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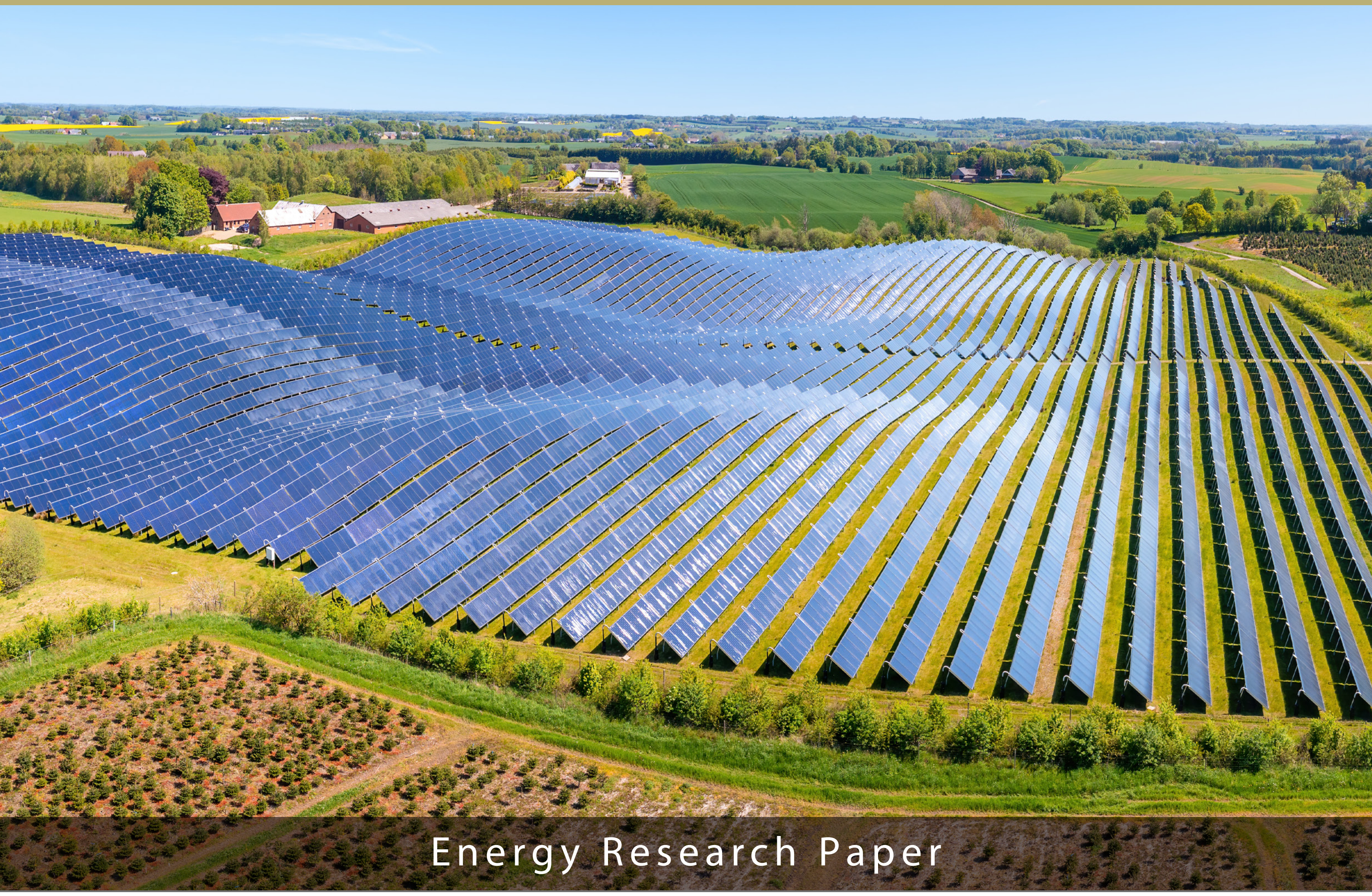
Tripling Renewable Capacity To 2030: Will It All Be Solar?



Energy Research Paper

The Al-Attiyah Foundation

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The 2023 United Nations Climate Change Conference (COP28) united parties around a pledge to triple current global renewable capacity from about 3.8 GW currently to reach 11 TW by 2030, placing renewables at the centre of achieving global climate commitments. If fully realised, 11 TW of capacity could see renewable energy contributing to 62% of all emissions reductions by 2030. Still, this is not fully sufficient to realise net zero goals and will have to be complemented by other important pledges signed / reiterated at COP28. What is the outlook for renewable, especially solar, capacity over this period? Can its growth be sustained, and which are the main established and emerging markets? What are the implications of large-scale, very low-cost solar power for the global energy system and geopolitics?

ENERGY RESEARCH PAPER

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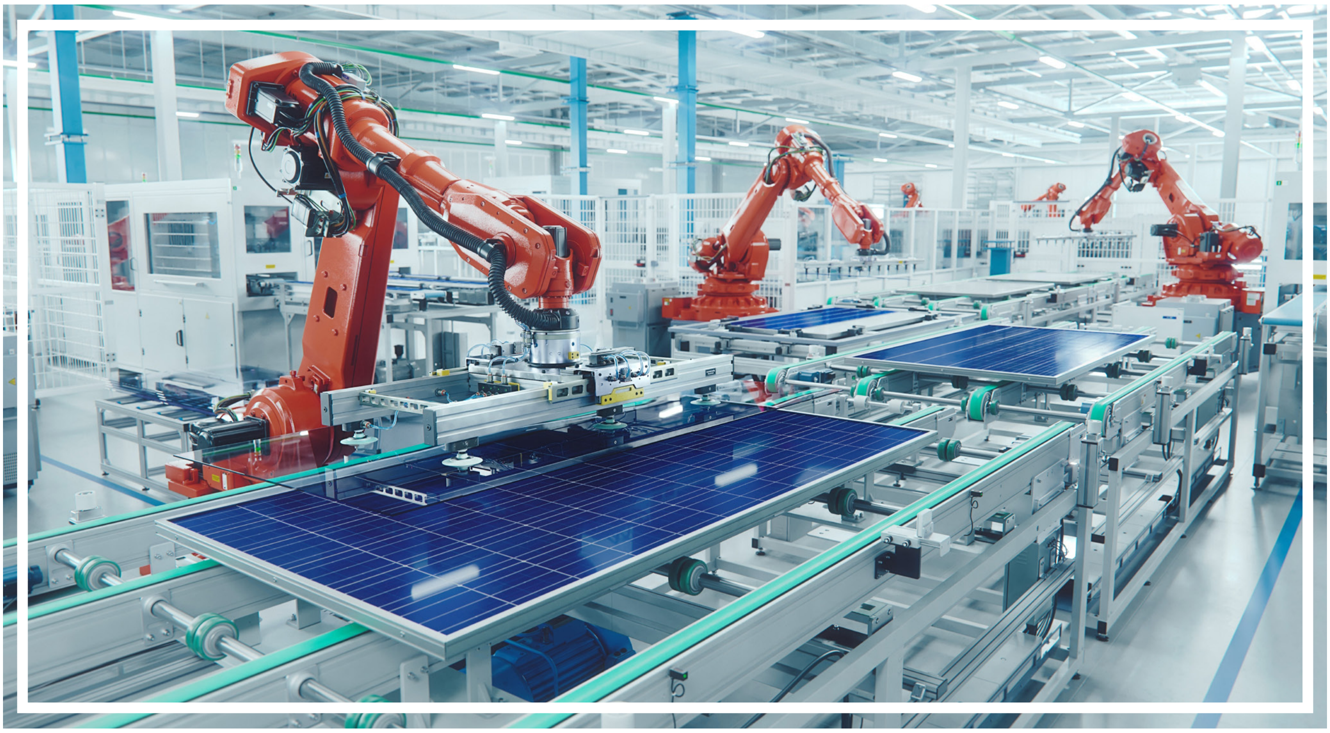
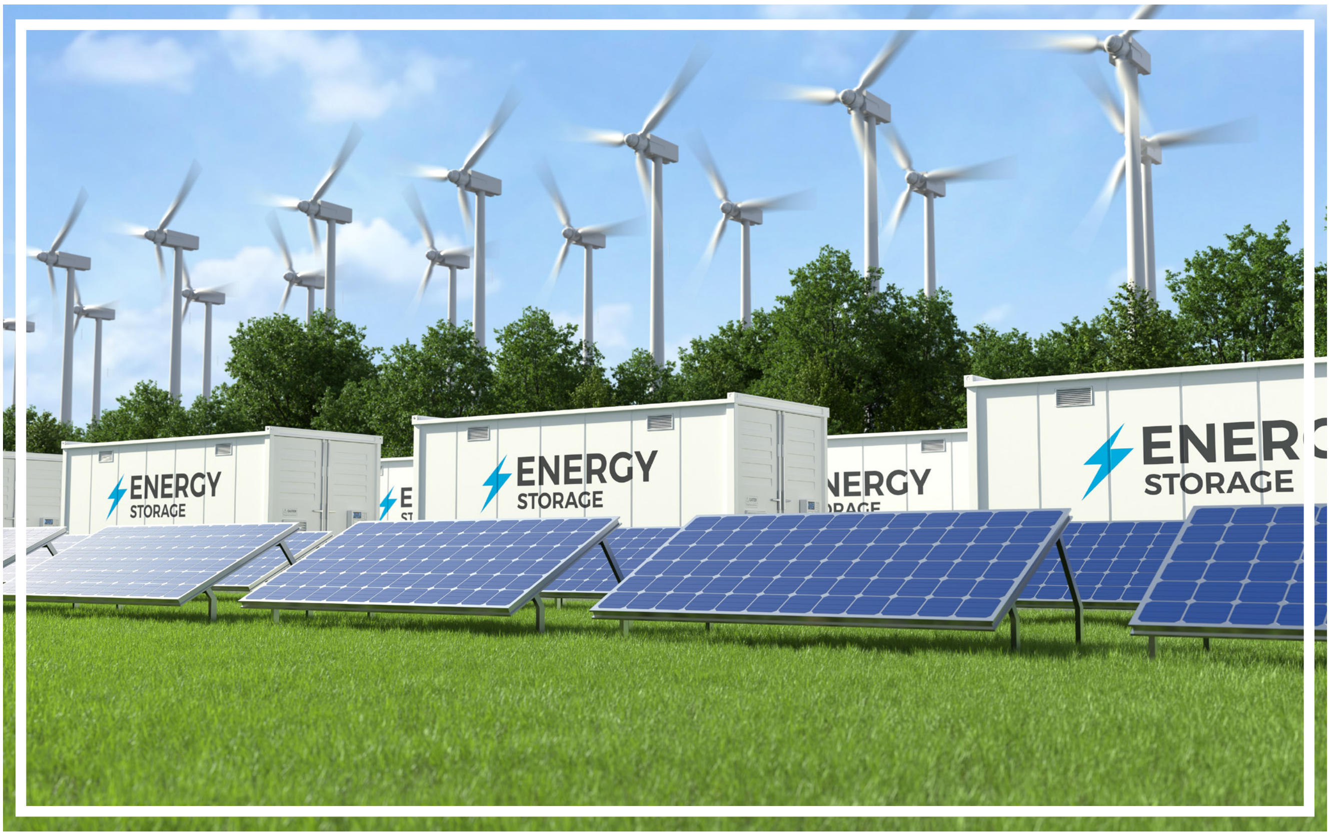




- The 2023 United Nations Climate Change Conference (COP28) united parties around a pledge to triple current global renewable capacity from about 3.8 GW[i] currently to reach 11 TW by 2030, placing renewables at the centre of achieving global climate commitments.
- If fully realised, 11 TW of capacity could see renewable energy contributing to 62% of all emissions reductions by 2030. Still, this is not fully sufficient to realise net zero goals and will have to be complemented by other important pledges signed / reiterated at COP28.
- Solar makes up the majority of forecast installed capacity to 2030, but it does not make up the total. For climate goals to be achieved, other renewables need to scale up alongside solar.
- Industry and government must move fast. Meeting the tripling capacity target will require doubling the rate of investment in renewable energy to an average of US$ 1.2 T per year to 2030 from US$ 564 B in 2022.
- Non-economic factors have become the primary hurdles to realising accelerated deployment. Scaling up the right mix of technologies will require addressing barriers to access, enabling competitive auctions and incentivising flexible power systems.

- Oil and gas producers can leverage their expertise with supply chains and market development to realise COP28's tripling renewable capacity by 2030 goal, as well as supporting low-carbon energy deployment in the energy transition on-the-whole.
- They can build strategies for renewable and low-carbon business models that minimise carbon use while remaining profitable, and articulate these strategies clearly to markets and other stakeholders
- They can support the development of ESG metrics that are transparent, objective, and accessible to investors, and which can boost the financing of renewable projects in the pipeline.
- They can also encourage the development of better renewable market design by helping in the evolution of carbon markets and expand the possibilities for joint cross-border projects for emissions reduction.
- Lastly, for oil and gas producers from the GCC, they can utilise their low-cost manufacturing bases to explore entry into different parts of the renewables value chain to reinforce strategic energy trade relationships based on the energy transition

Tripling renewable power capacity by 2030 is technically feasible and economically viable, but delivery requires determination, policy support, investment at scale, and overcoming systemic and structural barriers to the energy transition.

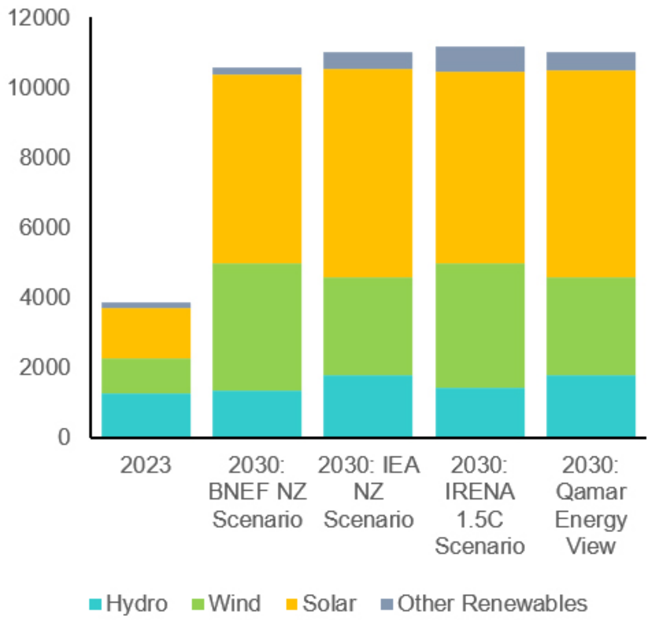
Renewables accounted for 87% of all newly installed power capacity in 2023[ii]. Out of the 473 GW added, solar energy accounted for 345 GW or nearly 75%, driven by the decreasing costs of utility-scale solar, supportive energy and industrial policies (in regions like Asia), and geopolitical shifts that catalysed rapid renewable energy growth in markets affected by heightened energy security concerns, such as the EU.

COP28 united parties around a pledge to triple current global renewable capacity from about 3.8 GW[iv] currently to reach 11 TW by 2030, placing renewables at the centre of achieving global climate commitments.

Several leading net zero pathways align with this view, including the IEA's Net Zero Emissions by 2050 scenario, BNEF's New Energy Outlook Net Zero Scenario (which sees 10.5 TW of renewable capacity by 2030 to stay on track for global net zero by 2050)[v], IRENA's 1.5°C scenario, and the NGFS' (Network for Greening the Financial System) Net Zero by 2050 scenario.

If fully realised, 11 TW of capacity could see renewable energy contributing to 62% of all emissions reductions by 2030[vi], compared to stated policies-only scenarios (such as the IEA's Stated Policies scenario and BNEF's counterfactual no-transition pathway scenario).

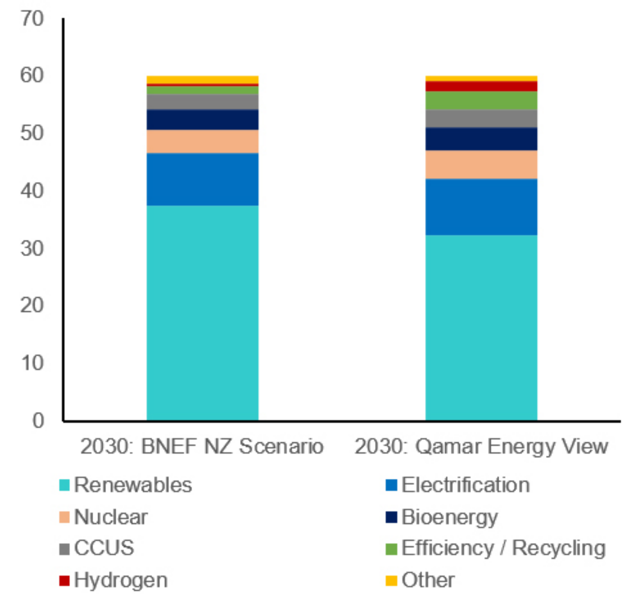
Figure 1 Global Renewable Capacity by 2030 to Achieve 2050 NZ, GW[vii]



Still, this is not fully sufficient to realise net zero goals, and will have to be complemented by other important pledges signed / reiterated at COP28, including a doubling of energy efficiency by 2030, and a reduction in methane emissions by at least 30% from 2020 levels by 2030. Electrification of end-use sectors will also make an important contribution to total carbon abatement required to stay on track to achieve net zero goals (Figure 2).

Tripling renewable capacity by 2030 does not mean that renewable generation would be tripled. For example, even though global renewable energy capacity tripled between 2010 and 2022 (from 1.2 TW to 3.6[viii]), global renewable energy generation only doubled during this period (from 4,000 TWh to just over 8,000), i.e. a GW increase does not correspond to a TWh increase by the same factor. This is because traditional renewables were dominated by hydropower, with a higher capacity factor; new installations favour wind and, especially, solar. In our view, a significant share of cumulative emissions abated by 2030 will be achieved by technologies additional to renewables, including electrification, CCUS, hydrogen, and energy efficiency, compared to BNEF's scenario.

Figure 2 Cumulative Emissions Reductions from 2022-2030 Under Net Zero Scenarios by Measure, GtCO2;



07 SOLAR MAKES UP THE MAJORITY SHARE OF FORECAST INSTALLED CAPACITY TO 2030

Although solar makes up the majority share of forecast installed capacity to 2030, it does not make up the total. For climate goals to be achieved and net zero scenarios realised, other sources of renewable energy need to scale up alongside solar. These include most importantly wind, and to a lesser degree solar thermal or concentrated solar power, and geothermal. Biomass energy, a significant part of current capacity, is in practical terms not always truly "renewable" and has various other environmental drawbacks. Our outlook sees over 21,000 TWh of renewables generation in 2030, largely from 2.8 TW of wind power and ~6 TW of solar[ix]. This is 2.7x as much renewable energy generation as in 2022, from triple the capacity.

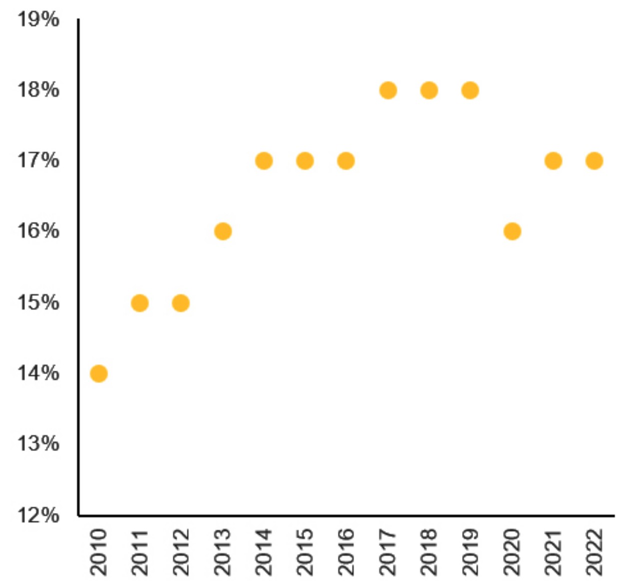
Tripling of RE capacity between 2010-2022 offers necessary lessons for the next tripling to 2030. Firstly, recorded renewable energy generation increased only by a factor of 2.1. This is because most of the new capacity added was solar. Despite solar skyrocketing in the past decade and a half, and its important role for the transition, the technology has low-capacity factors, ranging from ~30% in Chile (which receives great sunlight at higher altitudes with clear skies), 20-24% in the Middle East, and about 11% in major markets like Germany and eastern China (11-14%)[x].

Global average capacity factor (excluding small-scale generation) was about 13.2% in 2022 according to BNEF[xi] (although IRENA reports a reasonably higher capacity factor of 17%[xii], likely due to definitional issues). By contrast, wind farms had a global average capacity factor in 2022 of 27.2%, hydro plants of 40%, and geothermal at 68%[xiii] (despite it being relatively niche and concentrated in only a handful of markets worldwide).

Secondly, low capacity factors are a structural feature of solar power, meaning that even if solar technology continues improving, gains in capacity factor might be marginal at best, depending on the site location of the plant. Solar is cheap (usually the cheapest source of bulk electricity) and relatively easy to site, which makes it a quick technology to deploy. It could meet the goal of tripling renewables capacity by 2030 on its own.

Still, even with a marginally higher capacity factor, the impact on increasing electricity generation will not be sufficient (not withstanding seasonality concerns). That is, a higher capacity of solar power will not mean a higher amount of emissions reductions, when compared to a generation mix with a more diverse fleet of renewables.

Figure 3 Global Average Solar PV Capacity Factor[xiv]



Thirdly, solar is highly seasonal, meaning that in certain seasons and in the daytime, it could cannibalise the return of other clean energy technologies such as wind farms and nuclear power, driving more fossil fuel use at night and in the winter.

Addressing emissions abatement will therefore require a more balanced deployment of renewable technologies, and consideration of seasons and times when different sources are likely to be available.

A mixed portfolio makes it easier to remove residual emissions from the power sector. For example, relying solely on solar would require natural gas balancing to meet demand during the night, or a gas reserve during emergency situations (such as insufficient battery storage or battery failure, or unexpectedly high demand). The emissions from the gas generation could be captured to 90% or more with technologies like carbon capture and storage (CCS), leaving a residual that would have to be mitigated by other means, such as DAC. Hydrogen can be produced from renewable energy and stored for long periods but remains expensive. Long-duration battery storage which is employed rarely is also expensive because of the high capital cost of the battery.

Or, nighttime generation could be carried out by other renewables, such as wind power (wind speeds at hub height during the night can be 2.6x higher than during the day, plus wind has a complementary generation profile to solar and a much higher capacity factor), solar thermal (molten salt heated during the day could release the energy for power at night), geothermal, biomass or others.

This does not mean that a mixed portfolio would help remove all residual emissions from the power sector, but it could help reduce them by a considerable margin. For the last 5-10% of emissions, solutions like DAC or offsets might have to be employed. More importantly, this further confirms that solar alone cannot get the world to net zero emissions.

Some regions might have to do more than triple. This is particularly true in regions with a small starting base of renewables, where tripling capacity will not be sufficiently ambitious to set a pathway to net zero emissions. Regions like South and Southeast Asia, the Middle East, and Africa require a much steeper trajectory away from current fossil fuel usage while developing capability and capacity to meet growing electricity demand with clean energy.

For the Middle East, the rapid decline in costs of renewables means that they could theoretically triple in capacity by 2030 relatively easily, but pace of development in individual countries could keep this goal from being realised.

Forecast capacity by 2030 required to be on track with net zero goals is about 400 GW, nearly 14 times current installed capacity (28.4 GW as of 2022). However planned capacity amounts to ~250 GW[xvii], with main players leading the expansion being the UAE, Saudi Arabia, Egypt, and to a lesser extent Israel and Morocco.

The UAE is set to surpass 19.8 GW of clean energy capacity by 2030, from 3.6 GW in 2022 (excluding 2.45 GW of nuclear), with nearly the entirety consisting of solar PV. On current growth levels, the country could have solar PV for generation reach >17 GW by 2030. This is based on past targets being achieved on time and without logistical holdups, such as the previous 2020 target of achieving a 7% renewable energy share in the power generation mix. This suggests that future 2030 and 2050 targets should also be achieved relatively quickly.

Figure 4 Forecast RE Capacity by 2030 Required from the MENA Region to be on Track with Net Zero Goals GW[xv]

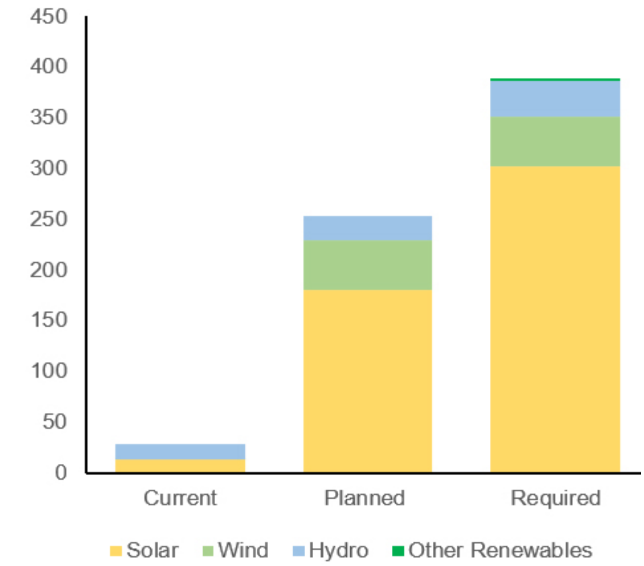
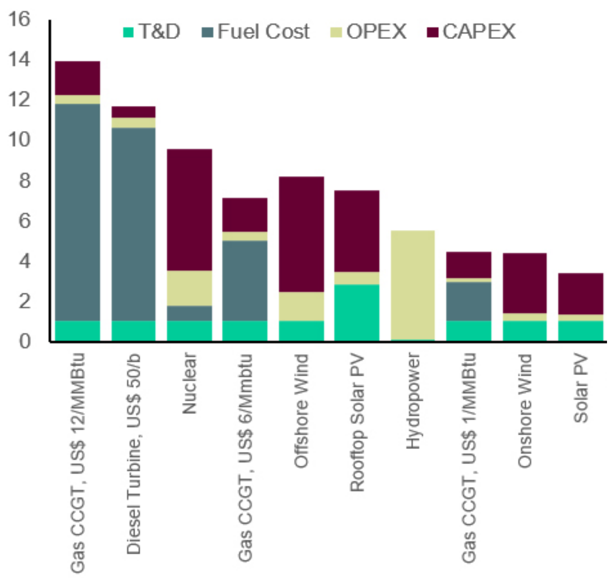


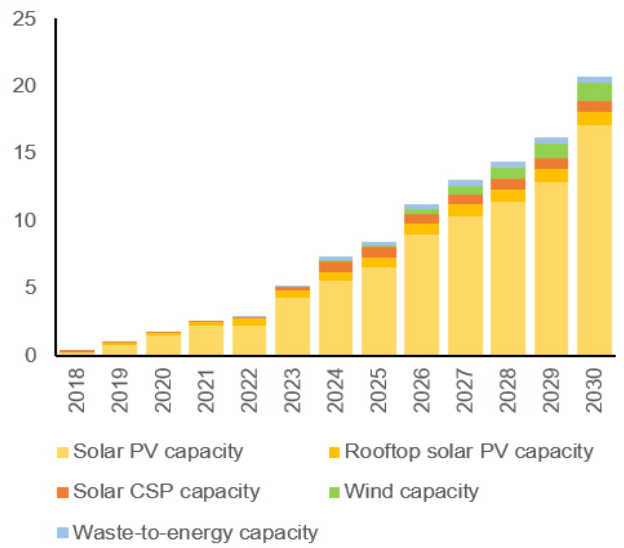
Figure 5 Breakdown of LCOEs in MENA, US$c / kWh[xvi]



Saudi Arabia is a slightly different story. Introduced in 2016, the Saudi Arabia Vision 2030 had an initial target of deploying 9.5 GW of renewables by 2030, with multiple revisions since, the latest in 2023 suggesting ~59 GW by 2030, which has now been revised in April 2024 to 130 GW of renewable power capacity by 2030[xix], 2.2 times higher than the previous target, and a whopping 293 times higher than the current miniscule capacity of 443 MW (as of 2022).

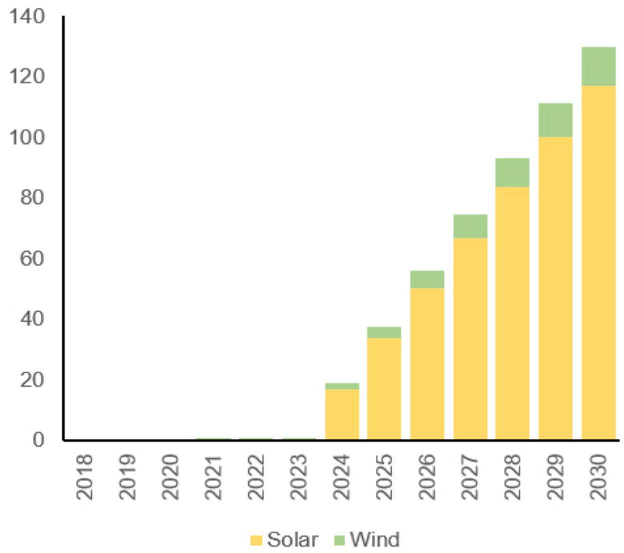
The country was targeting 27.3 GW by 2023 as part of the Vision 2030 overall target, but as it is nowhere even close to this figure, it gives rise to reasonable doubt over Saudi actually realising the 130 GW figure. The bulk of this is earmarked for solar despite having excellent wind resource in the northwest part of the country (with capacity factors that could much more dramatically decarbonise generation than relying solely on solar).

Figure 6 UAE forecast RE capacity by 2030, GW[xviii]



Egypt meanwhile has a capacity target of 62 GW[xxi] by 2030 from the current 6.3 GW, split equally between solar PV and wind power at 31 GW each. This would mean adding upwards of 9 GW each year to 2030 (hydropower capacity in the country is already fully utilised at ~2.8 GW). The current project pipeline indicates that the 62 GW target could be met if projects are realised on time, but past experience points to the continuing challenges of high debt rates and capital, a cumbersome bureaucracy and opaque regulatory frameworks that could hold back progress.

Figure 7 Saudi Arabia RE Capacity by 2030 from Solar and Onshore Wind GW[xx]



The renewable sector also appears sensitive to developments in the green hydrogen sector, with limited to no offtake agreements so far dampening investor confidence in the country's overall clean energies development.

Other countries pursuing a substantive growth in solar (and renewables) capacity by 2030 are Morocco, Israel, and Oman, but progress there has also been slower towards near-term targets, partly due to the pandemic in 2020, and partly due to the higher solar module prices in 2021 and 2022. In Oman's case, a lot of planned capacity is earmarked for future green hydrogen production (in addition to grid power), whilst in Israel, war will stifle activity.

Current plans exclude hydrogen dedicated RE capacity. For example, a country like Egypt that has a 44 GW hydrogen project pipeline[xxii] would have to develop dedicated hydrogen-only renewable capacity instead of relying on the national grid for electricity (to power electrolysers) due to the country's struggles with meeting power demand.

This means additional renewable capacity on top of planned capacity for decarbonising generation. Others might utilise more nuclear energy to decarbonise their generation (such as the UAE, and possibly Saudi Arabia), leaving more renewables available to be dedicated to green hydrogen processes.

The UAE is targeting close to 200 GW of renewable energy by 2050[xxiii], including for electrolysis to meet its ambitious green hydrogen production target of 7.07 Mt/y[xxiv]. Over 90% of this will be achieved from solar PV.

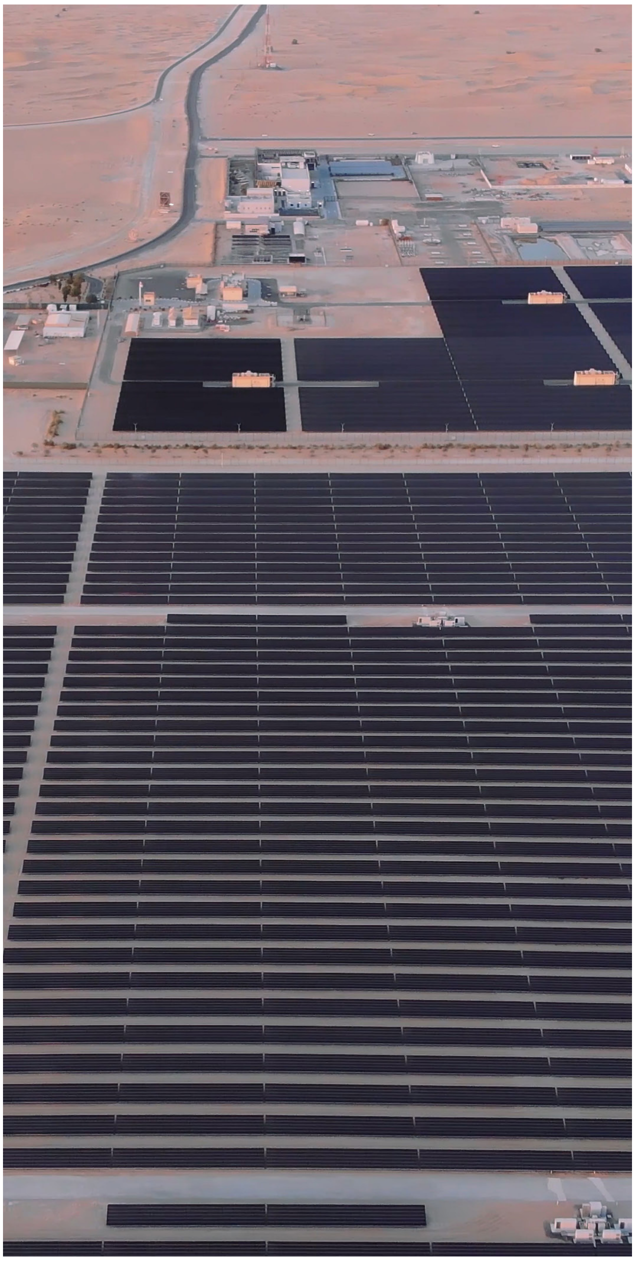
Among other markets, earlier adopters of RE might meet net zero with the tripling goal. In the US, Europe, Japan, and China – who were some of the earlier adopters of renewable energy – tripling capacity by 2030 should be sufficient to align with a net zero pathway to decarbonising generation, but not all are on track to achieve it.

Current renewables capacity in Europe is 663 GW[xxv]. Tripling this would take it to ~2 TW, which would be sufficient to align with net zero. However, the region is set to miss this goal by a third, mainly due to long development timelines as a result of grid and permitting bottlenecks, and challenges expanding the offshore wind sector faster (to make up for sluggish onshore growth).

The majority of planned build is set to come from solar with wind falling behind. Germany, for example, is not awarding planning permission to nearly enough onshore wind farms to build the 12 GW/y it needs to hit its 115 GW goal by 2030[xxvi]. Wind is also not usefully substituted by solar in northern Europe, because it blows more in the winter, when demand for heat and lighting is much higher than in the summer.

Expanding capacity will also have to go hand-in-hand with increased storage and demand-side flexibility, else power prices would crash at times of high renewable energy generation, supressing further build and causing system problems.

The US, similarly, will fall behind on renewable capacity deployments unless it improves bottlenecks around permitting and grids, despite the IRA and its incentives.



The challenge of tripling the US's 385 GW current capacity is non-economic factors[xxvii]. Complex solar trade restrictions have made solar modules twice as more expensive in the US than in Europe or any market that has a free trade agreement with China. Permitting regulations and a lack of investment and clarity in regional and local electricity grids have also hampered solar and wind deployment.

Still, there are steps being taken to debottleneck the expansion. Transmission lines such as Trans West Express, Champlain Hudson Power Express and Grain Belt Express have benefited from fast-tracked permit approvals. Similar reforms could help the US triple its capacity to get on track to net zero from current projections of ~900 GW by 2030.

Japan, meanwhile, has had several subsidy-driven renewable build (almost entirely solar) booms since 1991, so tripling its capacity (from ~119 GW today) would in fact take it above the level required to align with a net zero pathway[xxviii]. However, the Japanese government has shifted focus to nuclear restarts and wind (due to higher capacity factors there) and a gradual replacement of coal and LNG for thermal power plants with clean ammonia and hydrogen.

This seems more reasonable given Japan's struggles with limited land availability and an unfavourable topography that is unable to support a further massive buildout of renewable capacity. Renewable capacity, therefore might reach just under 200 GW by 2030, about 130 GW short of the level required to align with a net zero pathway[xxix], but which Japan is now looking to meet with alternate clean fuels in generation.

China is the only country that appears on-track to triple renewable capacity by 2030 although that may not mean that its generation would be aligned with a net zero pathway. Despite having the world's largest base of installed renewables that can expand to ~4 TW by 2030[xxxi], 60% of that will be low capacity solar, which might be unlikely to generate enough to align with a net zero pathway.

Table 1 Regional Assessment of Global Renewables Tripling Goal[xxx]

Contribution to Global Target	Region	RE Capacity, 2022	RE Capacity needed by 2030 for Net Zero	Planned RE Capacity, 2030	On Track for 2030 Tripling?
Need to triple RE capacity by 2030	Europe	663 GW	1.99 TW	1.4 TW	No
	US	385 GW	1.15 TW	900 GW	No
	Japan	119 GW	357 GW	190 GW	No
	China	1.24 TW	3.71 TW	3.9 GW	Yes
Need to more than triple RE capacity by 2030	MENA	28 GW	390 GW	253 GW	No
	Africa	48 GW	N/A	146 GW	Yes
	India	177 GW	750 GW	420 GW	No
Less than tripling is sufficient	Brazil	181 GW	310 GW	310 GW	No

The government is pressing ahead for the expansion of new solar builds above wind capacity additions as part of a new mandate to install rooftop solar PV in eastern provinces closer to electricity demand. Solar capacity there can be as low as 11% (compared to western provinces that receive far better sunshine). This will limit the benefits of accelerated rooftop solar deployment through ongoing bulk purchasing schemes in 676 counties, where state-owned developers are issued the remit to build solar and share revenue or savings with rooftop owners. In May 2024, China's State Council relaxed rules on curtailment of wind and solar generation in resource-rich areas, allowing for more deployment despite grid constraints, and potentially allowing another 30 GW of annual solar installation[xxxii].

Separately, large-scale solar and wind projects are being deployed through the "energy "mega" base" programme, but this will depend on the expansion of the long-distance, ultra-high voltage electricity transmission grid. Interest in floating wind can support new wind build to support coastal power demand, while storage mandates at utility-scale projects could help manage generation output better, perhaps helping China align with a net zero pathway for generation.

High capacity-factor hydro users should be able to meet net zero without tripling RE capacity. For example, Brazil has 110 GW of high capacity-factor hydropower making up its 181 GW of total renewable energy capacity. Tripling this to 544 GW by 2030 would be far more renewable energy than the country realistically needs, with 85% of power generation already coming from clean sources[xxxiii].

Staying on track for net zero would require a focus on integrating additional renewables – resulting from an ongoing net metering programme for solar which incentivises projects up to 5 MW – and adding technologies like CCUS to any remaining natural gas generation. Wind seems to be lower on the list of renewable priorities for now, but additional transmission lines and storage capacity could help support its development. Brazil could also export more electricity to neighbours, with Argentina, for example, having a much lower renewable share.

DESPITE MOST REGIONS COMMITTING TO TRIPLING, THE GLOBAL GOAL MAY FALL SHORT

Current policy, economics, project pipelines, regulatory and infrastructure developments, and the pace of such developments in each country suggest a gap of 2 to 3.5 TW from COP28's pledged 11 TW of installed renewable capacity by 2030[xxxiv]. This means that by 2030, the world will have amassed, based on current conditions, a maximum of overall renewable capacity of 9 TW, or in the event of conditions evolving much slower than expected, only 7.7 TW.

Renewable deployment trends established over the past two decades continue, primarily focussed on China, Europe, and more recently, the US. This concentration means that many countries in other parts of the world continue to miss out on the opportunities renewables offer in overcoming development and energy access challenges. This is particularly true for Sub-Saharan Africa, for which a net zero scenario involving renewables is yet to be assessed.

Tripling the target requires that all forms of renewable energy and their associated technologies can be leveraged by all countries based on their natural endowment, rather than pursuing only the lowest-cost option which may or may not have the right capacity factor and generation profile to decarbonise generation fully.

Unsurprisingly, however, a significantly lower cost profile, lower land availability needs, easier maintenance, lack of noise pollution, easier integration with grids and transmission systems, and an overall more liquid supply chain, will make solar the majority share of renewable capacity in all major regions pursuing the tripling goal, regardless of whether they achieve it or fall short.

Solar is lower cost than wind, supporting capacity uptake, but requires investment in storage. A lot more of lower capacity factor solar will demand significant investment into battery and other types of electricity storage, even in regions with some of the best irradiation in the world, such as the Middle East. Or it will require gas or hydrogen backup to provide power at times of no-generation.

Global storage capacity deployed by 2030 will have to be upwards of 700 GW to support increased solar capacity and upwards of 1000 GW combined to support new wind uptake, from a combined starting base of 87 GW[xxxv] (excluding pumped hydro) in 2023.

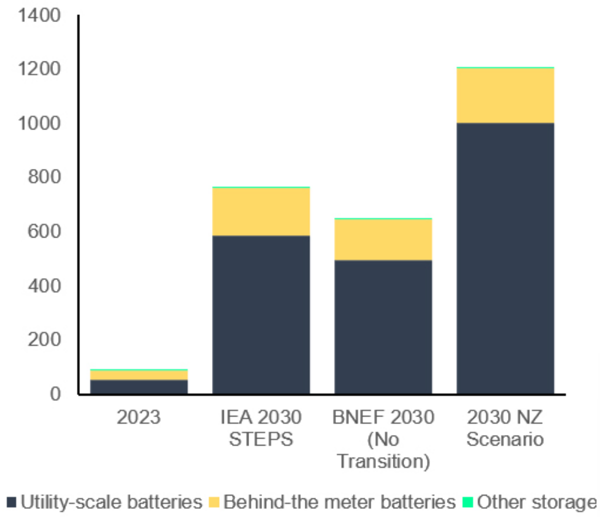
Current projections point to overall energy storage capacity reaching 760 GW by 2030 under IEA's Stated Policies scenario[xxxvi], and about 100 GW lower at 650 GW under BNEF's counterfactual no-transition scenario[xxxvii] (Figure 8). Despite an investment increase of 122% from 2022 levels (US$ 45 B to ~US$ 100 B) by 2030[xxxviii], this would still be insufficient for net-zero goals.

To align with net zero would require an investment increase 6.6 times higher than 2022 levels to reach US$ 297 B by 2030[xl] (Figure 9, Fact Box 1).

Achieving the scale of investment required to get onto and maintain a 1.5°C-compatible pathway will not be easy, especially in emerging market and developing countries, where country and macro factors can become a major contributor to high costs of capital, currency fluctuations, convertibility issues, and others. Regulatory risks can result in storage not always having equal access to power markets compared with other technologies, and lack of a strategy to renumerate flexibility services such frequency regulation, spinning and not-spinning reserves.

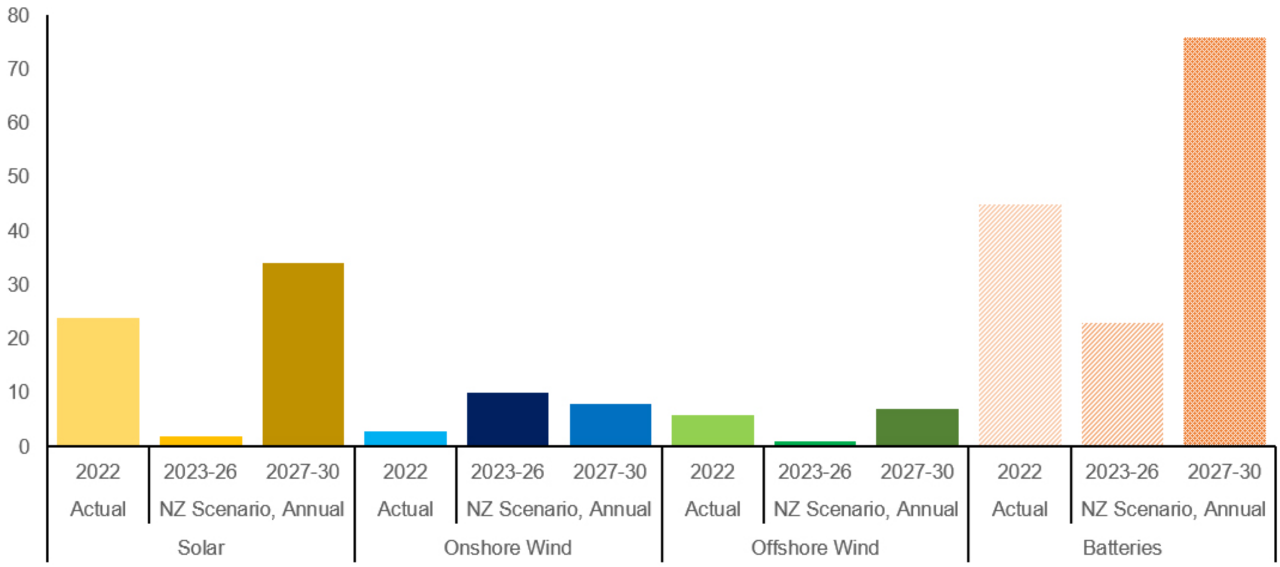
Even legacy renewables markets like Europe struggle with these regulatory challenges, contributing in part to the scepticism around solar being able to keep the bloc on-track to net zero.

Figure 8 Global Installed Energy Storage Capacity by Scenario, 2023 and 2030, GW[xxxix]



Also, current storage solutions can provide short-term flexibility for 1-8 hours continuously but may not be sufficient for longer times especially in regions that have a poorer solar resource or one that is not closely correlated to demand. These regions will require different forms of grid backup to ensure stable supply.

Figure 9 Clean Energy Investment by Technology, 2022 Actuals vs Average Annual Spend Required to be Net Zero Compatible, US$ B (nominal). Note that growth of the global renewables supply chain is concentrated towards the end of the decade



Some regions have both a poorer solar resource and a lack of good wind and other renewable resources. These regions will have to either import green power or electricity from countries generating a surplus. This idea was initially proposed as part of the GCCIA interlink to Iraq from the GCC countries, and now exceedingly being explored via subsea pipelines to Europe from North Africa. They can also rely on other technologies and alternate fuels to decarbonise their generation, such as nuclear and CCUS.

First-generation technologies remain the principal driver of solar development and still hold the majority of the market value. However, tandem and perovskite technologies offer interesting perspectives, albeit in the medium-term (2027 onwards), as several barriers still need to be overcome.

The emergence of new cell architectures has already enabled higher efficiency levels. In particular, the most important market shift in cell architecture has resulted from bifacial cells and modules, the increased adoption of advanced cell architecture, such as passive emitter and rear cell (PERC), and by its compatibility with other emerging innovations, such as half-cut cells and others.

Still, taking advantage of these newer innovations requires prototypes and demonstrations to stimulate future market growth. China leads in terms of architectural innovation and manufacturing, which could help it and its trade partners deploy more solar capacity more quickly and effectively than countries that have banned Chinese imports, such as the US, making solar module and panel prices there much more expensive.

One example is building-integrated PV solar panels that China has been developing since 2007, which provide multifunctionality, cost-efficiency, versatility, and design flexibility by seamlessly integrating solar PV systems into the building envelope and as part of building components such as facades, roofs, and windows. As of 2023, China has cemented itself as the powerhouse of the technology by moving from niche to mass market, but not all countries worldwide have been able to access its innovation due to trade restrictions.

Such restrictions put an additional burden on the realisation of ambitious domestic solar deployment goals by 2030, noting that other renewables have not moved as far ahead.

Fact Box 1 Growth of the Global Renewables Supply Chain is Concentrated Towards the End of the Decade[xlvi]

Figure 9: Growth of the Global Supply Chain is Concentrated Towards the End of the Decade

Current rates of investment are sufficient to meet near-term projections of global capacity growth, i.e. to 2026. This means that for the next couple of years, the tripling renewables target should not require a major scale-up in the supply chain. However, required investment from 2027 is set to overshoot investment required currently (which also does not account for the duplication of supply chains – an inevitability as policies prioritise resilience and job creation).

For example, the battery storage investment pipeline is already far higher than projected near-term demand, and solar module makers are under severe margin pressure due to oversupply.

OVERCOMING MACRO CHALLENGES IS ESSENTIAL TO REALISING THE 3X TARGET

It is well understood that without other renewables in the mix, solar would be unable to lead the way in the transformation of the global grid. Reaching that stage, however, will require overcoming non-economic “macro” challenges, including barriers to access, complicated deployment policies, improper power market design, and permitting delays.

Many markets still offer explicit or implicit subsidies to fossil fuel-based power generation, making it more competitive than solar and storage for on-site backup power generation to ensure supply resiliency. This makes it difficult for renewables to compete economically and can lead to an inefficient allocation of government revenues if renewable energy support schemes are introduced.

Many markets also require developers to acquire complicated and unnecessary licences to build and connect projects, such as a double licencing standard on storage, undefined rules requiring owners of grid-connected plants to qualify as a utility, and onerous regulations falling beyond the remit of power generation.

This also extends into land ownership rights particularly in emerging markets and developing countries, leading to lengthy development cycles or shallower project pipelines. Land ownership rights are slightly different from the permitting challenges common in Europe, as they represent a fundamental barrier to clean power development at the grassroots level.

Auctions often have developers responsible for site evaluation and grid connection when bidding for power contracts for no guaranteed reward. This makes it an inefficient process and can result in auctions being undersubscribed. Taking over pre-bid work, as India has done in some solar auctions, and Germany and the Netherlands in offshore wind tenders, or guaranteeing winners a grid connection, would help accelerate renewables deployment.

In markets where developers buy equipment in US dollars but earn revenue in local currency, auctions designed to manage currency or inflation risk can also increase build, as was effectively done in Vietnam.

Providing visibility on future auctions can also help developers looking to participate in new markets like Sub-Saharan Africa, and to give a supply chains a sufficient signal to build out capacity.

Awarding contracts on a per kWh basis would result in solar winning almost all capacity, which would limit energy mix diversification, and consequently generation. Well-designed auctions should include criteria that enable higher-cost solutions to compete.

These can include carve-outs for specific technologies, rewards for power produced at the most useful times, or complex availability and capacity factor requirements like India's "24/7 auctions", which encourage a mix of solar, wind, batteries, and even fossil power for emergencies.

To align with a net zero pathway, grid investment needs to match renewables investment dollar for dollar, i.e. for each dollar spent on renewable deployment, a further dollar must be spent on T&D networks. The current global ratio is far below that at a mere US$ 0.5 spent on grids for every US$ 1 on renewable investment[xlii].

A lack of the right grid infrastructure leads to extremely long queues for grid connection, as witnessed in Europe, where it can currently take up to 8 years to get a connection permit for the grid. This means that a project proposed today would not be able to connect in time to meet the COP28 target. In the US, projects in grid queues are already sufficient to triple the country's renewable capacity by 2030, if they receive their permits on time.

Creating central plans for grid expansion, including interconnectors, to match the amount of capacity targeted by 2030 can help preselect corridors for new grid development, thereby providing greater certainty for renewables site selection. They can also lay out the role of new hardware deployment and non-wire solutions, like digitalisation and flexibility, in achieving greater grid capacity. Enabling anticipatory grid investment can allow projects to meet differentiated needs-testing thresholds, helping them progress in the face of uncertainty, assuming they meet environmental and construction permitting requirements.

An effective market design is critical for renewables to be built on a cost-effective basis. It can also help them compete with existing fossil fuel fleets and ensure the power system itself can handle increased renewable penetrations (or achieve 24/7 production of low-carbon generation). Developing competitive price signals for both capacity development and dispatch can enable a higher deployment of the lowest-cost renewables.

Flexible low-carbon loads can be encouraged through scarcity pricing in a wholesale, energy-only market, dynamic tariffs to encourage power users to load shift, or capacity payments that consider carbon intensity. Ancillary service markets could also be initiated and standardised to encourage the scale-up of energy storage systems.

Lastly, emissions pricing and regulations can set an immediate premium for renewable power over the local price of fossil fuels. To drive decarbonisation, prices need to be high enough and credible for the long-term, while concessions to participants (such as free credits) should not be too generous. Regions with large renewables capabilities, such as MENA, could swiftly and almost immediately benefit from an emissions pricing mechanism (with the UAE reportedly looking at establishing a carbon price in the near future) by favouring renewable energy power over fossil plants.

19 FUTURE SOLAR GROWTH NEEDS TO NAVIGATE A COMPLEX GEOPOLITICAL LANDSCAPE

Both the US and Europe are increasingly aware of the strategic and security implications of relying on Chinese imports of materials, parts, technology, and equipment for their renewable transitions. To foster supply chain diversity, the US is pursuing moves to support domestic manufacturing and address security concerns by increasing tariffs on Chinese-made products and banning Chinese polysilicon in imported solar panels.

Europe faces a similar challenge, producing less than 3% of its required solar panels, meaning it depends almost entirely on imports for the other 97%. The region is caught in a dilemma of rapidly expanding renewables in its generation mix while at the same time attempting to re-develop a practical domestic solar industry.

Rising Western protectionism has caused Chinese firms to diversify manufacturing bases. They are now setting up solar manufacturing facilities in Southeast Asia and exploring joint ventures in countries like Saudi Arabia.

Mexico is another likely target to enter the US market. This strategy serves a dual purpose: it bypasses the geopolitical risk of relying on Western markets as main buyers of its products, and also circumvents tariffs, while keeping Chinese firms' leadership in global solar supply.

Major solar resource holders of the world, such as the MENA countries, are showing increasing willingness and initiative to partner with Chinese firms in helping them establish manufacturing bases in their countries, which can signal increasing Chinese influence in a region that has historically been a cornerstone of US and other Western nations' security, defence, and energy trade interests.

Restricting Chinese supplies may hinder western countries' transitions away from fossils as the financial implications could be significant, as domestically produced solar panels in the US are twice as costly as those imported from China.

Moreover, reliance on Chinese imports isn't just about panels, it's also about supporting downstream jobs in construction, engineering, and installation, which often outnumber jobs in domestic manufacturing.

Higher costs and challenges with licensing and long permitting timelines could hinder, or at least delay, Western countries' transitions away from fossil fuels, resulting in missing crucial interim targets.

Conversely, this dynamic has now opened the opportunity for other low-cost manufacturing bases (such as south-east Asia and the GCC countries) to explore entry into different parts of the renewables value chain in order to establish trade relationships with Europe and the US based on the energy transition (Table 2).

It also helps them support their own economic diversification plans by developing competencies in non-oil and gas capabilities, creating new jobs and opportunities, and giving credence to their role as partners of the global transition.

Table 2 Business Prospects Being Explored by MENA Countries in the Global Renewables Value Chain[xlviii]

Value Chain Segment	Typical Business Opportunities	Segment Maturity
Production and Processing	Renewables production, renewables projects, grid-strengthening and expansion, energy storage, capacity build-out of solar thermal energy, battery manufacture and assembly, alternative production techniques	✓✓✓
Transportation	Pipeline expansion and retrofitting, materials compatibility, metallics and polymers, high quality steel tubes manufacture, high efficiency transport solutions, optimal storage technologies	✓
Storage	Novel storage technologies, localised manufacture of carbon fibre storage, alternate battery chemistries, innovative designs	✓
Distribution	Supply infrastructure, high efficiency transport solutions, rededication of grid network and grid expansion, manufacture of next-gen transmission lines; substation designs	✓
End-Use / Application	Sector and/or application-specific renewable infrastructure supply, next-gen heating technologies, renewables for transport (long-haul and freight), centralised offsite production and distribution, renewables-based inland transport	✓✓
Governance	Existing funding opportunities for different kinds of renewable projects, R&D and application; closer cross-sectoral cooperation of SMEs; public stakeholders' openness to organising prospective exercises at the federal level for the development of opportunities; promotion of market ramp-up through common standards	✓✓
Suppliers and Service Markets	Ecosystem development (high number of business parks, economic zones and projects); ramp-up of support programmes for innovative suppliers; local representation	✓✓
Partnerships and Collaboration	Research and development, technological innovation, academic partnerships, think tank partnerships	✓

Meeting COP28's triple renewable capacity by 2030 target requires a holistic approach to address all key aspects – from technology and economy, to geopolitics and sustainability. Accelerating progress towards this target requires changes in many aspects of the renewable energy market as it stands today, including the adaptation of its design and operation to support a higher share of mixed variable renewables (rather than focussing on only one technology alone), as well as distributed power generation.

Although there has been progress in the improving market design by adoption of practices like carbon pricing, substantial work is still required. The expansion of carbon pricing regimes and overcoming typical access barriers like fossil fuel subsidies will be key for the global agenda as they will help accelerate market-driven solutions to achieve COP28's goals.

As renewable capacity growth continues to outpace fossil fuels, the energy system will get closer to a tipping point, where all future electricity demand growth will be met through renewables, ultimately resulting in fossil fuels peaking in the global electricity mix. Structural changes, such as the reform of multilateral finance mechanisms, will therefore become essential to guarantee the transition away from fossil fuels while supporting local value creation in countries with strong renewable capabilities.

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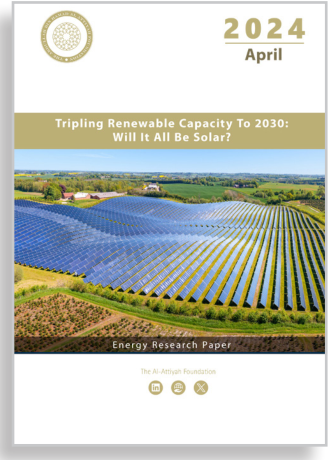

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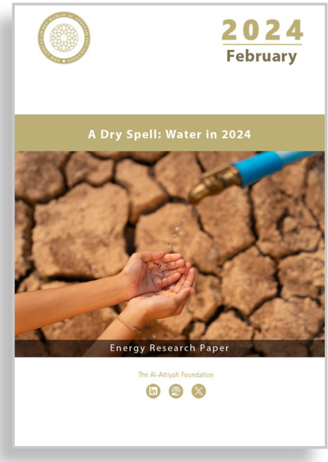

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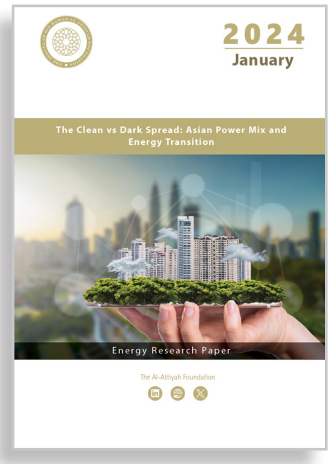

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