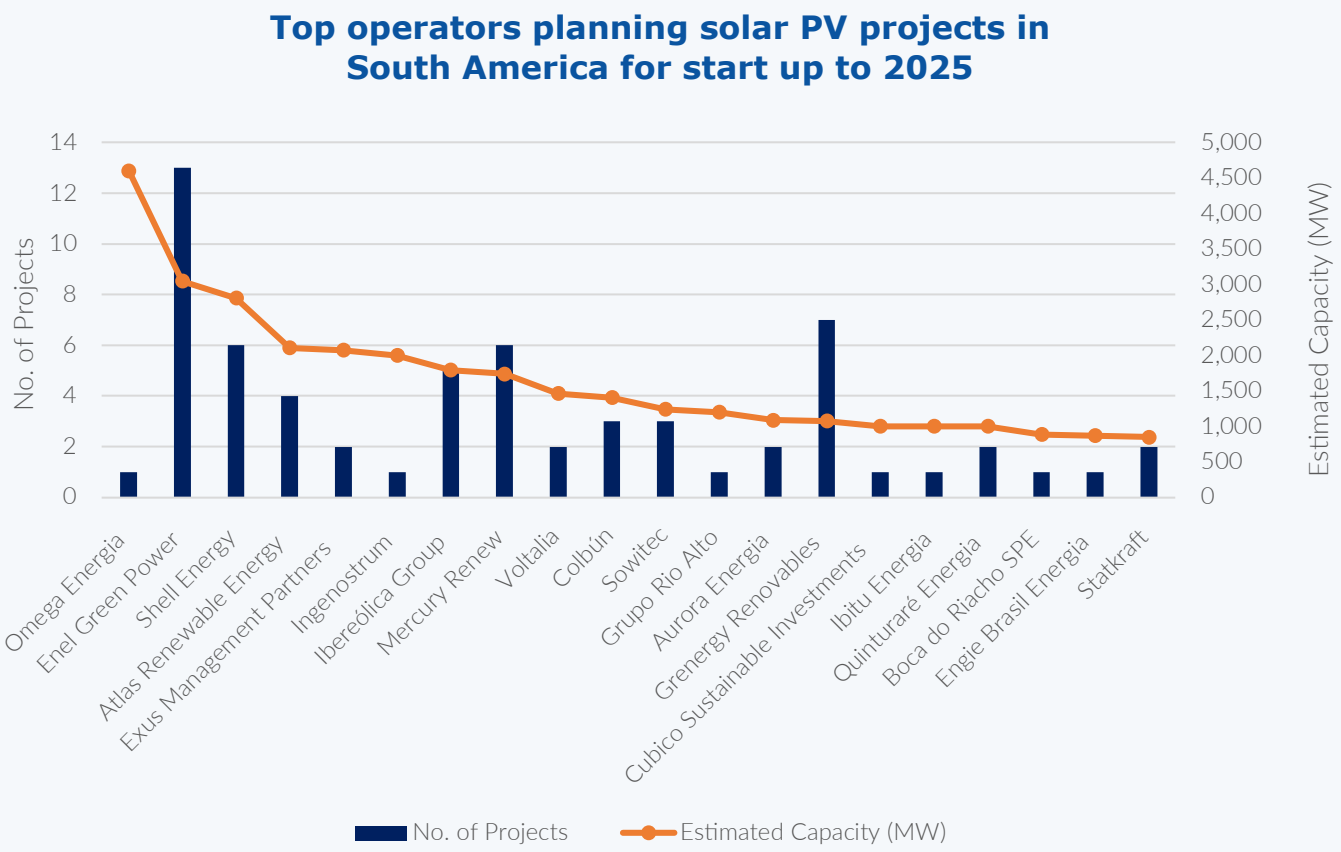

Figure 3.5.3: *Top operators planning solar PV projects in South America for start up to 2025.*

Source: EICDataStream

Geographical summary of solar PV projects by major players in planning across North America

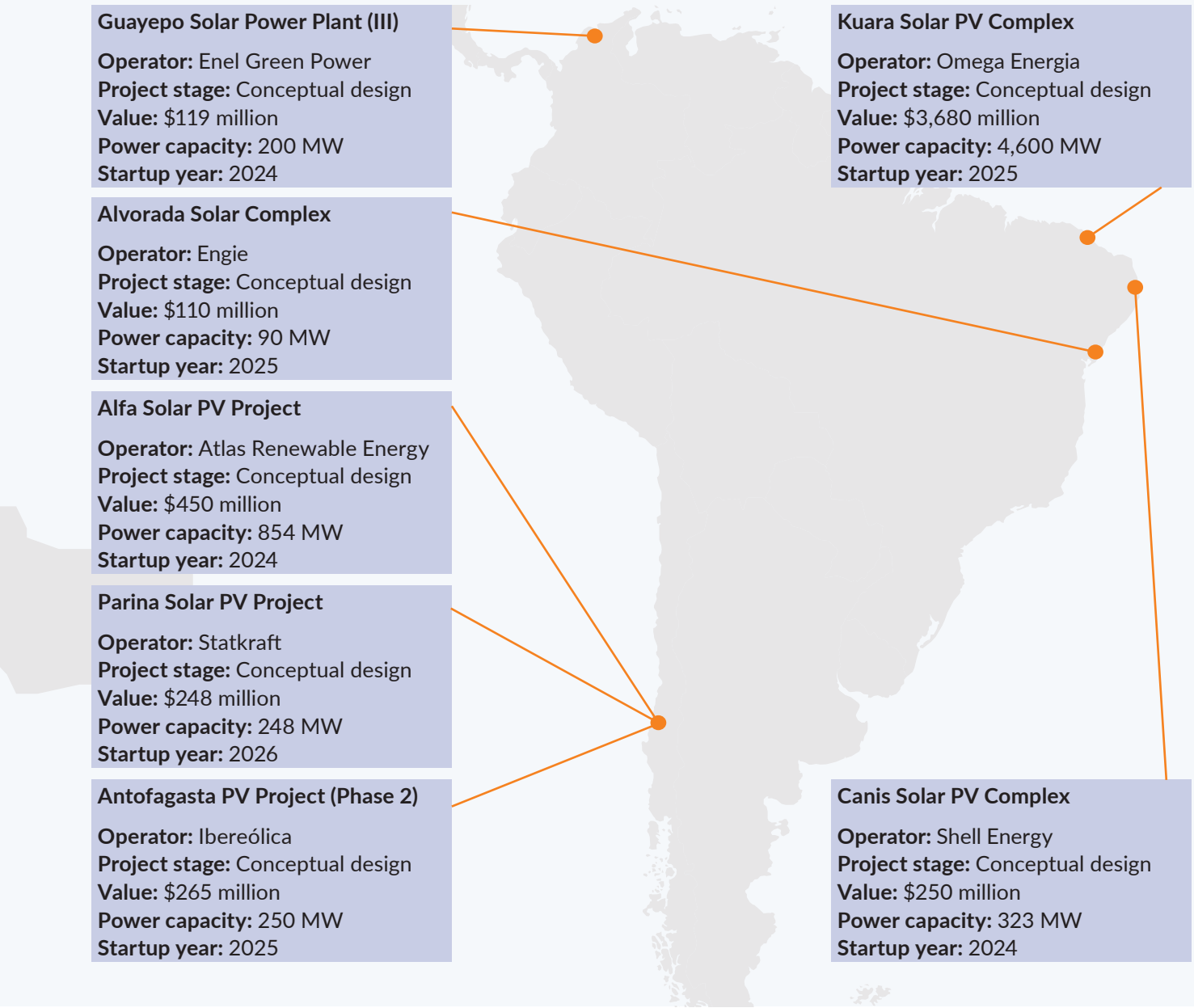

Figure 3.6.6: Geographical summary of solar PV projects by major players in planning across North America.

Source: EICDataStream

3.7.1 Brazil

Approximately 5 GW of large and utility scale solar PV is operational in Brazil and with almost 40 GW of solar PV capacity in planning or under development, the country is set to become one of top three global markets by 2025 (Source: EICAssetMap & EICDataStream). By 2024, Brazil could potentially increase its installed capacity eight-fold and will likely be a result of projects that have benefitted from cost-reducing federal subsidies and policies incentivising solar PV development. In terms of policy, the recent re-election of President Lula da Silva presents itself as an opportunity considering his administration stance on backing renewables and ambitions for zero carbon emissions from Brazil's electricity sector.

Policy	Governing body	Delivery years	Key targets & strategy	Financing
Energy Expansion Plan (PDE)	EPE	2019-2029	– Targets 49% renewable energy generation by 2029.	– Investments in utility-scale power generation est. to reach USD$62 billion by 2029
			– Expects to continue auction-based renewable procurement for capacity and solar PV project contract duration is 15 years (previously 20 years).	– Investments in utility-scale solar from contracted auctions projected to reach USD$5 billion by 2022.
			– Brazil electricity sector is modernising and includes expansion of a deregulated market; the plan sees an increase us of private sector PPAs and attract US investment.	– Investments in power transmission projected to reach USD$22 billion and annual investment of USD$2.2 billion per year for expansion and modernisation of distribution networks
			Transmission & Distribution:	
			– Expects to expand grid with an additional 32,000 miles	
National Energy Plan (NEP)	Ministry of Mines & Energy	2050	– Share of renewables in energy mix to increase to 45%	Forecasts 2050 installed capacity in three scenarios:
			– 50 GW solar by 2050 with potential to reach an installed capacity of 95-190 GW if it is favoured over wind or transmission is limited.	– No limitation on wind and solar capacity: R$742 billion (~USD$140 billion)

Policy	Governing body	Delivery years	Key targets & strategy	Financing
			- Considering floating solar up to 10km from shore and estimated that 4,443 TWh/year can be generated from FPVs	- Limitations on solar power (does not exceed 50 GW): R$746 billion (~USD$141 billion)
			- Considers hybrid potential so wind and solar and highlights intermittency and low dispatchable nature of the two energy sources	- Limitations on both wind and solar (does not exceed 50 GW): R$801 billion (~USD$152 billion)
			- Plans to integrate solar generation with T&D expansion; solar start-ups are quicker than T&D project start-ups which poses a problem for deployment	

Table 3.7.1.1: *Summary of policies in Brazil promoting solar PV development*

Brazil's solar auctions and types

Since 2004, Brazil's energy regulator, Agência Nacional de Energia Elétrica (Aneel), has used centralised auction-based renewable procurement to install new generational capacity. In 2013, developers for solar projects participated for the first time in the auctions for deployment from 2016 onwards. Auction types in Brazil, generally depend on delivery time; delivery in three years, four years, and five years (A-3, A-4, and A-5, respectively). The greater the delivery time, the more flexibility allowed for planning and development of the project. A-5 projects also generally allow developers the opportunity to profit from the falling costs of equipment needed for solar; a trend that has been prevalent during the commercialisation of solar PV. This in turn, generally leads to lower prices during A-5 auctions. A-3 and A-4 projects are typically used to procure solar and smaller scale renewables with A-5 reserved for hydropower and conventional power projects.

The latest auction in May 2022 (A-4/2022) allocated around 166 MW to solar PV projects of 950 MW renewable energy capacity at an average final price of R$0.178/kWh (USD$0.037/kWh) for start-up by 2026, and has shown how the cost of solar PV has greatly declined from an LCOE of R$0.215/kWh (~USD$0.09/kWh) in 2014.

In March 2022, a noticeable increase in the number of projects being registered with ANEEL was observed, in order to benefit from country's transmission network price subsidy for renewable energy before being scrapped, as per a regulatory law passed in March 2021. These subsidies halved the cost of transmission network usage for renewable generators and essentially incentivised renewable development, so this law was not particularly favoured. That being said, due to the country's free electricity market, the majority of these recent projects are targeting PPAs; this is likely the future of Brazilian energy generation.

Following the weakening of Brazil's economy because of the COVID pandemic and resultant supply chain issues, the government reduced the size of Brazil's energy auctions in 2021. But the cost competitiveness of solar has still incentivised large consumers to enter PPAs with developers for solar in recent years; Brazil's NEP also shows the government preferring the use of PPAs to drive solar development. Offtakers are particularly motivated from an ESG perspective too, with many corporations needing to meet their targets in line with the Paris Agreement.

3.7.2 Chile

According to the World Bank's Global Photovoltaic Power Potential study, Chile has a theoretical solar potential of 5.758 kWh/m2 and ranks 34 out of 183 countries analysed, in terms of irradiation (more specifically Global Horizontal Irradiation). The country is also second, just after Namibia in practical PV power potential, which accounts for factors including but not limited to: theoretical potential, air temperature, and land topography. This solar PV potential as well as other geographical factors make Chile a desirable location for other non-conventional renewable energies (NCRE), too. Chile is looking to harness this potential; in 2013, the Chilean government passed the Non-Conventional Renewable Energy Law which set a target for the country to generate 20% of electricity from renewables by 2025. Two years later, the government set out its long-term goals in the National Energy Policy 2050 which aims to generate at least 70% of electricity from renewable energy by 2030.

With an estimated CAPEX of USD$17 billion to develop almost 20 GW of solar PV capacity by 2025, Chile is making steps towards their clean energy targets. The Atacama Desert has great potential to generate solar PV and we are seeing the majority of projects in the pipeline being located in the desert regions of Atacama, Antofagasta, and Tarapacá. However, with the remoteness of the desert, Chile needs to develop and to invest more in its transmission and distribution (T&D) network to facilitate renewables. This will assist in renewable energy penetration, security of supply, and reduction in the cost of energy.

Chile's auctions

Much of the Chilean solar PV market is driven by auction; technology-neutral auctions for both renewable and non-renewable technologies for long-term PPAs were historically organised by distribution companies and drove solar and wind projects. In 2020, Chile submitted their updated Nationally Determined Contribution (2020 NDC) as part of the Paris Agreement. Aiming for greenhouse gas neutrality by 2050, a new bidding law framework came about, and Chile's National Energy Commission (CNE) gained responsibility in designing and coordinating the bidding process from there. The most recent auction was launched in February 2022 which aimed to provide 5.25 GWh of electricity for the country for 15 years from 2027. The winning developers included Zapaleri who submitted a bid of USD$0.038/kWh for a 126 GWh solar and storage facility and FRV Development Chile I who won the bid at USD$0.037/kWh for the development of a 651 GWh hybrid wind and solar project. This was a contrast to the energy action from the year before where the CNE allocated 2.31 TWh of renewable energy with the lowest bid in Latin America at the time coming at USD$0.01332/kWh for a large-scale PV plant.

Since 2017 the Ministry of National property has successfully tendered state land for the development of renewable energy projects, In April 2022, the Ministry launched a tender for 2,700 hectares of land for wind or solar projects in the northern region of Chile. With close proximity to transmission lines, it is a suitable area for large scale wind or solar development. This is particularly interesting as the energy sector is privately owned and there are generally no subsidies offered by the government to assist in deployment of renewables. Changing policy is likely to be a driver to increasing solar PV deployment. As of 2020, around 75% of the energy mix in Chile consisted of fossil fuels, with less than 25% being renewables and less than 5% being solar PV energy. In 2019 the Chilean government set a target to decommission all installed coal capacity by 2040, to be replaced by non-conventional renewable energy (NCRE) sources including solar PV. As a result of this, NCRE will likely penetrate Chile's energy mix and we will see more solar PV projects coming into operation over the next few decades.

3.7.3 Analyst Opinion

From north-eastern Brazil to the Atacama Desert in Chile, solar power plays a key role in the South American energy market. A region traditionally reliant on hydro power generation, South America saw in solar an opportunity not only to expand the share of renewable energy and meet climate change goals but also to diversify its energy mix and bolster energy security. Ideal solar irradiation levels, strong government support and robust backing from the private sector have enabled Brazil, Chile, and other South American countries to unlock and ramp up the development of the solar PV sector, with evident success: solar power has been the renewable energy sector with the highest year-on-year capacity growth in South America.

Brazil and Chile are the two key markets for the solar PV sector in South America, with a growing project pipeline put forward by local and international developers. While local companies such as Eneva, Ômega Energia and Colbún detain a significant share of CAPEX in their own domestic markets, international players including Enel Green Power, Engie and Ibereólica have a project portfolio spanning multiple countries across the region. While PV module, inverter and tracker packages are mainly sourced overseas, balance of plant contractors including Prodiel, Biosar, Tozzi and Sterling & Wilson provide opportunities for local supply chains in South America.

Looking ahead, solar PV development will unfold in different speeds across the region. While Brazil and Chile – which already have a robust participation of corporate PPA contracting – will further expand their utility-scale capacity and scale-up the development of hybrid solar/battery projects, markets such as Colombia and Peru will see solar PV capturing an increasing share of project activity and CAPEX.

Pietro Ferreira, Senior Regional Analyst - Americas

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Key contractors

According to EICDatastream, over 1500 contracts have been awarded for solar PV projects since 2018. Figure 4.1 indicates the top three contract types, EPC (Engineering, Procurement and Construction), OEM Supply (Original Equipment Manufacturer) and BOO (Build, Own, Operate) by region.

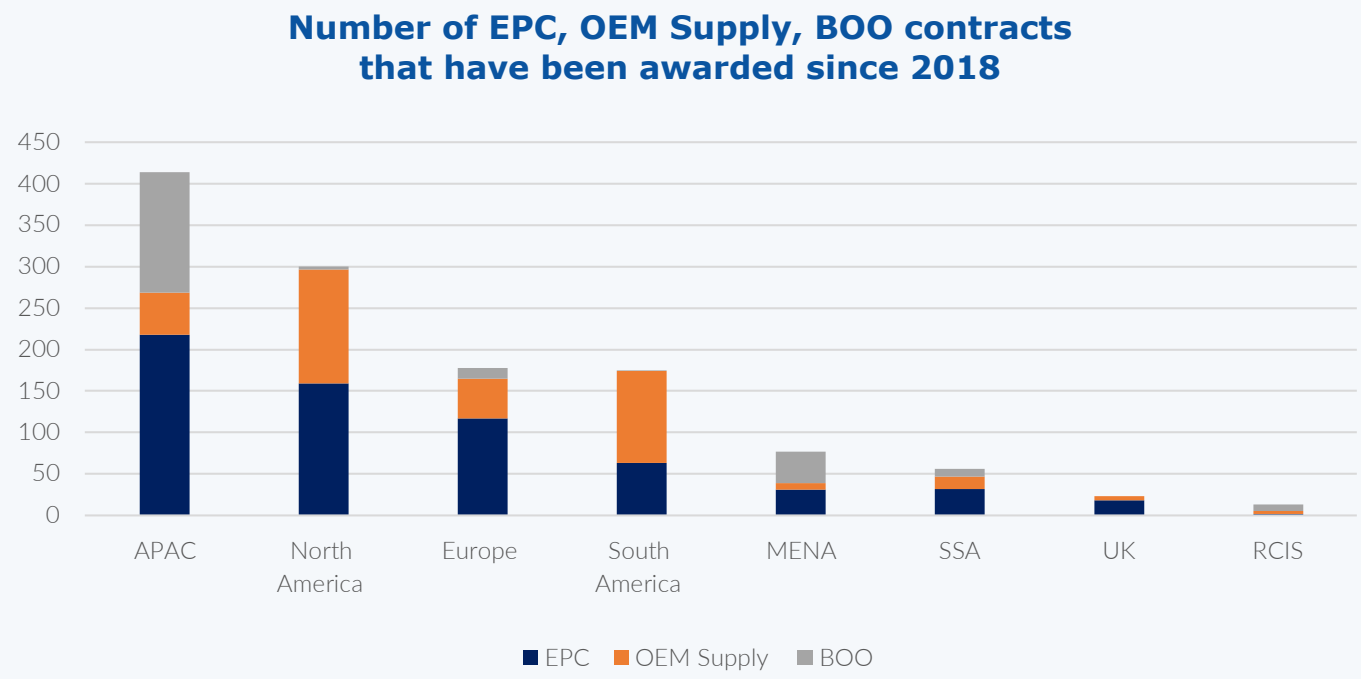

Figure 4.1: Number of EPC, OEM Supply, BOO contracts that have been awarded since 2018.

Source: EICDataStream

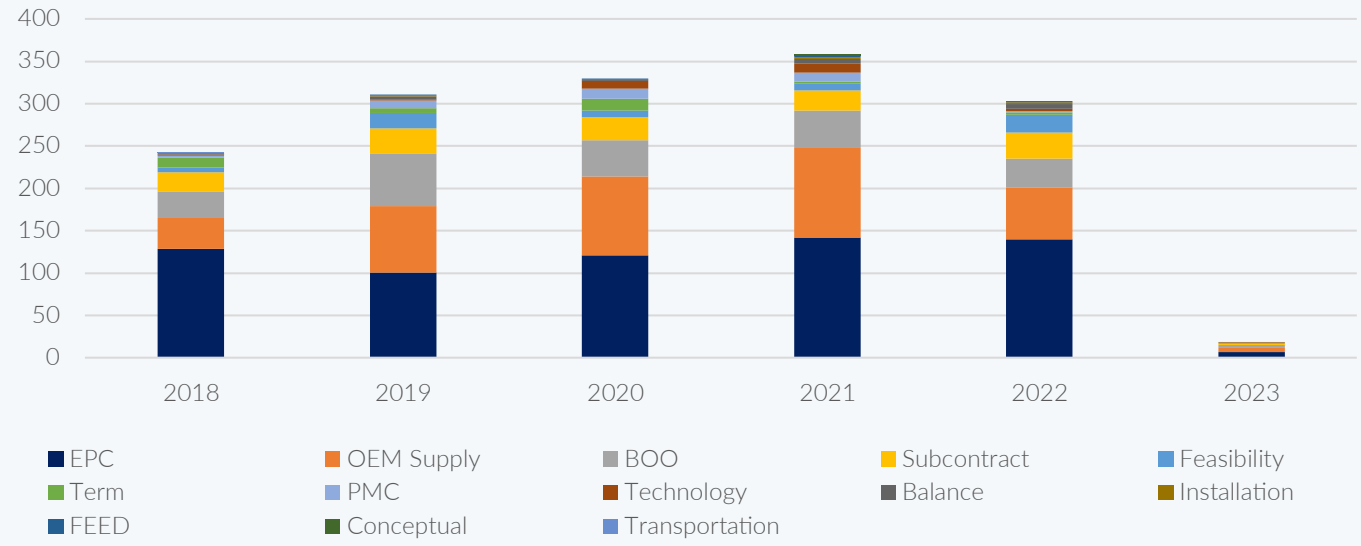

Figure 4.2: Number of awarded contracts awarded since 2018, by contract type.

Source: EICDataStream

It is evident that EPC contracts are the most common form of contract used to develop utility-scale solar projects across the global private sector. An alternative to an EPC contract would be separate supply, design, and constructions contracts with or without a project management agreement, often observed in the oil and gas (O&G) sector. EPC contracts are generally preferred as they satisfy Lender requirements for bankability of renewable projects by providing a single point of responsibility in the Contractor, a fixed contract price and a fixed completion date. Figure 4.2 shows the trends in award dates for EPC contracts over the last five years. It appears that the rate at which EPC contracts are being awarded is slowing down globally, although a downwards trends across all contract types – apart from feasibility contracts – was observed. Likely causes of this trend include, delays in permitting and grid connections, as well as supply chain constraints caused by post-pandemic economic recovery, Russia's invasion of Ukraine and reliance on Chinese imports, whilst the country faces lockdowns.

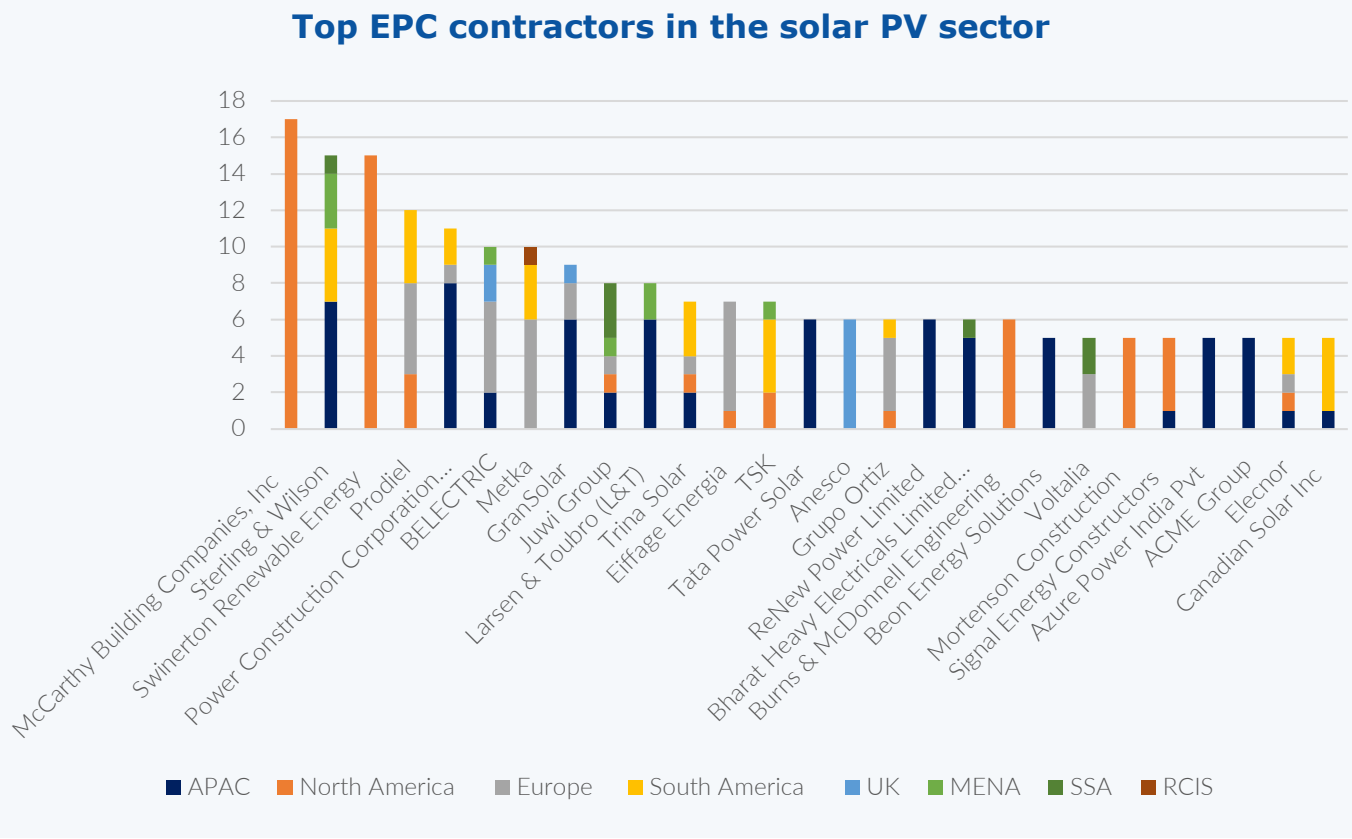

Figure 4.3: Top EPC contractors in the solar PV sector.

Source: EICDataStream

Figure 4.3 indicates the top 2 companies who have been awarded EPC contracts since 2018, globally. McCarthy Building Companies, who are an American construction company, have repeatedly been awarded EPC contracts for solar PV projects in the USA by regional and international major players such as Lightsource BP, NextEra Energy Resources and Silicon Ranch Corporation. However, globally, Indian-owned Sterling & Wilson is a leading solar EPC company who have been awarded contracts in Chile, India, Zambia, Egypt, and Australia.

As observed in Figure 4.2 in there is a significant decrease in the number of OEM supply contracts that were awarded between 2021 and 2022. This is likely due to the solar manufacturing being largely based out of China, who, according to the IEA, are responsible for 80% and rising of solar panel production, thus highlighting the need for diversification of the manufacturing supply chain. Figure 4.4 shows the top 20 OEM suppliers who have been awarded contracts since 2018 – almost half of the leading manufacturers are Chinese. China's competitive labour market and abilities to reach economies of scale has enabled strong global growth of solar PV over the last decade which has resulted in the cost decline of solar and made the technology the most affordable electricity generation technology in some regions. With the concentration of global solar PV manufacturing being located in China, this poses risks to the entire solar project value chain – volatility has been observed as a result of the pandemic, a global energy crisis and lockdowns in China, as aforementioned and is likely a cause for the slowed rate of awarded contracts since 2021. However, trade restrictions are also expanding, as major solar PV markets such as India who are aiming for self-sufficiency and the USA who is increasingly imposing import duties on Chinese solar panel manufacturers.

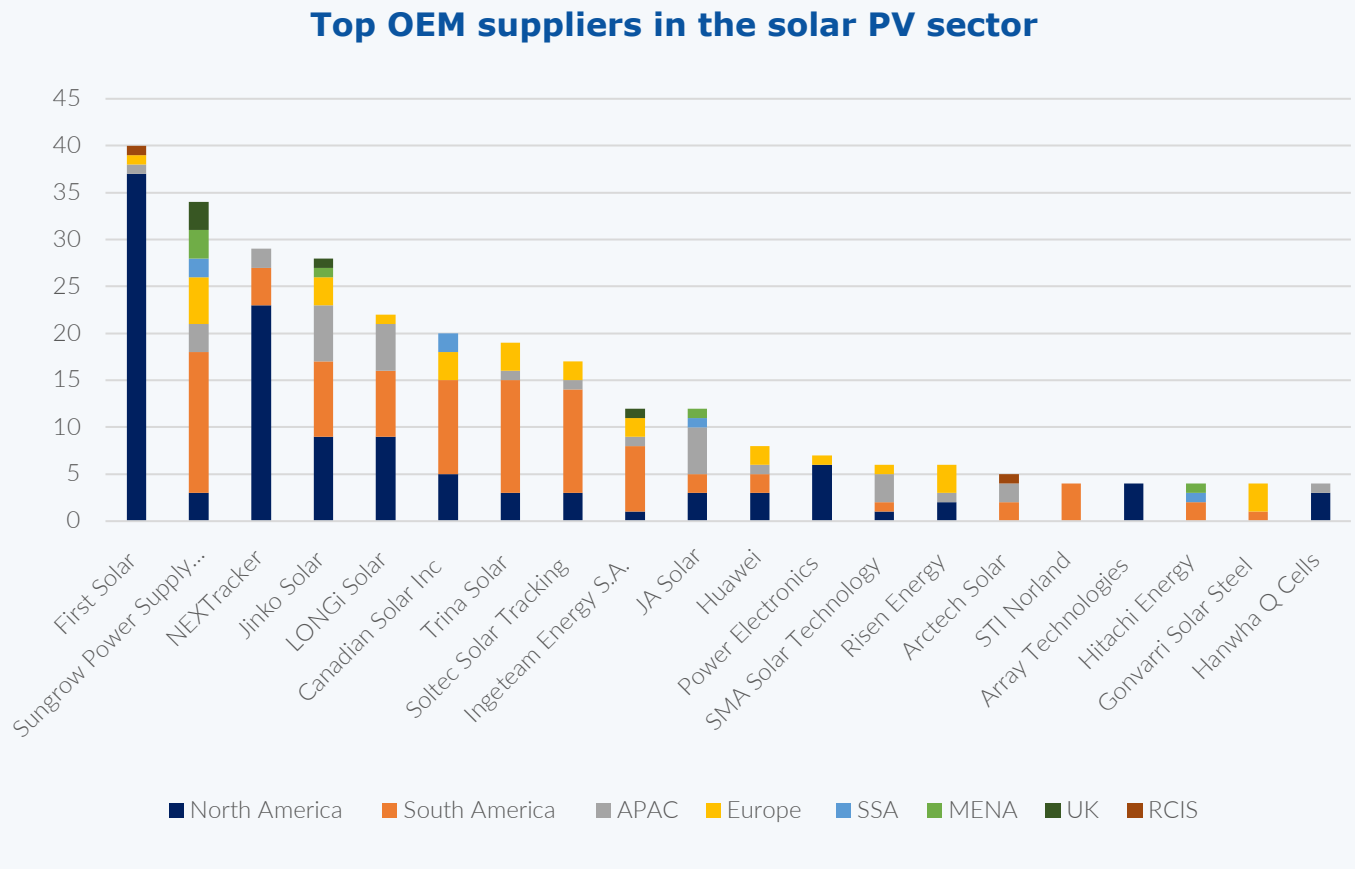

Figure 4.4: Top OEM suppliers in the solar PV sector.

Source: EICDataStream

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Conclusion

It is evident that the solar PV sector is seeing significant growth in operational installations, planned pipeline and in political ambitions. Solar PV capacity is a key in driving the transition to renewable energy and growth will be further driven by government climate ambitions, oil price and the need for energy security. The outlook is also positive by the trends observed around emerging markets that are attracting foreign investment, as highlighted particularly for the CIS and SSA regions. Declining costs and increased scalability will incentivise investment into this sector of which there is already evidence of this in established markets like India and Saudi Arabia. Policy support is increasing as shown in the USA, across Europe and in India with enabling strategies like tax credits and auction that are assisting in increased deployment of solar PV capacity. Investor interest to adhere to ESG targets is increasing particularly for large corporation and major oil and gas companies who are buying stakes in renewable energy companies or expanding their businesses to encompass solar PV development.

Global challenges do however remain in individual markets as well as across borders. Further R&D and technological investments will be vital in utilising alternative materials to reduce the dependence that solar manufacturing materials like copper and silver that are currently a factor in causing supply chain disruptions. R&D will also be important in increasing the sustainability of solar equipment, particularly recyclability of components at the end of a project lifetime and reuse of existing modules. Improved grid infrastructure or greater penetration of energy storage will be required to bring the 500GW solar PV pipeline online by 2025. Grid permitting and commissioning permitting processes remains as a challenge to the faster deployment of utility-scale solar PV plants in markets like Mexico, the UK, and across Europe.

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