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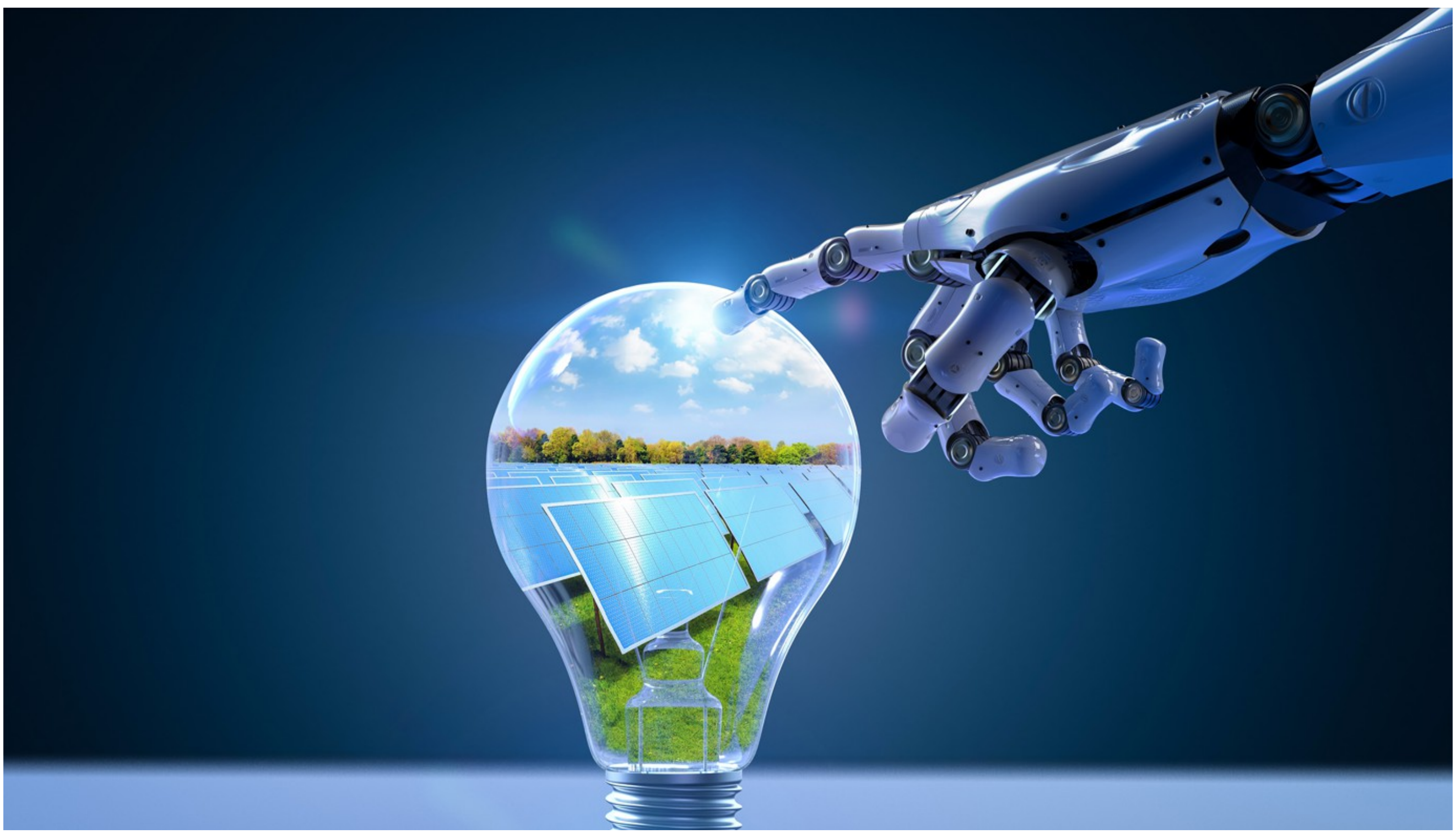
Clean Power

Deflation Path Supercharges Adoption

The world of electricity is transforming. Green generation costs will fall rapidly through 2030, accelerating adoption and reshaping the world's energy consumption mix as renewables meet most electrification needs through the end of the decade. Technology gains and government support will bolster, and alter, clean power supply chains and bring US$0.5trn in cumulative savings by 2030 – more than the entire annual investment in renewable power in 2022.

Sustainability



Contributors

MORGAN STANLEY ASIA (SINGAPORE) PTE.+
Mayank Maheshwari
Equity Analyst
+65 6834-6719
Mayank.Maheshwari@morganstanley.com

MORGAN STANLEY & CO. LLC
Stephen C Byrd
Equity Analyst
+1 212 761-3865
Stephen.Byrd@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Martijn Rats, CFA
Equity Analyst and Commodities Strategist
+44 20 7425-6618
Martijn.Rats@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Robert Pulleyn
Equity Analyst and Commodity Strategist
+44 20 7425-4388
Robert.Pulleyn@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Simon H.Y. Lee, CFA
Equity Analyst
+852 2848-1985
Simon.Lee@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Arthur Sitbon, CFA
Equity Analyst
+44 20 7425-5371
Arthur.Sitbon@morganstanley.com

MORGAN STANLEY & CO. LLC
Andrew S Percoco
Equity Analyst
+1 212 296-4322
Andrew.Percoco@morganstanley.com

MORGAN STANLEY & CO. LLC
Devin McDermott
Equity Analyst and Commodities Strategist
+1 212 761-1125
Devin.McDermott@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC, SEOUL BRANCH+
Young Suk Shin
Equity Analyst
+82 2 399-4994
Young.Shin@morganstanley.com

MORGAN STANLEY C.T.V.M. S.A.+
Miguel F Rodrigues
Equity Analyst
+55 11 3048-6016
Miguel.Rodrigues@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Jack Lu
Equity Analyst
+852 2848-5044
Jack.Lu@morganstanley.com

MORGAN STANLEY AUSTRALIA LIMITED+
Rob Koh
Equity Analyst
+61 3 9256-8932
Rob.Koh@morganstanley.com

MORGAN STANLEY INDIA COMPANY PRIVATE LIMITED+
Girish Achhipalia
Equity Analyst
+91 22 6118-2243
Girish.Achhipalia@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Tim Chan, CFA
Equity Strategist
+852 3963-4568
Tim.Chan@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Eva Hou
Equity Analyst
+852 2848-6964
Eva.Hou@morganstanley.com

MORGAN STANLEY & CO. LLC
David Arcaro, CFA
Equity Analyst
+1 212 761-1817
David.Arcaro@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Sheng Zhong
Equity Analyst
+852 2239-7821
Sheng.Zhong@morganstanley.com

MORGAN STANLEY C.T.V.M. S.A.+
Fernando P Amaral
Equity Analyst
+55 11 3048-6121
Fernando.Amaral@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC, SEOUL BRANCH+
Michael Koh
Equity Analyst
+82 2 399-9920
Michael.Koh@morganstanley.com

MORGAN STANLEY ASIA (SINGAPORE) PTE.+
Vivek Rajamani
Equity Analyst
+65 6834-6740
Vivek.Rajamani@morganstanley.com

MORGAN STANLEY ASIA (SINGAPORE) PTE.+
Ryan M Heng
Research Associate
+65 6834-6465
Ryan.Heng@morganstanley.com

MORGAN STANLEY ASIA (SINGAPORE) PTE.+
Winston Kaijie Yao
Research Associate
+65 6834-6443
Winston.K.Yao@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Serena Chen
Research Associate
+852 2848-7107
Serena.Chen@morganstanley.com

MORGAN STANLEY & CO. LLC
Asmita Baskar
Research Associate
+1 212 761-5994
Asmita.Baskar@morganstanley.com

Deflation Path Supercharges Adoption

Green electricity at a tipping point. The energy transition continues to be a critical global thematic for investors and the world at large. This report details what we expect will be a significant reduction in the cost to produce clean power, which should catalyse a dramatic increase in adoption. We do not believe this is captured in consensus thinking, where green energy costs are expected to inflate rather than deflate and clean energy adoption remains slow.

Clean power will be the backbone of global electrification, meeting 90% of incremental demand for electricity by 2026, with generation capacity growth estimated at 5x more than fossil fuels this year. Contrary to the consensus view, we forecast an acceleration in the adoption of green energy, driven by rapid and structural reductions in cost. As electricity consumption grows 10% faster than GDP, we estimate demand for clean power will double to account for nearly half of the world's electricity requirements by 2030. With increased competitiveness over fossil fuels, clean power will metamorphose the electricity landscape, overtaking fossil-based generation by 2030. While the transition to clean electricity in the power sector is likely to be deflationary in many parts of the world, this is not universally the case. We lay out the conditions that will drive inflation in certain regions.

Innovation will surprise with its ability to raise efficiency and deflate the per-unit cost to produce green electrons by about a third. We estimate solar and onshore wind electricity generation will be 35% cheaper than fossil fuels on average by 2030, creating investment conditions that will lift the adoption of clean power. On its own, an increase in solar panel efficiency from 22% to 28-30% would be enough to fulfill the annual electricity needs of Indonesia, the fourth-most populous country.

While the focus in this report is on the broader deflationary drivers of clean electricity production, there are important regional differences. In Europe and the US, for example, we expect heavy government involvement, which will impact budgets, while in much of the rest of the world the transition is occurring with less government oversight. As renewable deployment grows rapidly in Europe – and as mandates for lower carbon emissions cover many industries – large public and private capital outlays will be needed for grid upgrades, the move to green steel, and clean hydrogen infrastructure. In other parts of the world, the primary deployment of capital is from development companies that specialise in clean technologies, rather than governments, implying a less significant impact on government budgets. In addition, the focus in Europe is on decarbonisation, even if such a shift results in higher costs (one example is green steel), while in other parts of the world it is more typical to see transition spending only if the economics are attractive.

The >US$2trn renewables pipeline will reshape clean power supply chains. Contrary to consensus, we do not expect this shift to be inflationary in the US and Asia. Globally, over US$500bn of direct subsidies for low-carbon equipment manufacturing have been announced, along with various tax breaks (Exhibit 36), making equipment supply chains in Asia and the US as competitive as imports. The capital investment to produce one gigawatt hour of power will decline 25% by 2026 and 50% by 2030, we estimate. As local supply chains develop in pursuit of energy security, overbuilding will also drive down costs. For example, solar panel capacity outside China will likely account for a third of production by 2030, up from a small fraction now. These drivers of deflation, coming after two years of elevated inflation, should allay investor concerns that the energy transition will be slow and costly.

Identifying winners: Cheaper clean power generation raises the urgency for corporates to transform, especially as the economic benefits increase the pace of consumer adoption. Energy producers that are ahead in the adoption curve should benefit the most, while companies that are pioneering local supply chains and are ahead on the technology curve should also emerge stronger. We would look to invest in 1) renewable generators with larger exposure to solar and battery energy storage, 2) corporates that are investing in clean power localisation in the US and Asia, and 3) energy corporates that are supporting the green transition with investments in green hydrogen and associated low carbon value chains.

The top eight global equities that we believe are mispriced and have significant energy transition upside are: NextEra Energy, Bloom Energy, Reliance Industries, Enel Chile, AES, Orsted, Sembcorp Industries, and RWE. Globally, we identify 25 winners as well as six stocks that will be challenged (Exhibit 1 and Exhibit 12).

Contents

Executive Summary

The world of electricity is transforming. We believe clean energy growth will accelerate throughout this decade, with our estimates topping International Energy Agency (IEA) forecasts. It can be challenging to stay ahead of the developments in clean energy across geographies and sectors, especially as the pace of newsflow makes it hard to distinguish signal from noise. The Morgan Stanley Global Energy and Utilities team has collaborated on this Blue Paper to help advance investor thinking on the clean power ecosystem, pinpoint what's driving the changes right now, introduce a scenario framework, and offer sector- and stock-level insights. The story of the renewable economy is one of innovation and growth, offset by commoditisation and deflation, which then drive further adoption.

Renewables' share of the global power supply increased from 23% in 2015 to 30% in 2022, according to the IEA. The IEA forecasts that global renewables capacity will grow by almost 2,400 gigawatts (GW) between 2022 and 2027 in its 'main case' forecast, equal to China's entire installed capacity and representing an 85% acceleration relative to the prior five years of renewables growth. While this growth rate is quite rapid, the IEA notes that "globally, the pace of renewable capacity expansion in the main case needs to increase 60% to be in line with the IEA Net Zero by 2050 Scenario." Morgan Stanley's estimated renewables growth globally is 2% faster than the IEA's main case forecast, with especially rapid growth in Europe, the US, India and China (Exhibit 8). Our forecast is driven by four primary 'force vectors':

1. Renewables are now the cheapest form of power in much of the world, which is the biggest fundamental driver of demand growth. To put our ⅓ cost reduction forecast through 2030 into context, renewable costs in the US fell 15% per year in 2011-20 – a declining trend that was only temporarily interrupted by Covid (Exhibit 2 and Exhibit 3). In most of Asia, solar PPA prices are now below grid parity and cheaper than coal-based generation (Exhibit 5).

2. Continued innovation will improve performance and reduce the per-unit cost of renewable energy, with the fall in storage costs serving as an added driver of growth given the supporting role that storage plays in renewable adoption. More efficient equipment can significantly lower producer costs/levelised cost of electricity (LCOE). To put things in perspective, we estimate that a 5% increase in solar panel efficiency would add enough supply to power Indonesia for a year while lowering global costs by 3-4ppts. The next wave of efficiency gains will come from new solar technologies like HJT/perovskite, the rising adoption of LFPs/liquid metal and metal air in batteries, and the scaling-up of the green hydrogen market (similar to LNG in the 1970s). One factor that is underappreciated is how quickly this technology is diffusing across borders and growing the scale needed to make them even cheaper. The decline in renewable production costs in India, Vietnam and Indonesia is a great example of this trend. We see the Jevons Paradox playing out in clean power as increases in energy production efficiency lead to more, not less, adoption – see the section Deflation: Technology + Tech Diffusion Upside.

3. Major policy support in many nations, including the US, EU and China. Globally, at least US$500bn of direct subsidies for low carbon equipment manufacturing have been announced, not counting other tax breaks and incentives. Most countries are using these subsidies to develop local supply chains, with a notable increase in announced factory investments in places like the US (over US$100bn following the passage of the Inflation Reduction Act), India, Vietnam, and China. These multi-continent supply additions for low carbon equipment will raise the magnitude of supply of solar panels, energy storage and electrolyser equipment, with Asia ex-China/US producer costs to be as competitive as imports from China/Southeast Asia, including government incentives. Europe and Australia, however, will see limited benefits from this localisation trend, as they remain net equipment importers.

4. A substantial increase in renewables (solar plus wind), clean hydrogen and energy storage manufacturing capacity is driving per-unit costs lower and leading to oversupply, which we have seen occur many times during the growth of the clean energy sector. We have already seen substantial deflation in polysilicon prices this year, which we expect to improve economics and drive strong global demand for solar and energy storage – note that the US has already started to see a substantial increase in growth, with 1Q23 solar installations up 47% Y/Y. For global solar panel manufacturers, a sharp decline in polysilicon prices is driving concerns around the sustainability of margins. A few noteworthy company-specific data points: **(a)** Trina, a large China-based solar panel OEM, believes the three key challenges for China's solar industry are intensified competition from oversupply, technology iteration, and international trade tensions; and **(b)** LONGi (601012.SS) said it has made a breakthrough in HPBC cell technology and large-scale production (HPBC would help to drive down solar power prices for distributed users). See details in Upcoming Technology Improvements.

Regarding the outlook for battery cost reductions, our China Energy team highlights the downward price trajectory of energy storage, and we think second-tier battery makers may adopt more aggressive pricing strategies to gain share in 2H23. Despite seeing a recovery in value chain orders in the near term, we expect battery capacity to remain excessive near term, making price competition virtually inevitable.

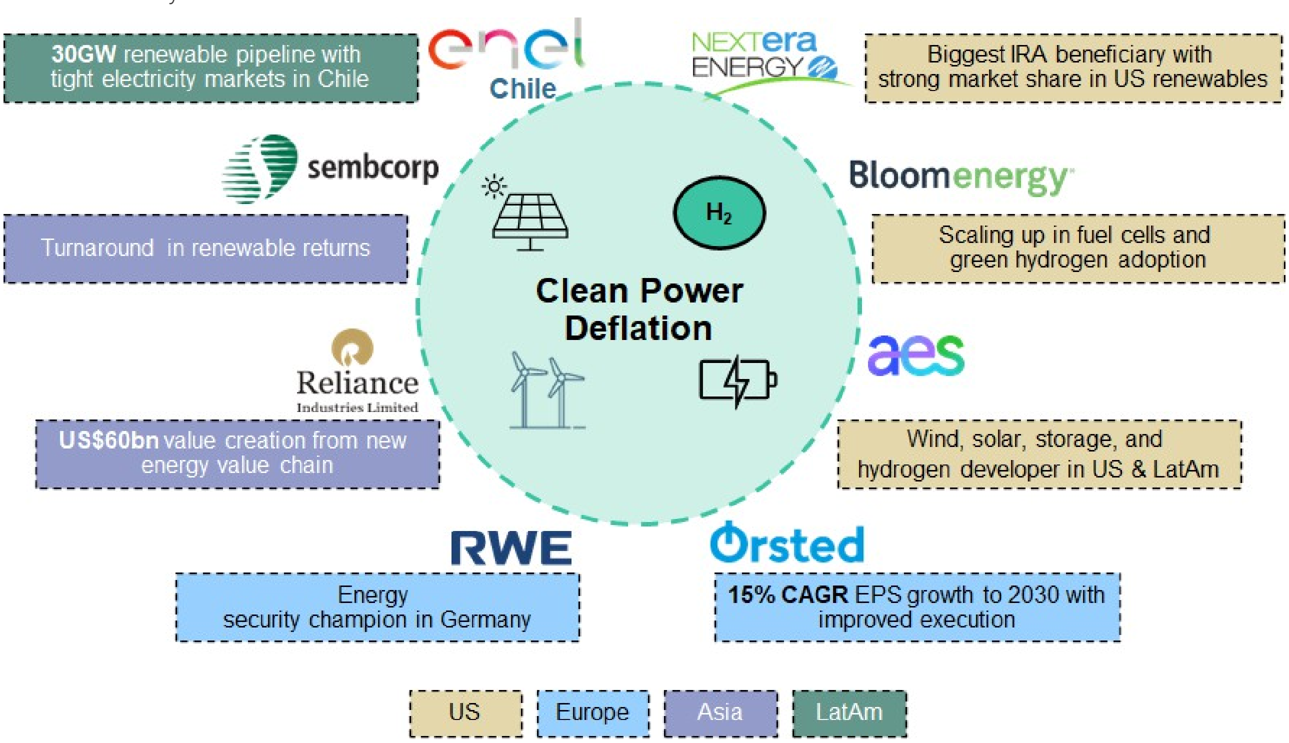
While the transition to clean electricity within the power sector is in our view likely to be deflationary in many parts of the world, this is not universally the case. The conditions required for deflation are: 1) a significant spread between required per-unit power revenue for renewables relative to fossil fuel power plants, 2) transmission upgrades that can be implemented with low permitting/legal risks and 3) at certain levels of renewables penetration, further reliability upgrades (such as energy storage) to ensure grid reliability. In practice, the most challenged regions, in terms of achieving a deflationary energy transition, would be areas with high population density (which can lead to challenges in effecting grid upgrades) and unfavorable solar/wind conditions. In some markets, higher renewables penetration can also create a need for fossil-fuel power plants to serve as 'grid stabilisers' – though if energy storage costs continue to fall rapidly, this grid stabilisation role may increasingly be played by storage.

An example of a potential game-changing technology is metal-air storage. In the US, private company Form Energy has developed an iron-air battery with capital costs that are a fraction of lithium-ion batteries, and that could be cheaper than natural gas-fired power plants in terms of the cost of power production – see our full analysis of this technology here.

While the conventional view is that the localisation of supply chains for energy security will be inflationary, our bottom-up work suggests that most countries will be competitive if government incentives are taken into account across most green infrastructure production costs. This enables developers to secure core technology near the point of demand, and reduce geopolitical risks, driving more certainty and supporting more aggressive growth targets. The cost to produce green electricity will evolve in different regions, with the US and Asia seeing larger benefits from supply localisation, technology improvements, and government support. Europe and Australia, however, could see disinflation, but not outright deflation. By technology, we see solar and green hydrogen prices declining the most, but offshore wind equipment costs may rise from current troughs. As renewable electricity gets even more competitive vs. fossil fuels, it will increase the low carbon fuel's market share in global electricity mix to 45% by 2030, we estimate.

Energy transitions take time. It took decades to switch from coal to oil, and then from oil to gas, and the current transition will follow a similar trajectory. Hence, while a technology like hydrogen is only 0.1% of total energy production now, we believe a tipping point will eventually be reached. We expect demand for fossil fuels (especially gas) to keep rising until such time as renewables can keep up with growing global energy demand. Work done by our Global Oil team, headed by Martijn Rats, shows that oil demand will reach 105-106mbpd by 2030, even after accounting for all current wind and solar projects.

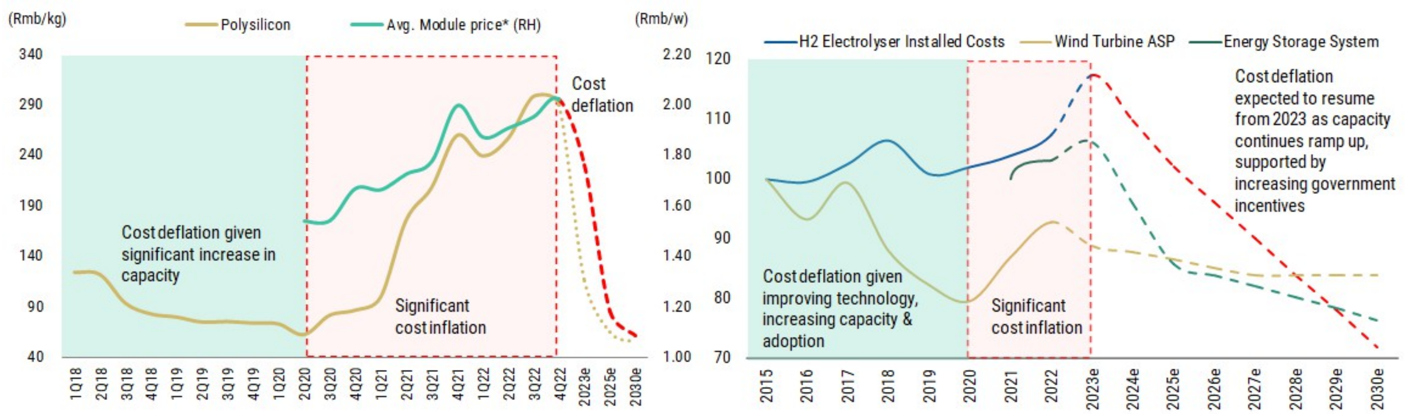
Exhibit 1: The Metamorphosis: Silicon+Hydrogen to drive cost deflation and clean power adoption: Global equities are not pricing in these multi-year shifts – we identify NextEra, Reliance Industries, ENEL Chile, Bloom Energy, Orsted, and Sembcorp Industries as key beneficiaries



Source: Morgan Stanley Research

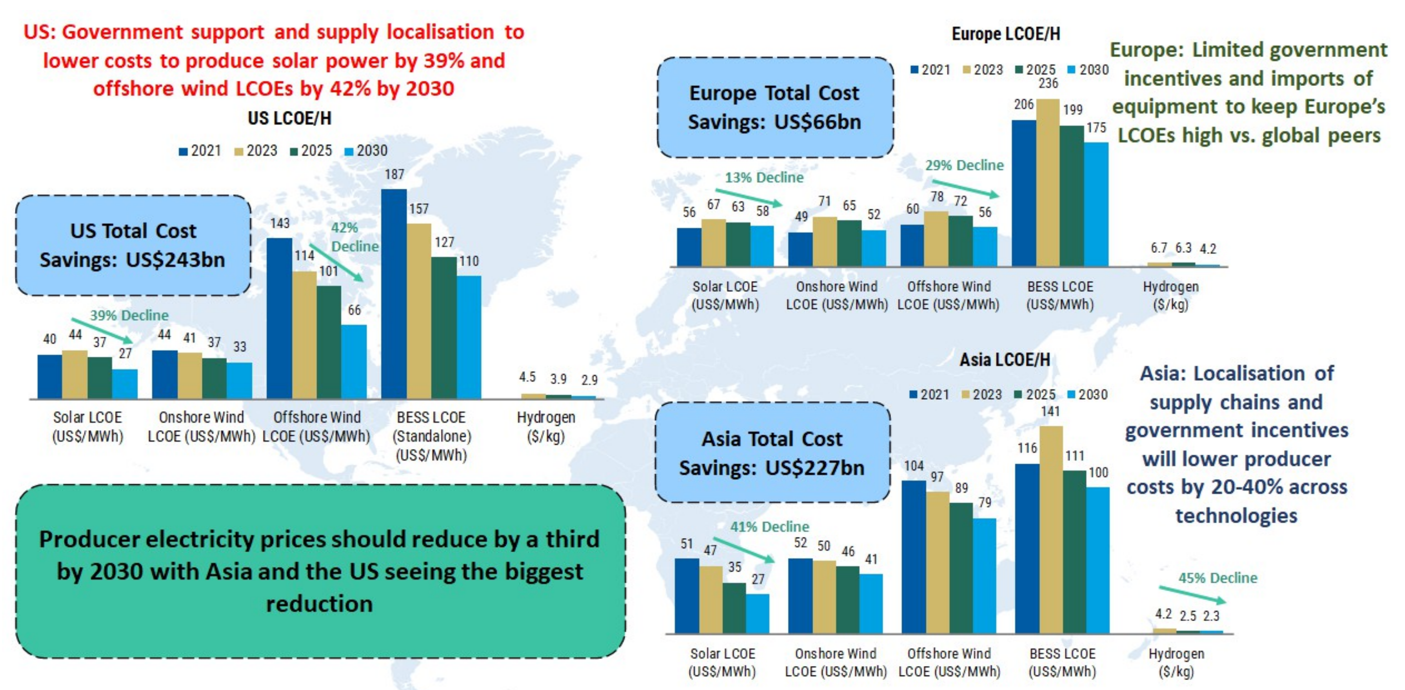
Putting Generation Cost Deflation In Context: Technology, Localisation and Savings

Exhibit 2: Cost deflation across technologies took a pause in 2021-22 as supply chain and raw material inflation pushed prices higher; we see this trend reversing and costs deflating by 15-40% for low carbon equipment by 2030



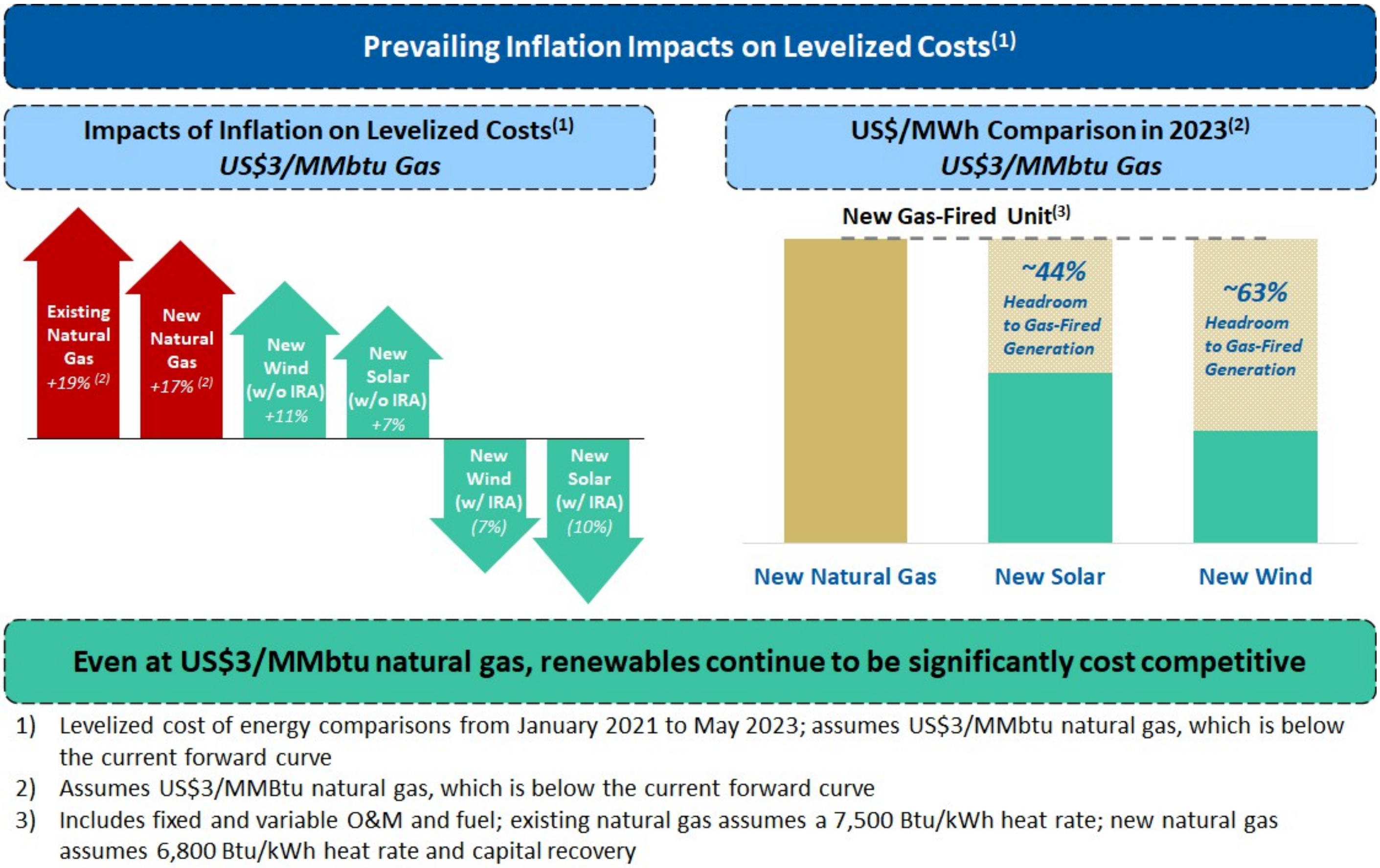
Note: For 2020-22, Avg. module price = Average PERC 440-450w and PERC 180/210mm. For 2023e-2030e, Avg. Module price = Average TOPCon 182mm and HJT Bifacial 210mm
Source: Company data, BNEF, PVinfo, Morgan Stanley Research estimates

Exhibit 3: We believe the renewable cost curve globally will decline as new technologies achieve scale and diffuse faster than before, amid substantial oversupply and component localisation over the ensuing decade



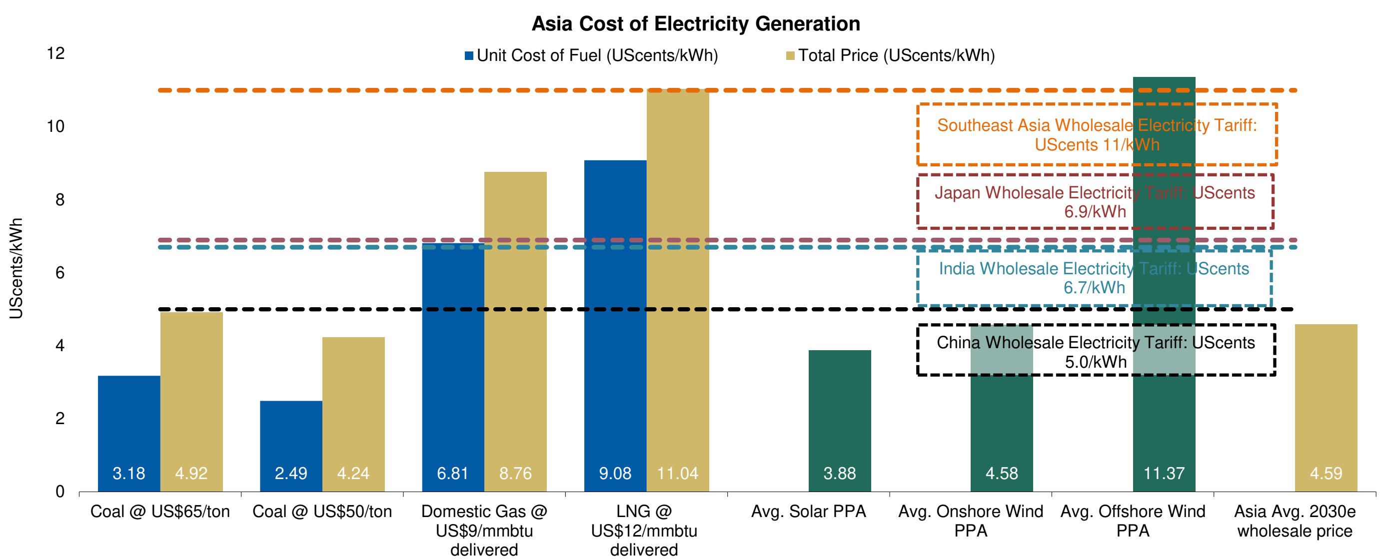
Source: IEA, Morgan Stanley Research estimates

Exhibit 4: Renewables are already cost-competitive in the US…



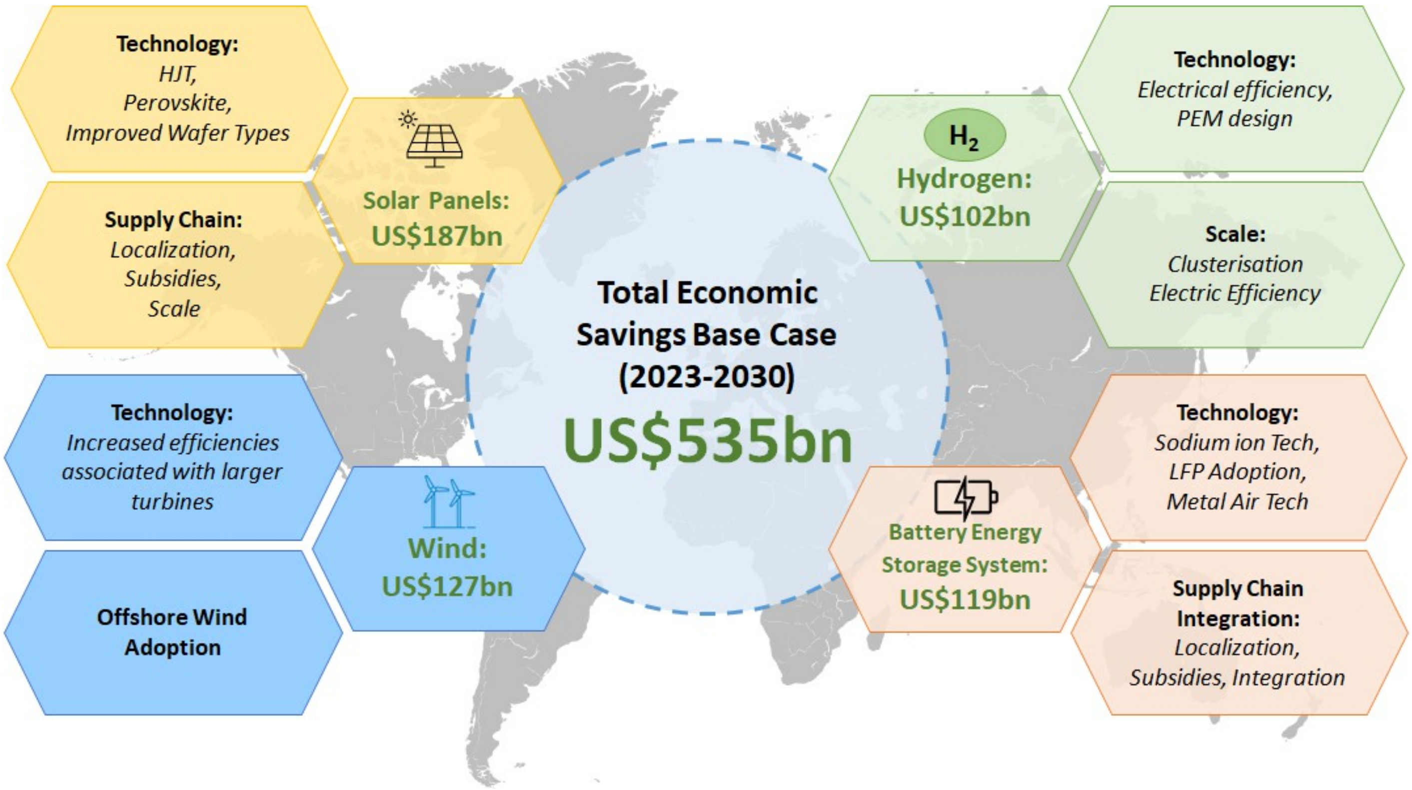
Source: NextEra Company Presentation

Exhibit 5: …Similarly in Asia, renewable costs have fallen below the cost of conventional generation, and adoption is picking up quickly, especially in India, China, Vietnam, and Thailand



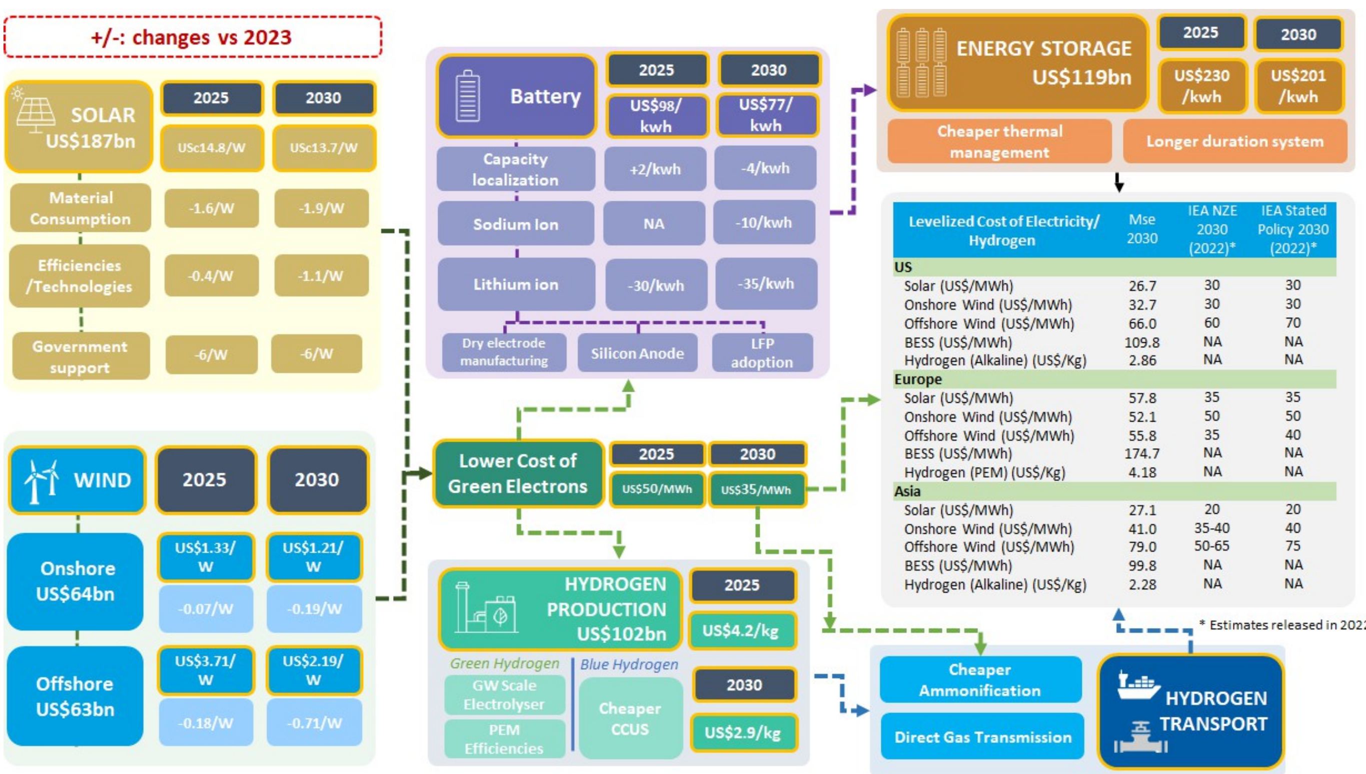
Source: Company data, IEA, India IEX, Japan JEPX, Philippines WESM, Singapore EMC, Morgan Stanley Research estimates

Exhibit 6: The energy transition to low carbon fuels and technological upside will drive over US$500bn of cumulative cost savings through 2030 and get us closer to net zero targets despite the current higher cost of capital



Source: Morgan Stanley Research estimates

Exhibit 7: Clean Power: The Cost Deflation Story in Numbers and the micro drivers of what makes us bullish on adoption



Levelized Cost of Electricity/ Hydrogen	Mse 2030	IEA NZE 2030 (2022)*	IEA Stated Policy 2030 (2022)*
US			
Solar (US$/MWh)	26.7	30	30
Onshore Wind (US$/MWh)	32.7	30	30
Offshore Wind (US$/MWh)	66.0	60	70
BESS (US$/MWh)	109.8	NA	NA
Hydrogen (Alkaline) (US$/Kg)	2.86	NA	NA
Europe			
Solar (US$/MWh)	57.8	35	35
Onshore Wind (US$/MWh)	52.1	50	50
Offshore Wind (US$/MWh)	55.8	35	40
BESS (US$/MWh)	174.7	NA	NA
Hydrogen (PEM) (US$/Kg)	4.18	NA	NA
Asia			
Solar (US$/MWh)	27.1	20	20
Onshore Wind (US$/MWh)	41.0	35-40	40
Offshore Wind (US$/MWh)	79.0	50-65	75
BESS (US$/MWh)	99.8	NA	NA
Hydrogen (Alkaline) (US$/Kg)	2.28	NA	NA

Source: Morgan Stanley Research estimates

The Path to Clean Power: Global Investment Implications

Quicker adoption of renewables in the global power mix should surprise investors as the cost to produce renewable electricity (referred to as the levelised cost of electricity, or LCOE) will reduce in our view by a third globally by 2030 (Exhibit 9) and reverse the last two years of cost inflation. We see renewables forming 45% of the electricity generation mix with solar and wind accounting for more than half of renewables generation by 2030 (Exhibit 8).

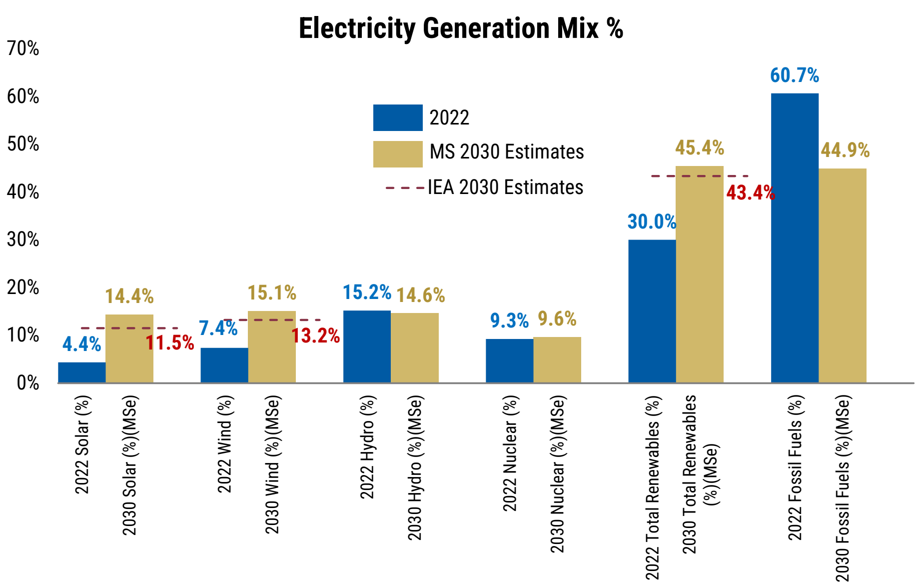
Solar, energy storage and green hydrogen in the US and Asia will drive this underappreciated cost deflation, and generators of green electrons – IPPs in particular – will be the largest beneficiaries as adoption inflects. We see four pillars of the path to deflation:

1) **New technologies** that raise efficiency across the low-carbon electricity ecosystem.
2) **Government support leading to technology advances, increases in manufacturing scale, and capacity overbuild,** bringing lower costs and powering faster adoption rates.
3) **Localisation of supply chains,** driven by energy security policy objectives, can also be deflationary as a result of broad technology diffusion by global equipment manufacturers into local markets, which helps to reduce equipment production costs. This is especially the case in the US, India and Southeast Asia (this has less of an impact in Europe and Australia, in our view).
4) **Scale benefits** will help lower costs for solar power and energy storage, and especially for green hydrogen.

The key to increasing low carbon fuels in the global energy mix is to improve affordability and make them more competitive vs. alternative fuels. We believe the four pillars above will help achieve that goal and see an inflection in adoption, as we saw with solar as a technology. Solar, we believe, will further improve its competitiveness vs. coal over the next two years, and clean hydrogen should be able to achieve parity with natural gas in multiple geographies at various points in the second half of the decade, with the exception being the US, where natural gas costs are likely to remain below the cost of clean hydrogen.

In the US, solar and onshore wind will remain highly attractive relative to fossil fuel power, and we expect the spread between the cost of renewables and the cost of fossil fuels will continue to improve through the end of the decade. Our renewable LCOE estimates are close to IEA target estimates despite our higher cost of capital assumptions (the IEA report was published prior to recent increases in interest rates). As with all transitions, the global energy transition will play out over multiple decades, and we see risks associated with new technology developments and government policies. We present three scenarios in Exhibit 10 that get us to a decarbonised future in a multi-polar world:

Exhibit 8: Electricity generation mix trends: Our estimates for solar and wind are above IEA estimates as we see multiple legs to cost deflation and faster adoption



Note: IEA calculations based on IEA 2030 Stated Policies Scenario
Source: Morgan Stanley Research estimates, IEA

Our Risk-Reward Framework:

1) Disappointing, modest deflation in costs to produce case (Bear Case): *Supply chain challenges (such as higher input costs and trade barriers), and disappointments in technology improvements lead to a slower pace of renewables adoption and cost reduction.*

2) Deflation case (Base Case): *Renewables cost reductions and well-functioning, geographically diversified supply chains support rapid renewables adoption. This requires that current policy action, capital deployment, and innovation remain on track. We estimate US$535bn in savings and 45% renewable penetration in this scenario.*

3) Path to Net Zero case (Bull Case): *Rapid low carbon fuel adoption continues, and policies that incentivise onshoring deflate costs quicker than expected, while new technologies drive improved efficiency and reduces costs more rapidly than expected. This is closer to IEA's more aggressive scenario on renewables penetration.*

Putting deflation into perspective and what's changing: The deflationary trend in solar has been the norm since 2010; it reversed in the last two years due to a 3x rise in polysilicon prices, as well as elevated shipping/logistics costs. While polysilicon prices have significantly corrected in the last two months, we see further scope for correction with declines into 2025 and 2030 as capacity builds in countries like China and Southeast Asia.

Technology upgrades which stagnated for the past three years should also help raise panel efficiency more quickly towards the 25%+ mark by 2026 (and to 28-30% by 2030), and should help multiple companies compete with alternative fuels. It will also achieve grid parity with gas-based generation providing the peak load as battery storage remains more expensive near term. Hydrogen offers an alternative to energy storage, especially during afternoons, when renewables production is high and can be used as a fuel along with gas for producing electricity. Multiple companies in Japan and Singapore are building hydrogen enabled gas fired capacity, which will be operational by 2026.

Who wins in a rewired renewable supply chain? Ultimately, it will be those firms that employ cost efficient, at scale and environmentally sustainable technologies in strategically beneficial geographies (with regard to labor availability, ease of permitting process, and US trade ally status). Based on our analysis of regional and sector-specific investment, we emphasize the prospect of new capital formation. Equipment producers in India and Southeast Asia should benefit from being lower on the cost curve compared to developed market peers. In addition, companies that can capitalise on government support (Reliance in India, PTT in Thailand, NextEra in the US, among others) and lower their capital costs should benefit as well. In the battery value chain, Korean corporates investing in the US should see upside in volume and scale benefits to lower cost. Corporates that are partnering with incumbents to scale their technology know-how and have domestic market demand support to scale production should see upside risks – multiple EM companies benefit from this (Exhibit 24). Finally, the capital creation by clean power producers will be material as they form part of the global ecosystem to produce nearly 45% of the electricity consumed globally by 2030.

Exhibit 9: LCOE declines across the globe should drive increased adoption

Key LCOE Estimates	2021	2023	2025	2030 Base	IEA Stated Policies
US					
Solar LCOE (US$/MWh)	39.72	58.40	37.25	26.65	30.00
Onshore Wind LCOE (US$/MWh)	43.63	56.20	36.64	32.68	35.00
Offshore Wind LCOE (US$/MWh)	143.40	152.70	101.00	66.00	60.00
BESS LCOE (US$/MWh)	187.18	259.00	126.80	109.84	NA
Hydrogen (Alkaline) ($/kg)	NA	7.29	3.88	2.86	NA
Europe					
Solar LCOE (US$/MWh)	55.65	66.70	63.14	57.81	35.00
Onshore Wind LCOE (US$/MWh)	49.19	71.05	65.29	52.10	45.00
Offshore Wind LCOE (US$/MWh)	60.07	78.43	71.59	55.83	40.00
BESS LCOE (US$/MWh)	206.02	235.92	198.54	174.68	NA
Hydrogen (PEM) ($/kg)	NA	6.68	6.27	4.18	NA
Asia					
Solar LCOE (US$/MWh)	51.45	46.63	35.25	27.11	20-25
Onshore Wind LCOE (US$/MWh)	51.81	49.93	45.97	40.95	40-45
Offshore Wind LCOE (US$/MWh)	104.04	96.58	88.94	79.04	45-70
BESS LCOE (US$/MWh)	115.94	141.30	111.20	99.77	NA
Hydrogen (Alkaline) ($/kg)	4.10	4.17	2.52	2.28	NA

Source: Morgan Stanley Research estimates

Exhibit 10: The path to electricity cost deflation: A risk-reward framework

	Disinflation (Bear Case)	Deflation (Base Case)	Path to Net Zero (Bull Case)
Levelized Cost Decline	20%	32%	42%
2030 Renewables in Global Electricity Generation	30-35%	45%	50-55%
Producer Cost Savings (US$ bn)	200	535	700
Stocks to Own	LG Energy Solution, Hanwha Solutions, Array Technologies, First Solar, NewFortress energy	aes, sunrun, sunnova, Bloomenergy, Altus Power, Ørsted, ptt, SK innovation, ExxonMobil, Chevron, NextEra Energy	Bloomenergy, Ørsted, aes, Reliance Industries Limited, NextEra Energy, ptt, sembcorp, ReNew Power
Most Challenged	Bloomenergy, sse	First Solar, Ginlong, Array Technologies, Sungrow, ITM Power	Hanwha Solutions, Array Technologies, LG Energy Solution

Source: Morgan Stanley Research estimates

How To Position and What's Priced In

We stack up the global low-carbon equities – equipment manufacturers, generators, incumbent energy players – and rank them in four key areas: technology shift, government support, supply localisation, and equipment oversupply. **NextEra Energy, Bloom Energy, AES, Orsted, RWE, Reliance Industries, Sembcorp Industries, and Enel Chile, we believe, will benefit the most globally**, *while China's solar equipment manufacturers could continue to see falling market share due to competition from US and Indian players that serve local demand and have increased government policy support.*

1. Renewable IPPs/generators with a larger exposure to solar and battery energy storage, and exposed to technology upside in solar panels, lower panel costs and significant opportunities to expand the renewable portfolio with long-term PPA contracts. Renewable generators should benefit the most. **NextEra, Orsted, Sembcorp Industries, AES, RWE, Renew Power, and Enel Chile** will be the key beneficiaries, in our view.

2. Non-China equipment manufacturers. Various companies are investing to localise manufacturing of clean power equipment in India, the US and Southeast Asia. We believe these companies could benefit on multiple fronts. **SK Innovation, LG Energy Solutions, Reliance Industries, PTT Group, and Bloom Energy** should be the key beneficiaries globally over the medium term. In the near term, however, investors may doubt whether these companies are able to deliver, though we expect Bloom Energy to achieve significant improvements in profitability over the next 12-18 months, which will allay these concerns, in our view.

Significant US government support also increases the attractiveness of ex-China equipment manufacturers looking to onshore production capacities in the US, while Chinese manufacturers are most at risk of lower market share as a result of the push for supply localisation. In the table Exhibit 12 , we rank the key winners and companies that are most challenged under the four pillars of our 'deflation supporting adoption' thesis, and highlight the upside to base case and what's priced in to these companies' equities.

For our top eight companies, these stocks are spearheading the acceleration in clean power deployment, and we believe as investors start to discount the cost deflation and improved returns above of cost of capital, these stock should outperform. An equal weighted portfolio of these stocks would have consistently outperformed the MSCI World index in the last one, three and five years, though underperformed YTD. *(The performance data provided is a hypothetical illustration of mathematical principles, it does not predict or project the performance of an investment or investment strategy. Past performance is no guarantee of future results.)*

1. NextEra Energy, **US:** Successful development of renewables plus storage in the US, coupled with solid utility growth. We expect NEE to be one of the biggest beneficiaries of the Inflation Reduction Act. NEE is also likely to be a major player in the nascent green hydrogen market, which is poised to rapidly accelerate given lucrative new incentives. Clear competitive differentiation gives NEE a strong line of sight to maintain share in a fast-growing US renewables market. See US: Who Wins in the Clean Power Landscape?

2. Bloom Energy, US: Early volatility with scaling the fuel cell product, but consistently delivering on growth and achieving significant EBITDA margins should drive meaningful valuation re-rating. 2023 is likely to be a breakout year for the company as it achieves rapid revenue growth and more importantly, improved profitability. See US: Who Wins in the Clean Power Landscape?

3. AES, US: Strong renewables plus storage growth and entry into green hydrogen, exiting coal entirely by the end of 2025

4. Orsted, Europe: We have a strong view that value creation is good in renewables and growth will materialise, therefore the market should value some of this outlook rather than none of it, as is evident in the share price today. Delivery execution improving post the recent headwinds and the company's growth ambitions extending and/or creating its own catalysts to reinvigorate investor interest should be a key trigger for the stock. See Europe: Who Wins in the Solar, Wind, Storage, and Hydrogen Landscape? .

5. RWE, Europe: A three-pronged investment case: 1) we see continued enhanced earnings and cash flow from elevated commodity prices and tight supply/demand in power markets to provide material cash for reinvestment. 2) RWE is an 'Energy Security Champion' and a likely beneficiary of Germany's energy policy for diversification away from Russia and wider decarbonisation. We expect significant investment opportunities and see upside to strategic growth targets. 3) RWE to transition to a majority green power business through the disposal of lignite assets in the coming years.

6. Reliance Industries, India: Reliance is investing to provide green infrastructure solutions and an alternative to China by developing five gigafactories (solar modules, green hydrogen, energy storage batteries, power electronics, fuel cells) at a single location in India – a US$60bn value creation opportunity by 2027. See India – Energy Transition with Growth

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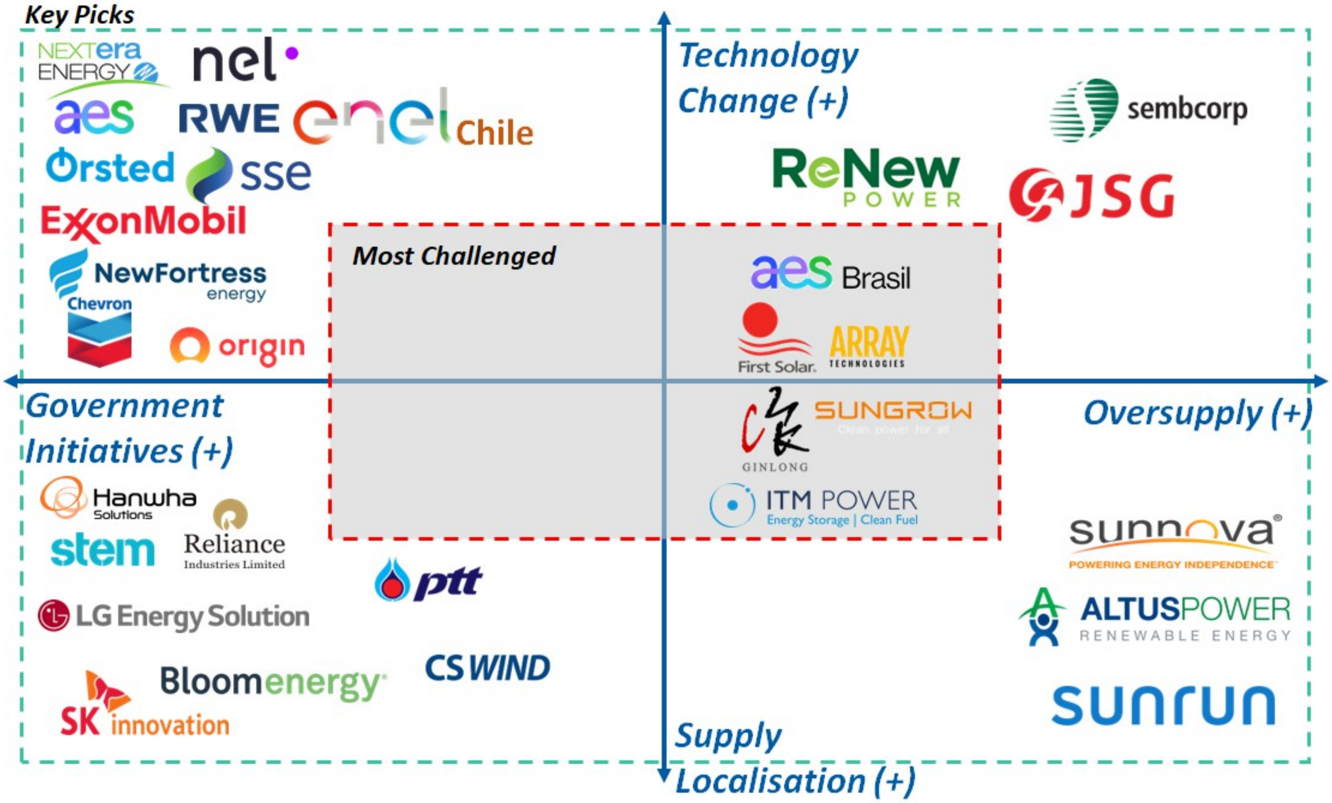
7. Sembcorp Industries, Singapore: Improved market share share gains in South Asia as it deploys new clean power projects and uses its conventional portfolio cashflows to reallocate capital to expanding renewables in China, India, Vietnam and Singapore. See Southeast Asia: Underappreciated Upside .

8. Enel, Chile: The largest integrated electricity group in Chile, Enel is highly exposed to renewables growth and the upward trend in power prices. The stock is pricing in no additional growth beyond projects under construction, and long-term power prices at US$40/MWh (below current market references of US$50/MWh). See LatAm Power Generation: Prefer Chile over Brazil .

Exhibit 11: Our key picks: Clean power producers, energy companies investing in low carbon fuels, and equipment manufacturers supporting supply chain localisation



Source: Morgan Stanley Research

Exhibit 12: Our key picks: Analyzing the drivers and investment theses

Company Name	MS Rating	Upside / (Downside)			Price Target (Local CCY)			Energy Transition Theme	Beneficiary of:				Average	Key Investment Thesis	What's Priced In?	MS Analyst
		Bull	Base	Bear	Bull	Base	Bear		New Technology	Oversupply	Government Support	Supply Localisation				
US Key Picks																
NextEra	OW	39%	28%	(19%)	101.0	93.0	59.0	Renewables, Hydrogen	5	5	5	4	4.8	Largest US large-scale renewables developer, growth poised to accelerate on IRA policy support and green hydrogen expansion	Stock only prices in 4 years of renewables growth (through 2026) despite much longer 10+ year industry growth and market leading development platform	David Arcaro
Altus Power	OW	177%	54%	(26%)	18.0	10.0	4.8	Solar	4	4	5	4	4.3	Market-leader in commercial and industrial distributed solar development	2-3 years of growth priced into the current share price.	Andrew Percoco
Bloom Energy	OW	237%	63%	(73%)	62.0	30.0	5.0	Fuel Cells/Hydrogen	4	3	5	5	4.3	Key beneficiary of growing demand for reliable distributed energy and hydrogen PTC.	Zero growth in electrolyzer and carbon capture, and a 16% revenue CAGR in its fuel cell business (vs. 25% annual growth in our base case) - assuming margins in line w/ our base case.	Andrew Percoco
AES	OW	87%	36%	(11%)	40.0	29.0	19.0	Renewables, Hydrogen	4	4	5	4	4.3	Leading US large-scale renewables developer, exiting coal entirely in 2025 and accelerating growth driven by renewables	Stock prices in minimal future renewables growth, and overly discounts the complexity of the asset mix	David Arcaro
Stem, Inc.	OW	271%	71%	(57%)	26.0	12.0	3.0	Energy Storage	4	4	5	4	4.3	High-margin energy storage software provider, with IRA support driving incremental demand for energy storage.	11% annual rev growth through 2035 vs. 20% in our base case. Assuming growth in line w/ our base case, the market is only pricing in ~300/1,000 bps of gross/EBITDA margin expansion through 2025 vs. 1,000/1,800 bps in our base case.	Andrew Percoco
Sunnova	OW	258%	83%	(56%)	82.0	42.0	10.0	Solar	4	4	5	4	4.3	Key beneficiary of rising demand for rooftop solar and next-gen home energy systems setup	No additional customer growth is currently being priced into the NOVA shares.	Andrew Percoco
Sunrun	OW	262%	79%	(59%)	79.0	39.0	9.0	Solar	4	4	5	4	4.3	Largest US rooftop solar developer; Key beneficiary of rising demand for rooftop solar and next-gen home energy systems setup	The market is pricing in ~3 years of customer growth into the RUN shares.	Andrew Percoco
ExxonMobil	OW	57%	19%	(27%)	159.0	121.0	74.0	Hydrogen, CCUS, Biofuels	4	3.5	4	4	3.9	Largest US Integrated Energy company with leading position in carbon capture and clean hydrogen/ammonia.	Stock reflects no value for Low Carbon investments, which we estimate could deliver $4B of EBITDA by 2030	Devin McDermott
Chevron	EW	71%	28%	(21%)	262.0	197.0	121.0	Hydrogen, CCUS, Biofuels	4	3.5	4	4	3.9	One of the worlds largest renewable fuel producers plus an active development pipeline in clean hydrogen, ammonia & CCUS	Stock reflects no value for Chevron New Energies, which we estimate could deliver >$2B of EBITDA by 2030	Devin McDermott
New Fortress Energy	OW	216%	84%	(37%)	86.0	50.0	17.0	LNG & hydrogen	4	4	4	3	3.8	Converts polluting fuels like coal & fuel oil to natural gas, reducing energy costs & supporting higher renewables penetration. Developing green hydrogen hubs.	Stock trades at fair value of existing assets, not reflecting potential upside from further downstream growth, FLNG, or clean hydrogen	Devin McDermott
Latin America Key Picks																
Enel Chile	OW	36%	0%	(31%)	79.0	58.0	40.0	Renewables	5	4	4	4	4.3	The largest integrated electricity group in Chile, highly exposed to renewables growth and upward trend in power prices.	Stock prices in no additional growth beyond projects under construction, and long-term power prices at ~US$40/MWh (below current market references of ~US$50/MWh)	Miguel Rodrigues
Europe Key Picks																
Orsted	OW	92%	36%	(4%)	1,200	850	600	Renewables	4	3.5	5	4	4.1	Industry-leading best in class offshore wind operator amid a long-term renewables growth story	Stock values no unsecured future growth and existing challenged projects at a discount	Robert Pulleyn
NEL	OW	171%	75%	(36%)	34.0	22.0	8.0	Hydrogen	5	3	4	4	4.0	Leader in the field with technological hedge. Benefits from energy transition through the US IRA and EU GDI	Expect it to trade on structurally higher multiples given its scarcity value and improving industry sentiment	Arthur Sitbon
RWE	OW	104%	33%	(13%)	80.0	52.0	34.0	Utilities	4	3	5	4	4.0	Benefits from energy transition to renewables and flexgen, potential re-rating if it exits lignite	1 year of discounted growth. Benefit of tight commodities market providing material cash for reinvestment.	Robert Pulleyn
SSE	OW	69%	41%	(16%)	3,000	2,500	1,500	Integrated Energy	4	3	5	4	4.0	Double offshore play - renewables development and related transmission infrastructure growth	Stock discounts zero value for offshore pipeline, limited for onshore, conservative <3x EV/24e EBITDA for Thermal	Robert Pulleyn
Asia Pacific Key Picks																
Reliance Industries	OW	40%	15%	(31%)	3,918	3,210	1,916	Integrated Energy	5	3.5	4.5	5	4.5	Focus on being an enabler rather than a producer of electrons and green molecules	Investments in green energy infrastructure is key to outperformance in the next decade to add $60bn in Market Cap	Mayank Maheshwari
Sembcorp Industries	OW	51%	24%	(25%)	8.0	6.6	4.0	Renewables	4	4	4.3	NA	4.1	Downstreaming into low-carbon hydrogen and ammonia to raise returns above cost of capital	Tight electricity markets and lower cost of gas should keep SCI's ROCE high	Mayank Maheshwari
ReNew Energy	OW	43%	15%	(34%)	8.06	6.48	3.75	Renewables	4	4	4.3	4	4.1	Renew is strongly positioned to play India's energy transition, with forays into module manufacturing and green hydrogen.	F23-26e EBITDA CAGR of 18% is one of the highest among global peers.	Girish Achhipalia
SK Innovation	OW	65%	28%	(39%)	270,000	210,000	100,000	Integrated Energy	5	2	4	5	4.0	Beneficiary of IRA with aggressive expansion in US and expected margin expansion	Korean companies have underestimated the growth of LFP market, and are now behind Chinese LFP suppliers	Young Suk Shin
LG Energy Solutions	EW	54%	17%	(20%)	830,000	630,000	430,000	Battery	5	2	4	5	4.0	Beneficiary of IRA with aggressive expansion in US and expected margin expansion	Korean companies have underestimated the growth of LFP market, and are now behind Chinese LFP suppliers	Young Suk Shin
CS Wind	OW	40%	23%	(22%)	116,000	102,000	65,000	Wind	3	4	4	5	4.0	Beneficiary of IRA with expansion in US; product diversification into offshore foundation	US capacity expansion guidance is priced in but improving wind industry cycle momentum is still met with some skepticism	Michael Koh
PTT	OW	22%	7%	(22%)	42.0	37.0	27.0	Integrated Energy	4	3	4	4	3.8	Transforming into energy transition giant with investments >US$10Bn by 2030	Upside from supply localisation and development of new energy value chain @ $15bn	Mayank Maheshwari
Hanwha Solutions	OW	56%	35%	(32%)	67,000	58,000	29,000	Renewables	4	2	4	5	3.8	Beneficiary of IRA with aggressive expansion and vertical integration in US	Increasing shipment into US from China is a risk for Hanwha's market share leadership	Michael Koh
Jingsheng Mechanical	OW	126%	43%	(32%)	150.0	95.0	45.0	Solar	4	3	4	4	3.8	Strong order backlogs on solar equipment with robust downstream capacity expansion in 2022-23, while solar materials segment expected to achieve faster growth with more capacity ramping production in 2023	Market is pricing in the expectation of solar equipment order peak out in 2023, however, missed the company's business expansion, and the potential on material business and semi equipment	Sheng Zhong
Origin Energy	OW	56%	3%	(25%)	13.4	8.9	6.5	Battery	4	3	4.0	NA	3.7	Preferable electricity market positioning with an uncomplicated renewable PPA strategy	Supply chain constraints are acting as a near-term inflationary driver for Australia's power prices	Rob Koh
Most Challenged																
ITM Power	UW	163%	18%	(34%)	200.0	90.0	50.0	Hydrogen	5	3	3	3	3.5	Weak order intake and operational issues that will take time to resolve	Market is pricing in a successful turnaround with the ability to grab significant long-term market share in the global electrolyser market	Arthur Sitbon
AES Brasil	UW	29%	3%	(31%)	15.0	12.0	8.0	Renewables	4	3	3	3	3.3	Pure GenCo with ~50/50 exposure to large hydro and renewables (mostly wind & solar). Main concerns are related to energy repricing and GSF risks	Stock prices in no additional growth beyond projects under construction, and long-term power prices at ~R$155/MWh (above current market references of ~R$115/MWh)	Miguel Rodrigues
Array Technologies	UW	60%	(20%)	(75%)	32.0	16.0	5.0	Solar	3	2	4	4	3.3	Beneficiary of IRA and reshoring of the supply chain, but risk of margin compression from intense competition within the solar tracker market.	Market is not pricing in future margin erosion as a result of increased competition	Andrew Percoco
First Solar	UW	3%	(13%)	(57%)	212.0	180.0	89.0	Solar	3	2	4	4	3.3	Vertically integrated US solar panel manufacturer. Increased competition will likely drive slowing backlog growth and margin erosion.	Market is pricing in the full IRA tax credit benefit and premium valuation multiple to its base business	Andrew Percoco
Ginlong Technologies	UW	69%	22%	(44%)	180.0	130.0	60.0	Solar	3	2	3	3	2.8	Limited room for share gains and fast capacity growth within inverter sector provides downside risk for gross margins	Market is pricing in strong volume growth and market share gains as well as stable margins	Simon Lee
Sungrow	UW	26%	(21%)	(53%)	144.0	90.0	54.0	Solar	3	2	3	3	2.8	Limited room for share gains and fast capacity growth within inverter sector provides downside risk for gross margins	Market is pricing in strong volume growth and market share gains as well as stable margins	Simon Lee

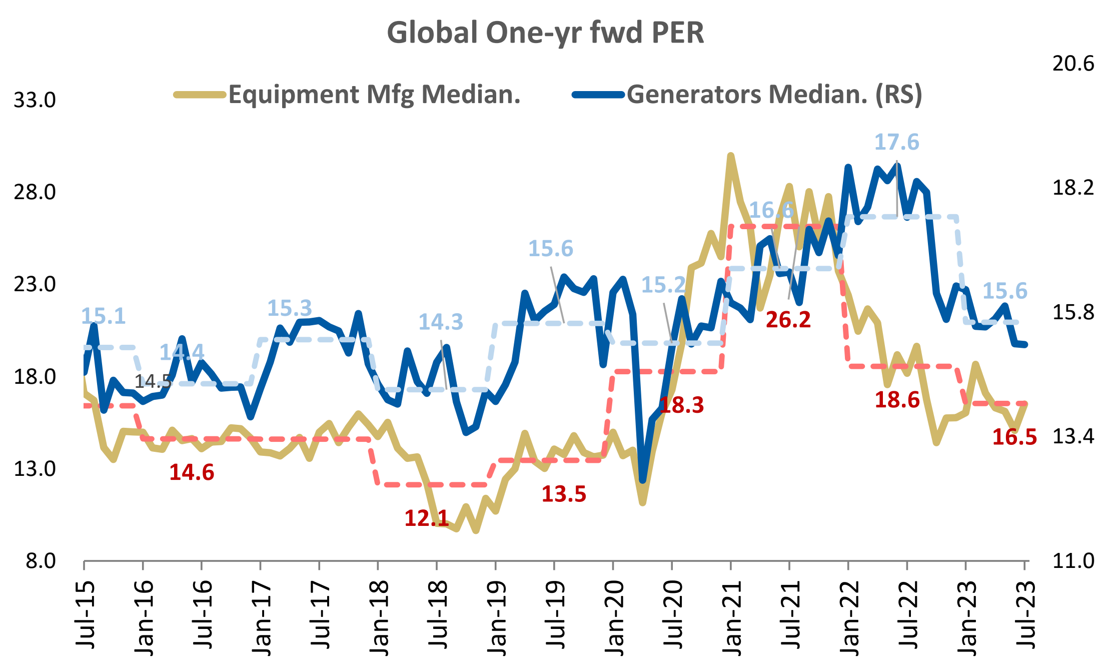
Source: Morgan Stanley Research

Exhibit 13: How are green equipment manufacturers and IPPs/developers positioned across the renewables space?

Across the renewables space, we think technology improvements will be seen across all 4 categories. Government support is strongest in the US given the IRA. Supply localisation is most challenging for Asia as developers/IPPs globally shift their supply chains to be more domestically oriented

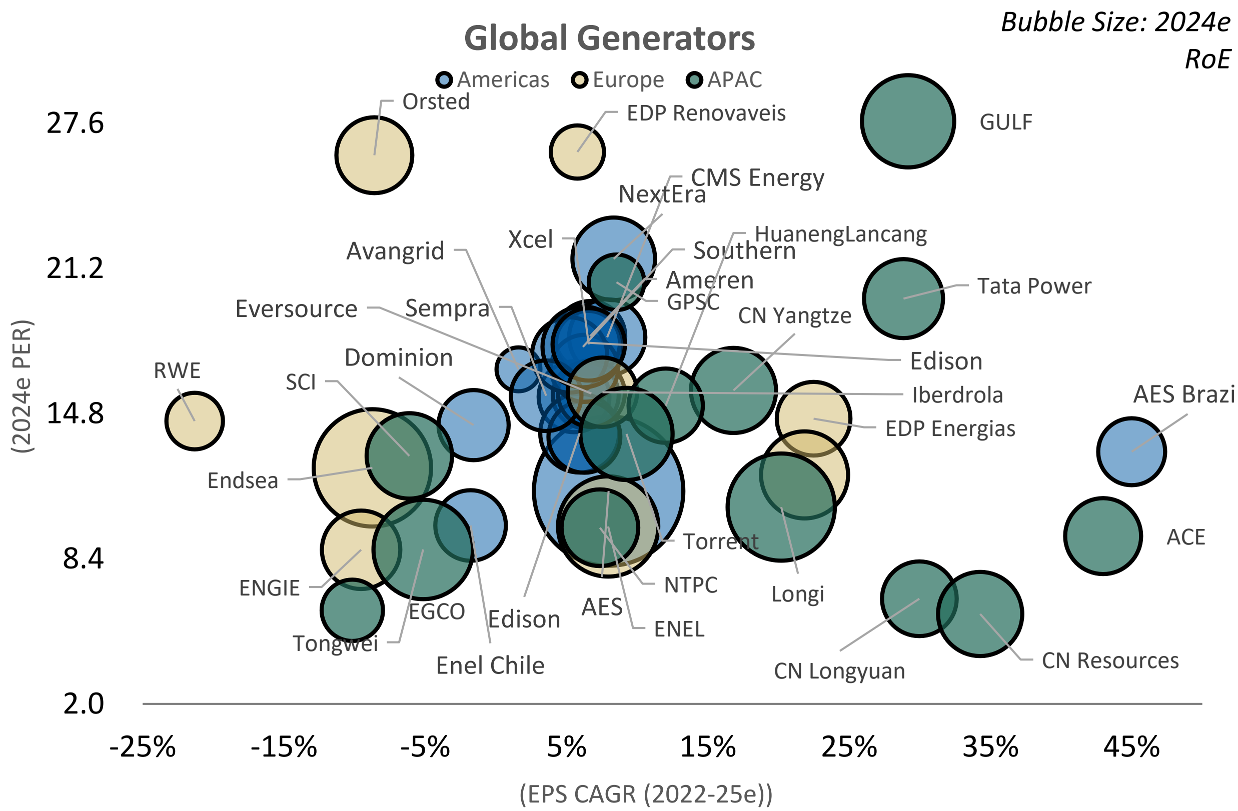
Source: Morgan Stanley Research

Exhibit 14: Valuations across renewable equipment manufacturers have corrected materially since 2022 as overbuilding starts to affect pricing; Generation companies offer upside as their investment costs reduce and the impact of higher interest rates unwinds



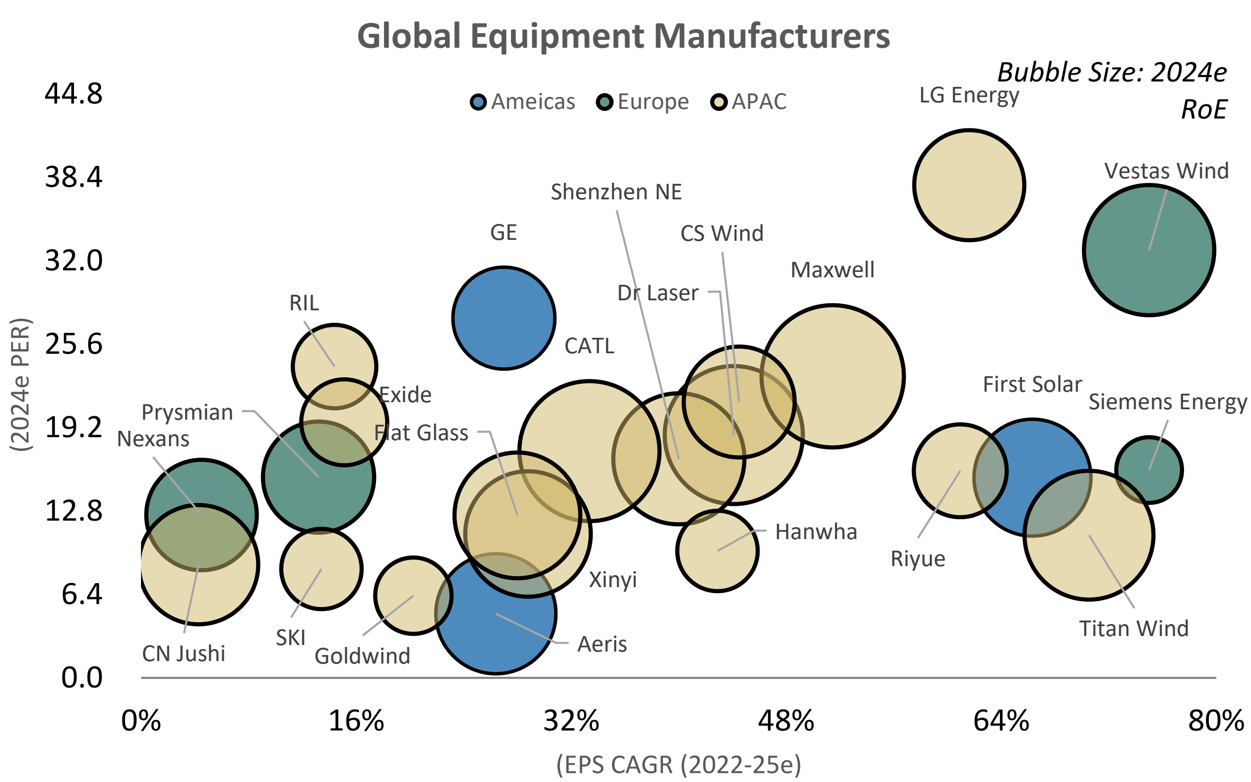
Source: Eikon, Morgan Stanley Research

Exhibit 15: The markets in our view are under-appreciating the earnings growth pipeline within global renewable producers



Source: Eikon, Morgan Stanley Research

Exhibit 16: Stay selective, with upside for companies developing local supply chains in India, Southeast Asia, and China

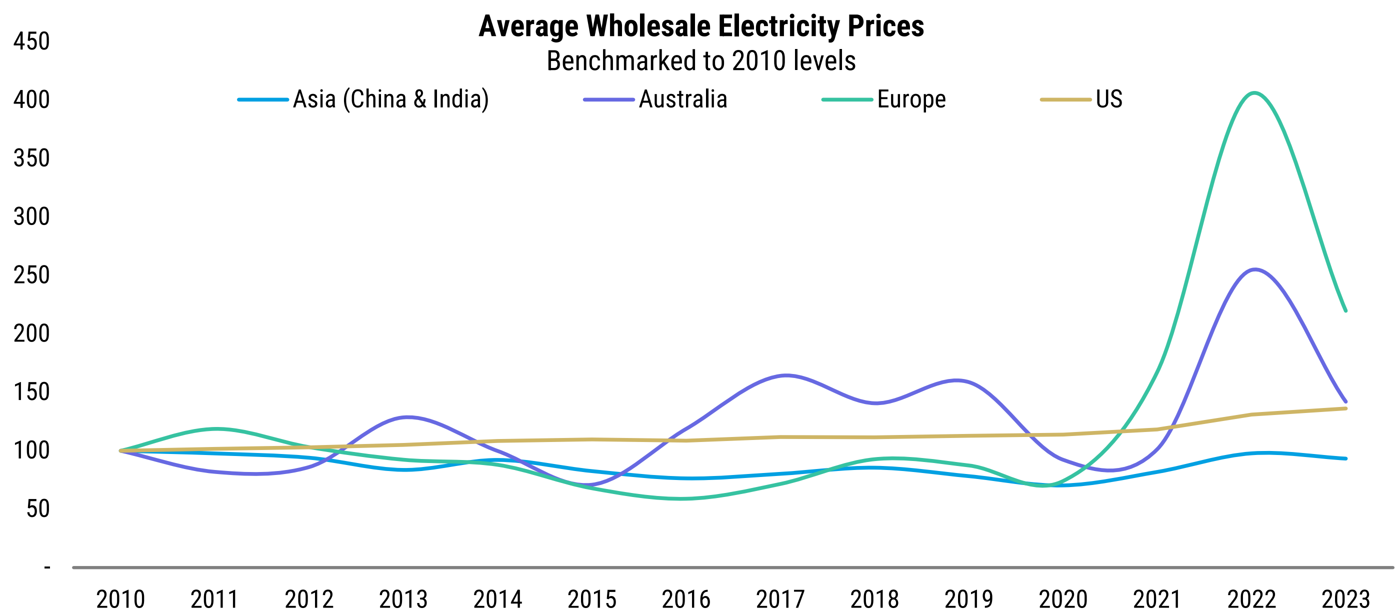


Source: Eikon, Morgan Stanley Research (e) estimates

Renewables Growth & Electricity Price Impact

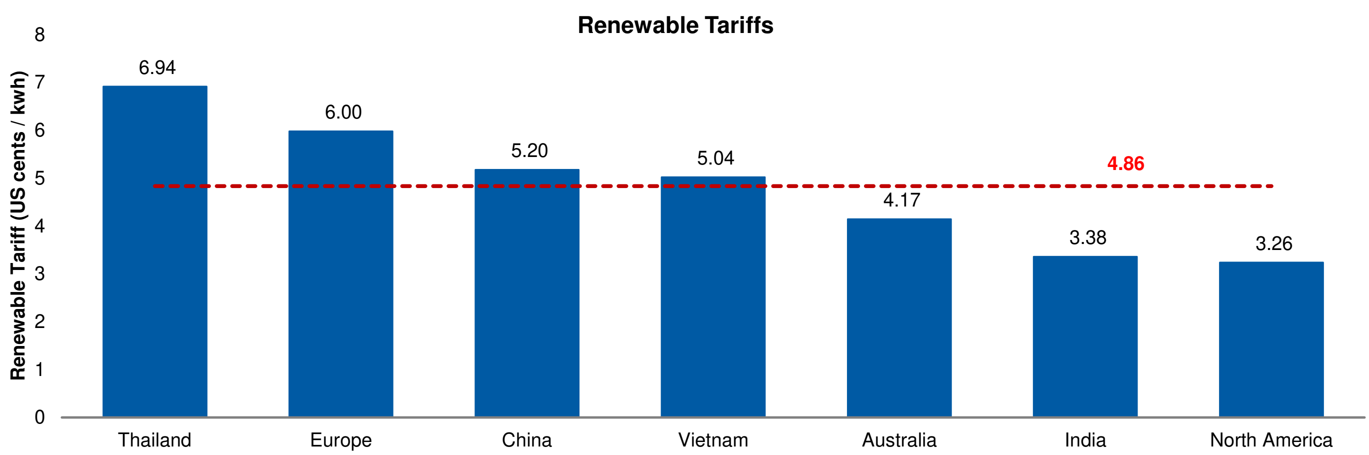
There has been a debate as to whether renewables have raised the overall electricity system prices, esp. as current solar/wind producers prices are very competitive to alternative fuels. Wholesale electricity producer prices globally have risen on average by 3.4% CAGR in 2010-2022, while renewable based generation in the electricity mix has grown at a 6.1% CAGR to reach 30%. Solar and Wind installations have accounted for nearly 70% of the increase. Hence the impact of renewables in the overall electricity whole sale price inflation has been quite muted. In 2022, about half of the renewable-based electricity generation was in Asia, with the remainder primarily evenly split between Europe and the US. In Asia and the US, wholesale electricity prices have increased at a 0-2% CAGR over the past 13 years (Exhibit 17). Europe and Australia, however, have stood out in terms of wholesale producer price inflation and, interestingly, a large part of it is due to higher domestic gas prices in Australia, while also shutting a portion of its coal-based capacity.

Exhibit 17: Average wholesale electricity prices over the past decade have risen by 3% CAGR pre-Ukraine conflict on average across continents. Renewables generation mix globally grew at a 6% CAGR to reach 30% of electricity production over this timeframe



Source: Bloomberg, CEIC, Morgan Stanley Research

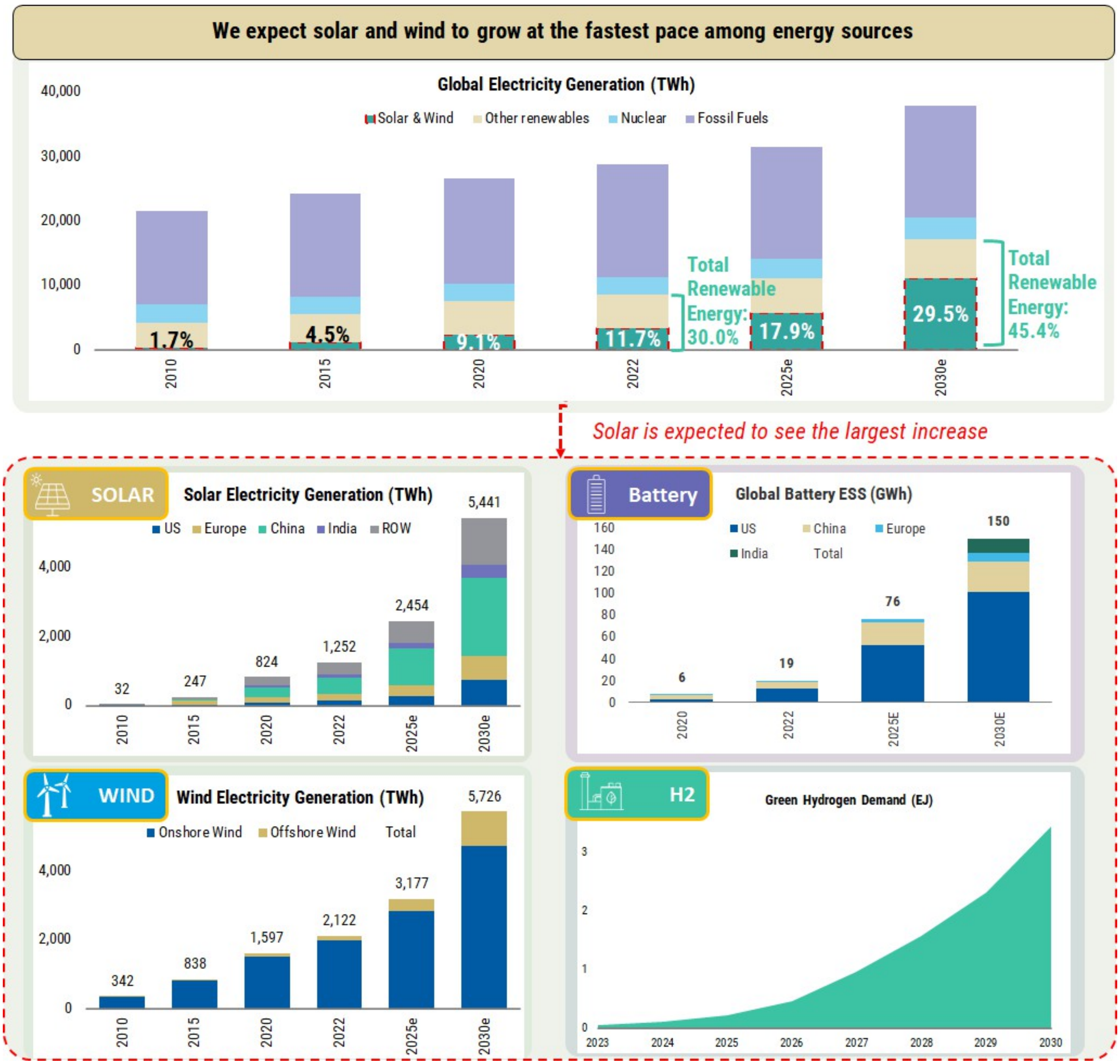
Exhibit 18: Putting global renewable tariffs in perspective



Source: BNEF, IRENA, ERC.

Outlook for renewable demand: We expect solar and wind powered electricity consumption to triple to 30% with the overall renewable mix at 45% by 2030 . Our estimate of solar/wind based generation in 2030 is 200bps above IEA main case estimates, as we see upside from better solar panel efficiency and higher installation of onshore wind in the US/Europe. Overall, China, India, the US and Europe will be key to driving the increase in renewable consumption and capacity, as cost to produce falls with equipment costs. Batteries and hydrogen will, however, still form a smaller part of the total implied electricity consumption (in the case of hydrogen) and power capacity (in the case of batteries) as these technologies will continue to scale up beyond 2030.

Exhibit 19: Renewable generation to contribute nearly half (45%) of global electricity consumption by 2030, and the share of solar and wind will nearly triple by 2030 in the power consumption mix



Source: IEA, Morgan Stanley Research (e) estimates

Deflation: Technology + Tech Diffusion Upside

As we look at the rest of the decade, technology evolution and adoption in energy transition will play a key part in deflating costs (Exhibit 20), as government support and supply chain localisation accelerate the adoption of these new technologies. Lowering the price per watt across the value chain from production to delivery is going to deflate by 30% vs. 2022 base line as technology adoption on HJT/N-type cell/ larger cells (in solar), Sodium ion/LFP (in batteries), scale/subsidies (in green hydrogen) and wind blade sizes (in offshore wind) lead to about US$0.5trillion in savings by 2030, on our estimate. Many of these changes are under various stages of implementation, but are less appreciated by the market due to the high cost inflation of 2021/2022. We highlight several key technology improvements below and how they can lead to lowering the cost of electrification.

Key Technology Improvements

Solar: Efficiency gains – key to lower producer prices

Polysilicon oversupply and efficiency gains (from new technologies and better manufacturing processes) will raise panel efficiency by up to 26-28% by 2030 after stagnating around the 22-24% range in the last half a decade, on our estimate. Component oversupply and subsidies (in key geographies) will underpin solar generation cost deflation by US$20/MWh (down 40% vs. 2023) by 2030. This will keep solar as one of the lowest cost energy technologies on the global cost curve.

- **Commodity oversupply:** Polysilicon overcapacity by ~2mn tons by 2025-26 (assuming all proposed expansions fructify) underpins the first leg of cost deflation, driving total wafer costs lower by 30%.
- **New technology:** Technology iteration is the key driver of solar cost reduction. We see continuous technology improvement along the value chain, including but not limited to granular silicon, superconducting crystal growing furnaces, and heterojunction (HJT) solar cells, to reduce production cost and improve conversion efficiency.
- **Production techniques** which focus on better process efficiencies, thinner/larger component parts and lower material usage that maximise efficiencies/limit cell degradation.

Wind: Scale benefits

Advancements in wind turbine capacity are lowering the overall cost per MW due to positive scale effects. We expect cost of generation to decline by US$10/MWh for onshore wind and US$30/kwh for offshore wind.

- **Larger capacity turbines** generate positive scale effects with lighter nacelles per MW and hence lower unitary capex. Larger blades also contribute to 2.5% higher capacity factor for every 50m increase in rotor diameter.
- Secondary improvements include modular manufacturing for reduced transportation and installation cost, and high voltage direct current transmission technology that lowers electricity transmission losses.

Battery: Cheaper chemistries

A paradigm shift in cell chemistry could reduce the use of rare earth materials, reducing unit capex costs by about US$70/kWh and cost of storage by US$30/MWh. We see significant potential for cheap long duration energy systems (LDES) providing firm, reliable power at low costs. Utilities with low customer bills and favorable economics could use LDES to 'generate' power while paired with renewable-generating assets as an economically-feasible alternative to new natural gas fired power plants.

- **Switch to LFPs** will result in cost savings given cheaper costs relative to NCM/NCA cells as LFP cathode chemistry avoids the use of expensive Nickel and Cobalt while advancements have improved cell characteristics sufficient for widespread adoption.
- **Sodium ion cells** replaces expensive lithium with abundant sodium with minimal additional capital outlay for manufacturers. CATL and BYD have heavily invested in the technology and could see cell costs reduce by 20-30%.
- **Metal Air batteries** represent a paradigm shift in battery technology, using air as a cathode and avoiding the use of rare earth metals, potentially reducing storage costs to a small fraction of current levels.

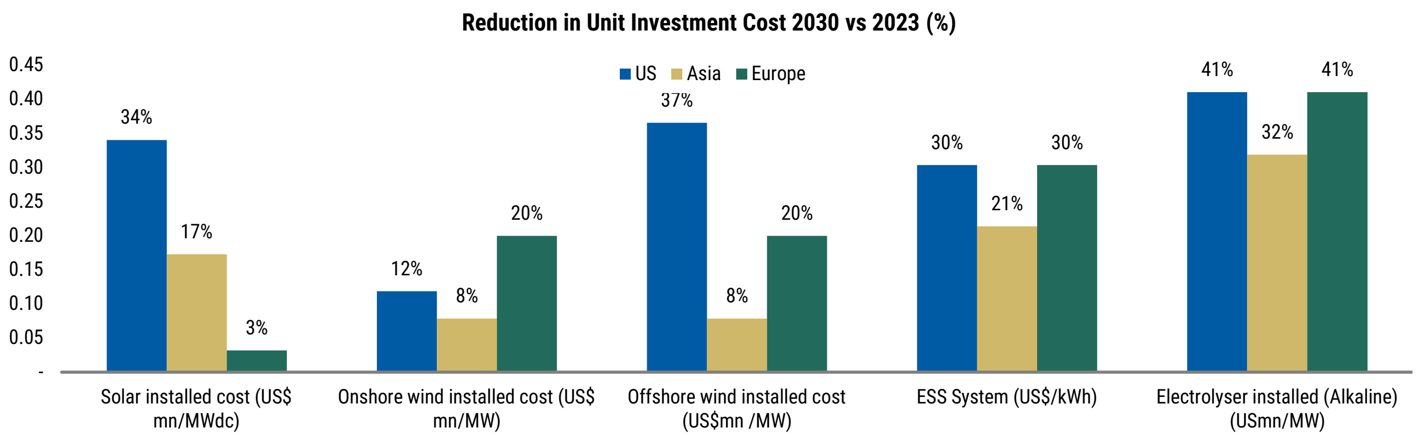
Low Carbon Hydrogen: All about electrical efficiency and scale benefits

Advancements in electrolyser technology and increased scale could improve electrical conversion efficiency, increasing hydrogen production thus reducing unit costs by US$2/Kg and making it competitive vs. alternative fuels like gas. Large scale industrial applications like refining, fertilisers and power plants will be key to adoption, and we do not see as much upside from B2C segments.

- **New electrolyser designs** could improve electrical efficiency to 70-75% from the current 68% and lower raw material inputs.
- **Reduction in rare earth materials** (platinum and iridium) for PEM electrolysers by reducing the thickness of the membrane.
- **Scale of operations** is also key for lowering the costs of green H2, similar to LNG.

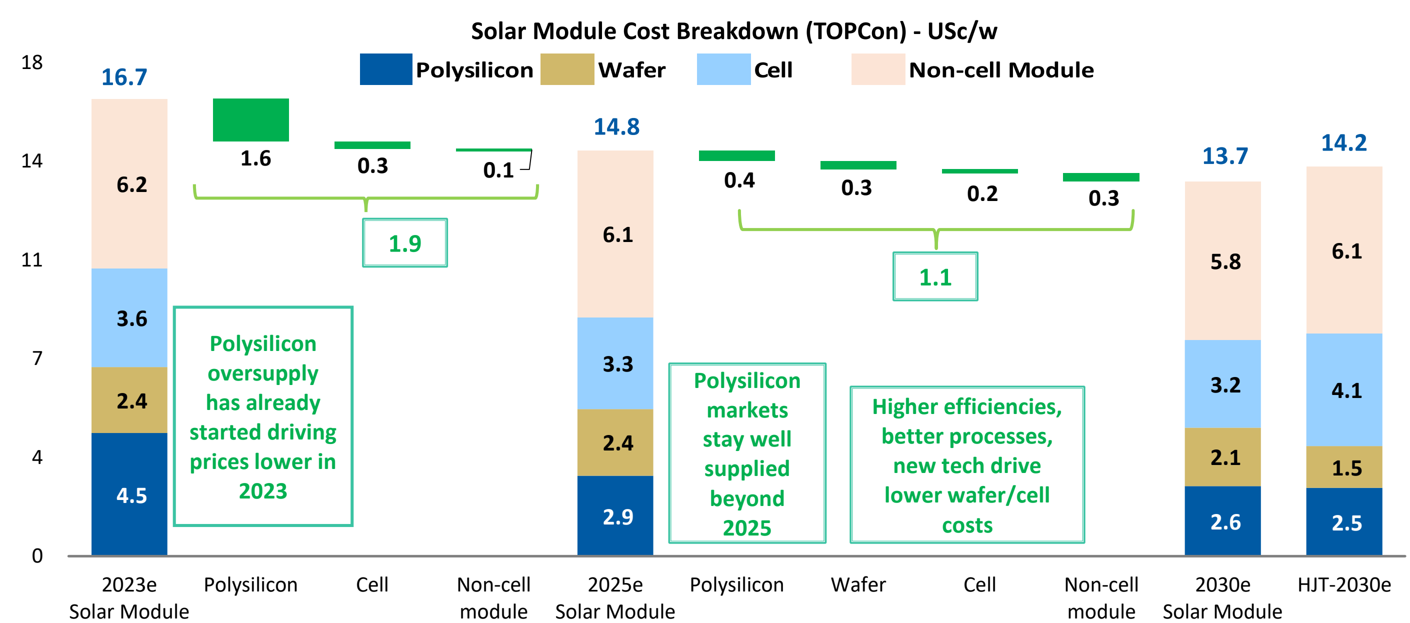
Risks: Like with all new technologies, we believe the above technologies do have risks, though they improve overtime like we have seen with solar modules for a long time or even with hydrogen electrolyser and batteries.

Exhibit 20: We see substantial cost declines globally led by multiple levers of technology advancements and equipment oversupply



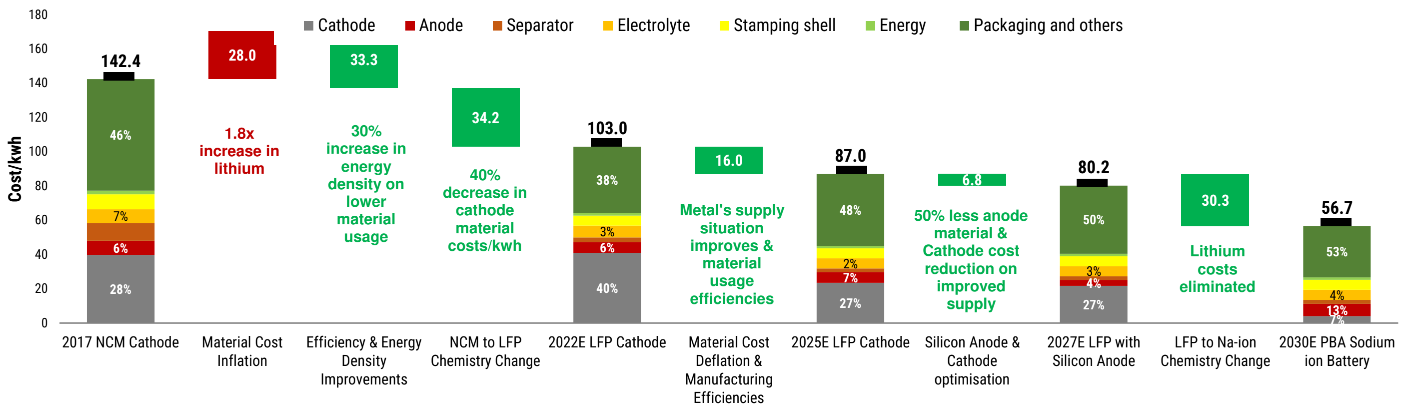
Source: Morgan Stanley Research estimates

Exhibit 21: Solar: We see solar module costs declining by a fifth, first led by over/well-supplied commodity/energy markets, followed by technology diffusion, efficiency gains, value chain localisation and component oversupply



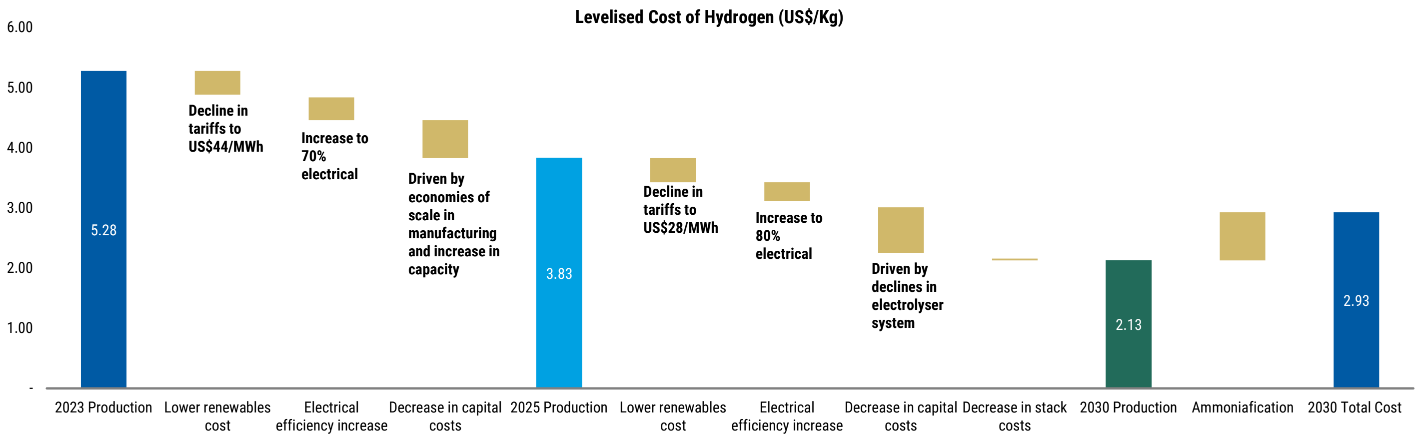
Source: Longi, JA Solar, BNEF, Morgan Stanley Research (e) estimates

Exhibit 22: Battery costs: Normalisation of lithium costs, improvements in cell chemistry with sodium ion technology, and introduction of silicon anodes should lower the cost of energy storage globally



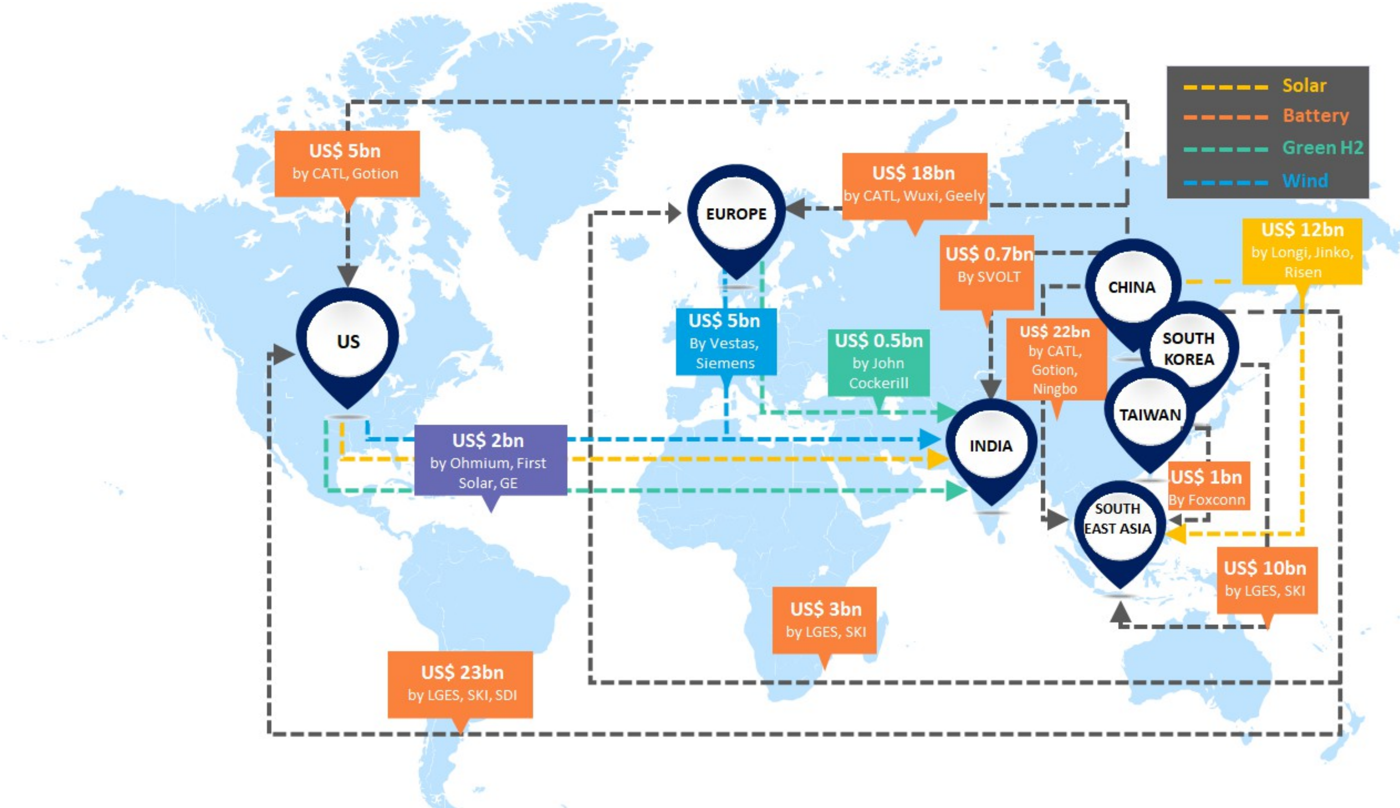
Source: CATL, BNEF, Morgan Stanley Research estimates

Exhibit 23: Hydrogen Costs: Levelised cost of hydrogen production is expected to decline by more than half and achieve gas parity



Source: Morgan Stanley Research estimates

Exhibit 24: Technology Investment Diffusion Map: We identify US$100bn+ of cross geography investments in low carbon equipment (and there could be a lot more) that help lower electricity production costs over the next four years



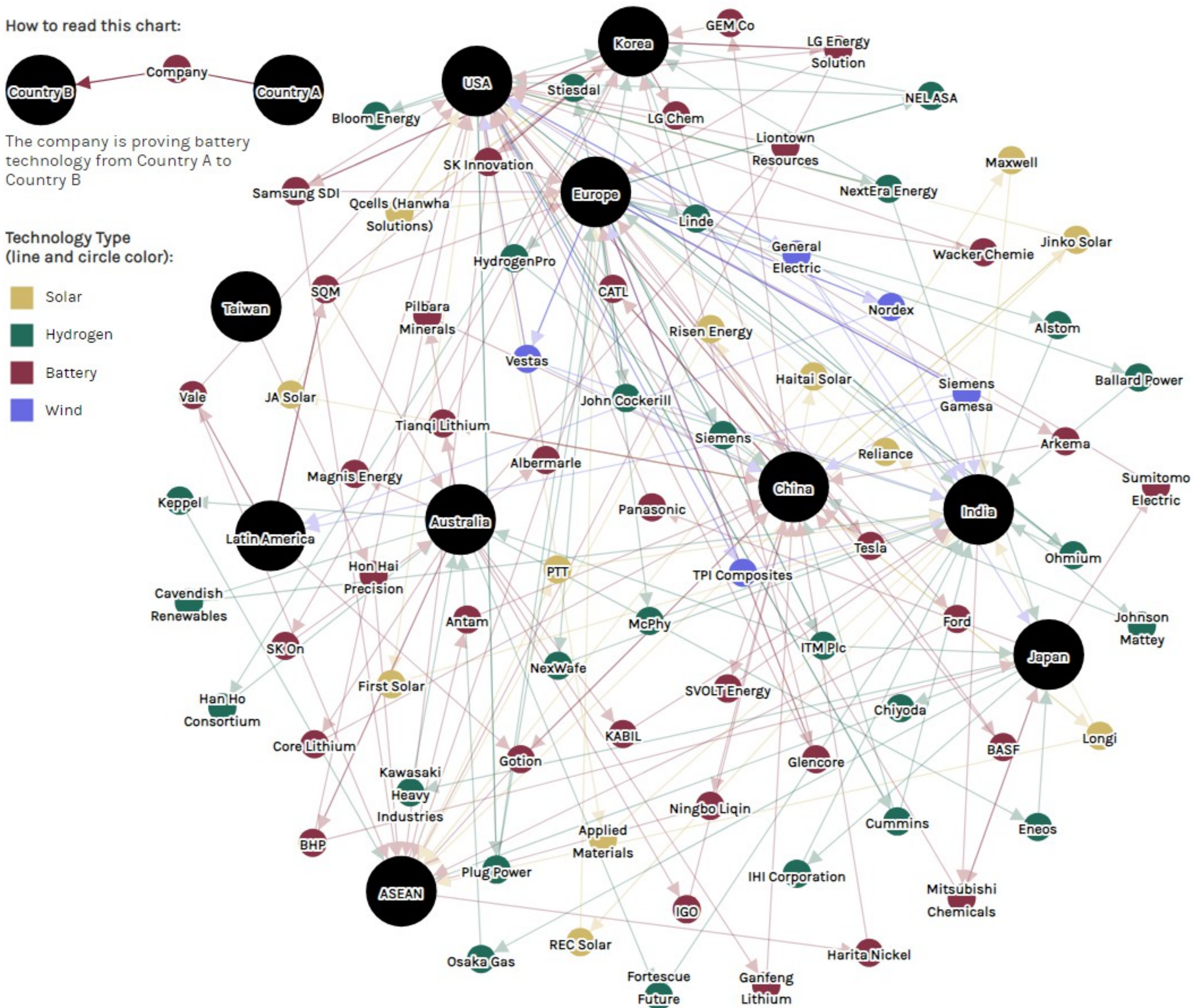
Source: Company data, Morgan Stanley Research estimates

Our bottom-up work on the investments across geographies by energy corporates with our global teams highlights at least US$105bn of cross country investments, and we expect the numbers to be higher as not all investment pipelines are within the public domain. The pace of technology diffusion has accelerated as evidenced by: US$23bn of Korean investment in the US battery value chain, with another US$12bn in Europe and Southeast Asia, including 25GWh of cell manufacturing capacity in Indonesia and Malaysia; US investment in Indian renewables and electrolysers; Chinese investment of US$13bn and US$22bn in Southeast Asian solar and battery value chains, including 15GWh of lithium-ion battery cell manufacturing capacity, partnerships across various Taiwanese companies and Thai energy/renewable companies, and Singapore corporates investing to source green hydrogen from Australia.

This diffusion of know-how is not only raising oversupply of equipment, but also lowering the costs to produce, especially as supply chains shift to India, the US and Southeast Asia. This ecosystem is getting a tailwind from pivots in government support in the US in the form of subsidies and more stringent enforcement rules in Europe for goods sourced globally. Hence, the amazing jigsaw is all coming together to deflate costs and raise adoption of low carbon solutions, which still only form less than 10% of global energy needs. See Exhibit 24.

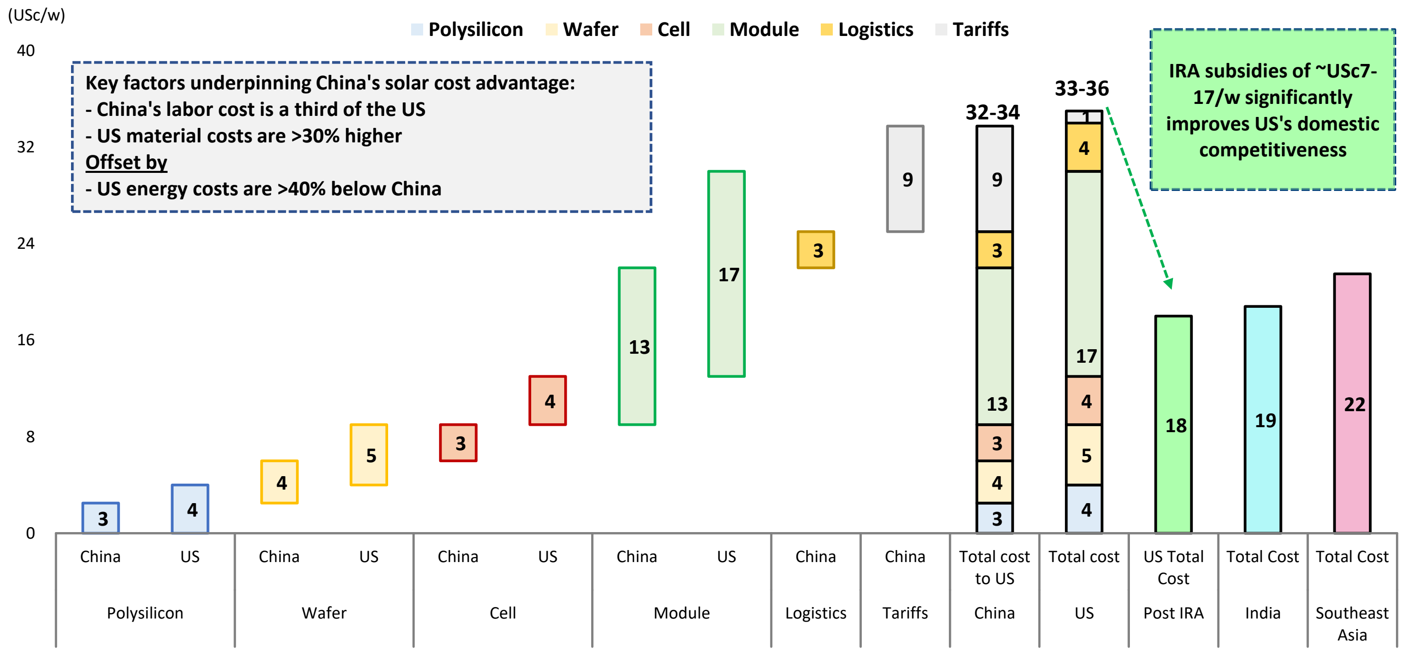
Low-Carbon Solutions: The Global Diffusion Matrix Remains Underappreciated

Exhibit 25 Clean Power Supply Chain: The Corporate Diffusion Matrix



Source: Company data, Morgan Stanley Research

Exhibit 26: Stacking up Asian and US solar manufacturing competitiveness – China, India and Southeast Asia remain the most cost-competitive globally, but IRA incentives significantly enhance US competitiveness



**Note: Standardised Production Assumptions and Scale*
Source: BNEF, US Department of Energy, IEA, Morgan Stanley Research estimates

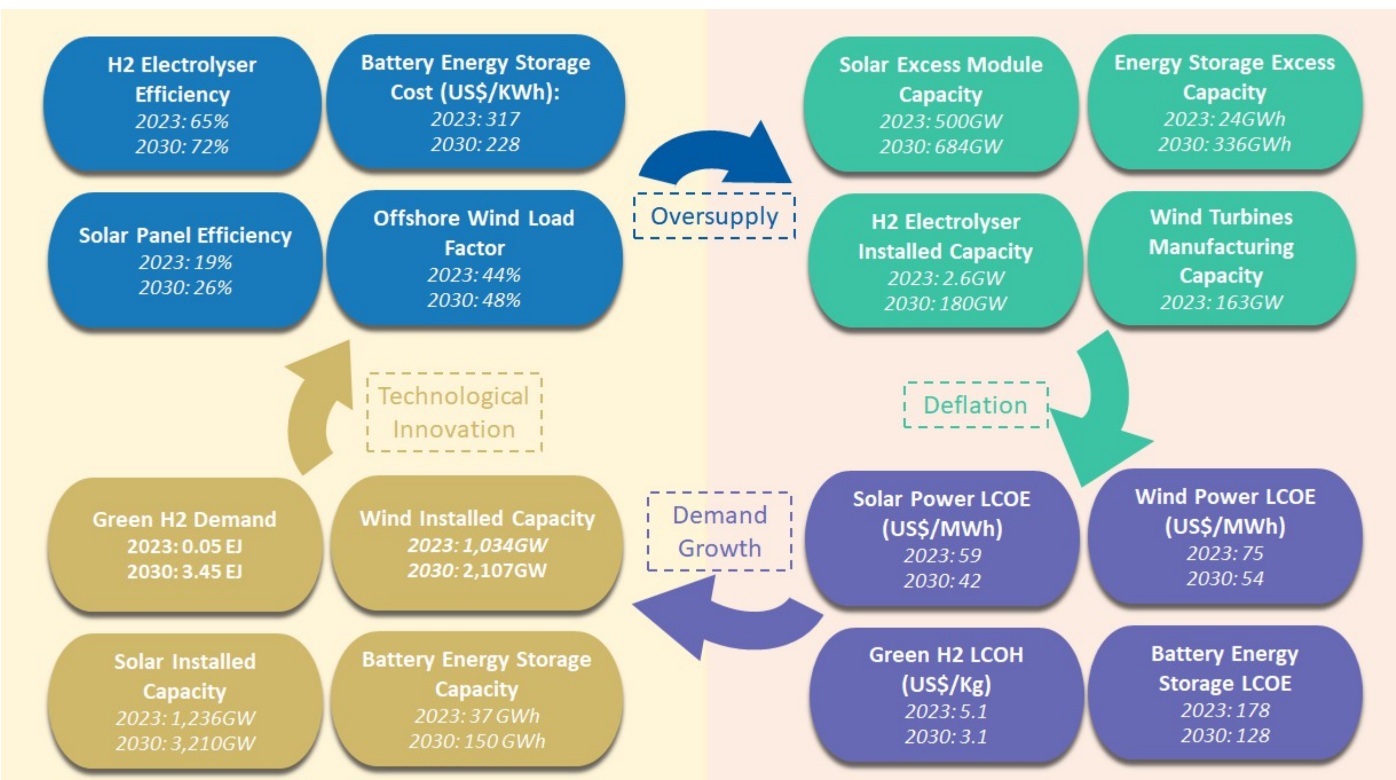
Equipment Overbuild Supports Renewable Adoption

Need for diversification: The EV battery supply chain is highly geographically concentrated, far more so than oil or natural gas. Over 90% of the solar panel supply chain sits in one nation, 60% of manufacturing capacity for wind turbines is in three nations, and over 75% of global output of lithium, cobalt and nickel – essential raw materials for batteries – is concentrated in three nations. Hence there has been focus to diversify the supply chains from an energy security perspective by various nations.

The capacity overbuild: As governments promote energy security through various incentives, the diversification of supply chains will in our view drive the development of excess equipment capacity, resulting in significant overbuild, as new renewable installations lag behind the step function growth in equipment capacity. Over the next decade, we estimate green equipment capacity (including solar modules, hydrogen electrolysers, and energy storage batteries) will rise at twice the pace of the past 10 years and will outstrip demand by at least 30-50% within the next five years. In our view, this trend remains highly underappreciated by investors across solar modules and energy storage (batteries), and we see this evolution also occurring for hydrogen electrolysers in the latter half of the decade. Most generation companies will therefore see investment costs per MW fall at a time when global interest rates have stopped increasing. While the PPA prices for renewable capacity will reflect the capex cost reduction, we believe the generation companies will see increased flexibility to bid for renewable projects above cost of capital.

The quantum of cost reductions: Lower equipment prices and government incentives will invigorate renewable capacity installations, in our view. Solar equipment and energy storage batteries will see the greatest increase in capacity, causing their prices to drop 20-40%. While the onshoring of capacity is considered inflationary by many in view of higher labor costs and reduced scale benefits, our bottom-up analysis shows that onshored supply chains in the US, India, South East Asia could actually be quite competitive with China's as such disadvantages are offset by government support. See Exhibit 26 and Exhibit 20 . Green hydrogen supply chains are still being built but should be more diversified, similar to gas.

Exhibit 27: A virtuous cycle of green electricity price deflation will be in play through 2030



Source: Morgan Stanley Research

Solar – Overcapacity and cost deflation: Globally we estimate solar capacity to expand 1,000GW annually in modules by 2030 I.e ~2x on average above the installations. Capacity adds in India, as well as re-shoring efforts in North America, should steadily lower China's dominance in the solar component supply chain. Through 2025, China's module manufacturing capacity is poised to grow 200GW, with another 80-100GW added offshore. See Solar: How Are Supply Chains Evolving?

The oversupply is particularly evident in China and India, where we estimate manufacturing capacity (especially modules) is growing at twice the rate of solar deployments. China's overcapacity has already caused polysilicon prices to fall 70% this year. The next wave of deflation is likely to come in wafer costs as China adds ~350GW of wafer capacity over the next three years. Similarly, as highlighted earlier, module manufacturing capacity growth will also outpace annual installations as only half of the announced solar manufacturing investments globally are fully integrated.

In the US, we estimate that 20GW of cell manufacturing and 55GW of module manufacturing capacity have been announced since the Inflation Reduction Act (IRA) was passed into law. However, we have seen little in the way of polysilicon capacity additions, though some dormant domestic capacity will restart production. Furthermore, the US Treasury recently announced rules around domestic content requirements and is still in the process of publishing rules for domestic manufacturing tax credits. In our view, clarification around these tax credits and subsidies will catalyse further investment in domestic manufacturing.

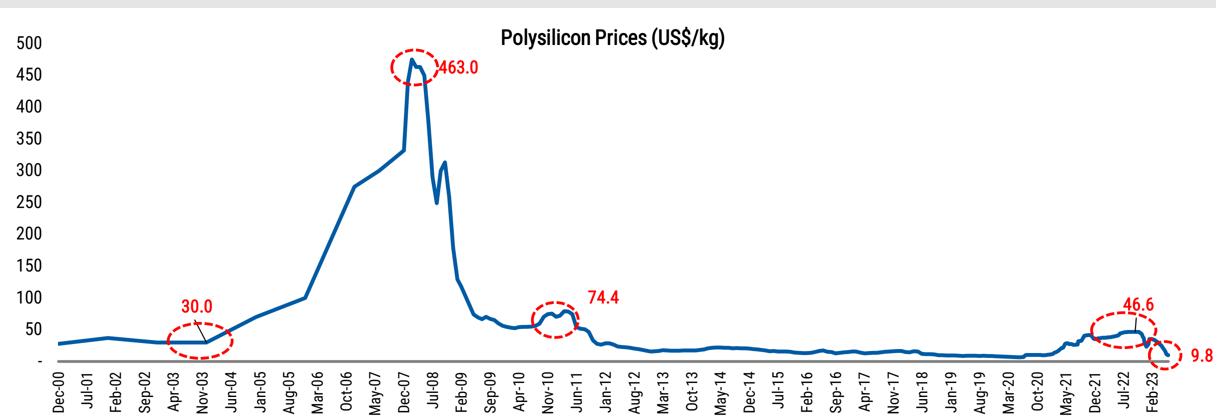
Commodity-like pricing: The oversupply situation causes solar panel prices to behave more like commodities, driving margins to the highest marginal cost, and should help lower costs for IPPs and consumers and eventually stimulate demand. While countries like India are still in the early stages of developing their own solar value chains, we believe that, as in China a decade ago, localisation in emerging markets will help lower costs further – this is in contrast to the market's view that it will inflate costs as scale benefits are limited. Reliance Industries in India is innovating by setting up the integrated solar panel manufacturing supply chain next to its refining/chemicals complex with multiple potential synergies. See Exhibit 120 . We see government support/subsidies helping to negate the impact of smaller scale in the initial ramp up stages for EMs.

History repeats: Localisation of polysilicon supply = commoditisation

We have gone full circle within polysilicon manufacturing for solar panels. The US enjoyed dominance of polysilicon manufacturing prior to 2010 (manufacturing was concentrated to only seven producers, collectively known as 'the Seven Sisters'), resulting in sizeable exports to China and then prohibitive import duties being imposed by China in 2013.

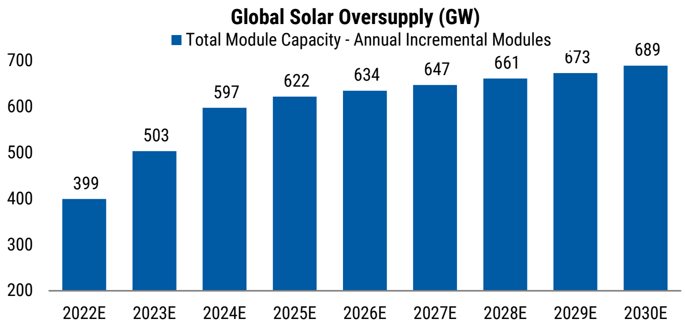
In the last few years, we have witnessed this story in reverse, with the US imposing substantial duties on Chinese and Asian solar imports to now offering substantial support via the IRA to set up local manufacturing value chains. As these supply chain investments materialise, we believe history could repeat itself as manufacturing costs deflate further and ex-China capacity reaches nearly a third of global solar module supply.

Exhibit 28: Polysilicon prices went from boom to bust as new entrants resulted in excess supply and the industry was hit by a sharp contraction in credit availability post GFC



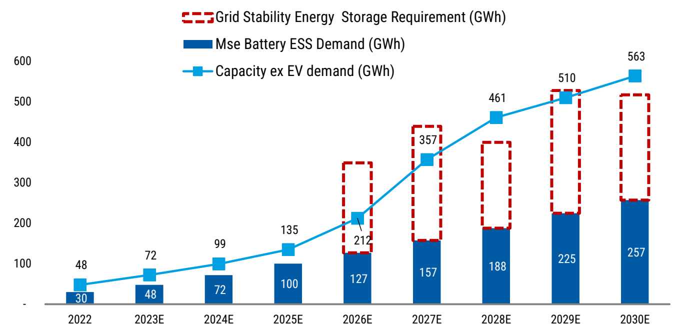
Source: Bloomberg, PVinfoLink, Morgan Stanley Research

Exhibit 29: Global solar module capacity is rising faster than new installations; we estimate modules will be 2x oversupplied by 2030



Source: Morgan Stanley Research (E) estimates

Exhibit 30: Similarly, global ESS demand is only half of the global energy storage requirement and will account for half of global supply by 2030

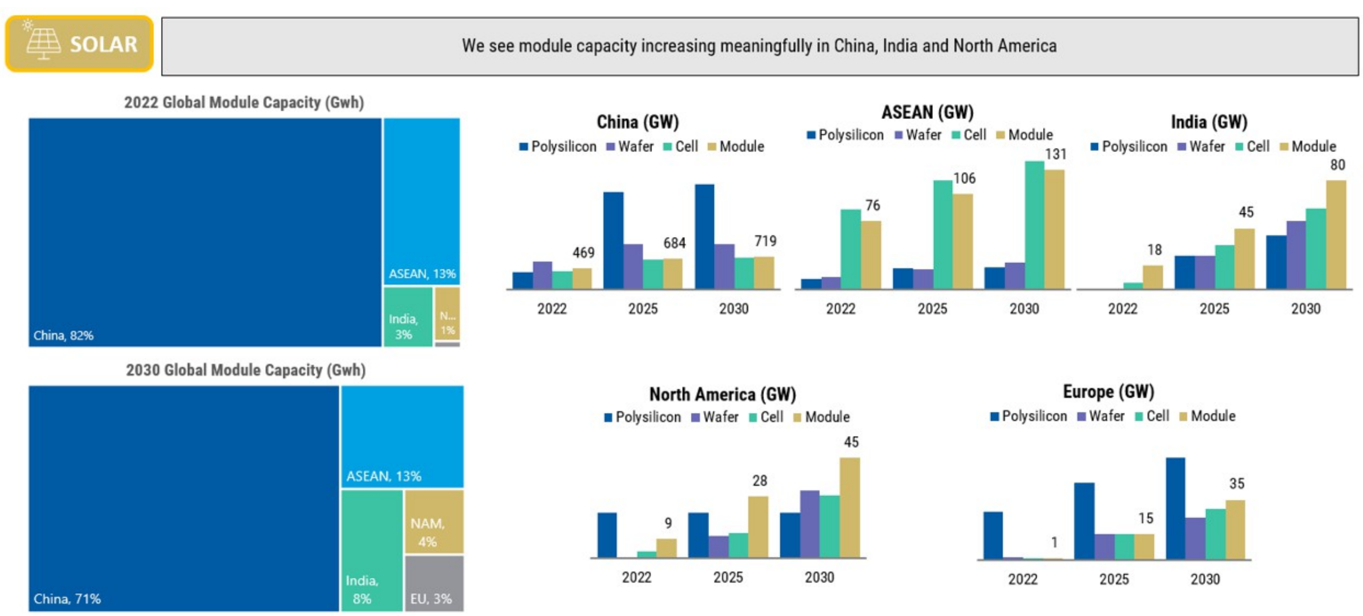


Source: Morgan Stanley Research (E) estimates

Oversupply in energy storage is becoming entrenched with nearly US$50bn of battery investments being announced by Korean, Chinese and US players. We estimate capacity for energy storage will be ~1.5x higher than demand, but if we were to see higher policy push for grid stability and hence storage, the demand vs supply gap could narrow. See Exhibit 30 . With capex/GW of Korean investments is similar to the capex in South Korea/China after government support. Relevant players in India, such as Tata Motors, are guiding for capex/GW that is very similar to Chinese and Korean players, despite their smaller scale. Hence we see the cost curve flattening and deflation in overall energy storage prices.

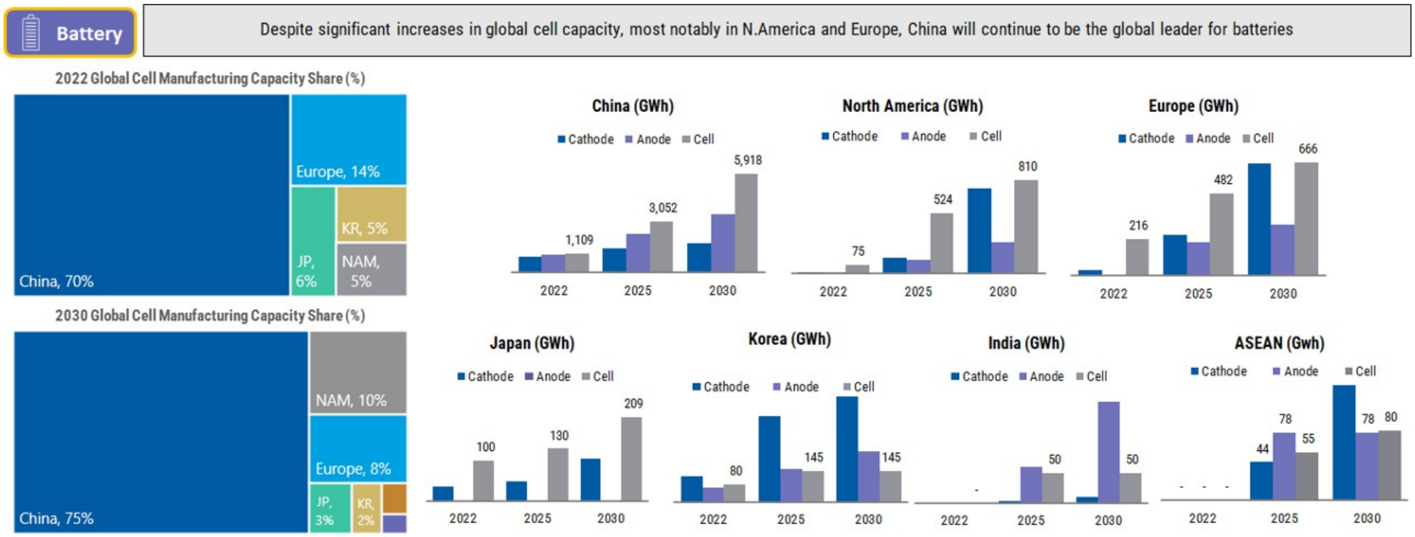
The cost of energy storage investments is similar in the US and Asia at US$80/MWh as government subsidies kick in. In addition, countries like Indonesia are investing in nickel smelter capacity and taking support from established players in China (which are co-investing with local partners in Indonesia) to add value to the domestic resources of nickel in Indonesia. This helps lower costs as manufacturing is done closer to raw material sources and also with cheaper capex locally. Globally, we estimate energy storage capacity with an LFP focus will rise to 160GWh. And although 3-4 hour storage is more in focus, demand growth may remain at 10GWh a year, partly due to battery economics. Another interesting trend in energy storage economics is higher electricity prices in multiple countries due to limited investments in fossil-fuel generation capacity, which also makes energy storage more viable. Sungrow expects the energy storage business to grow faster than solar installations as energy storage can help increase renewable consumption overall.

Exhibit 31: Ex-China, we see 80-100GW of incremental solar module manufacturing capacity growth in the next three years, as reshoring and component localisation accelerate, adding to an already oversupplied market



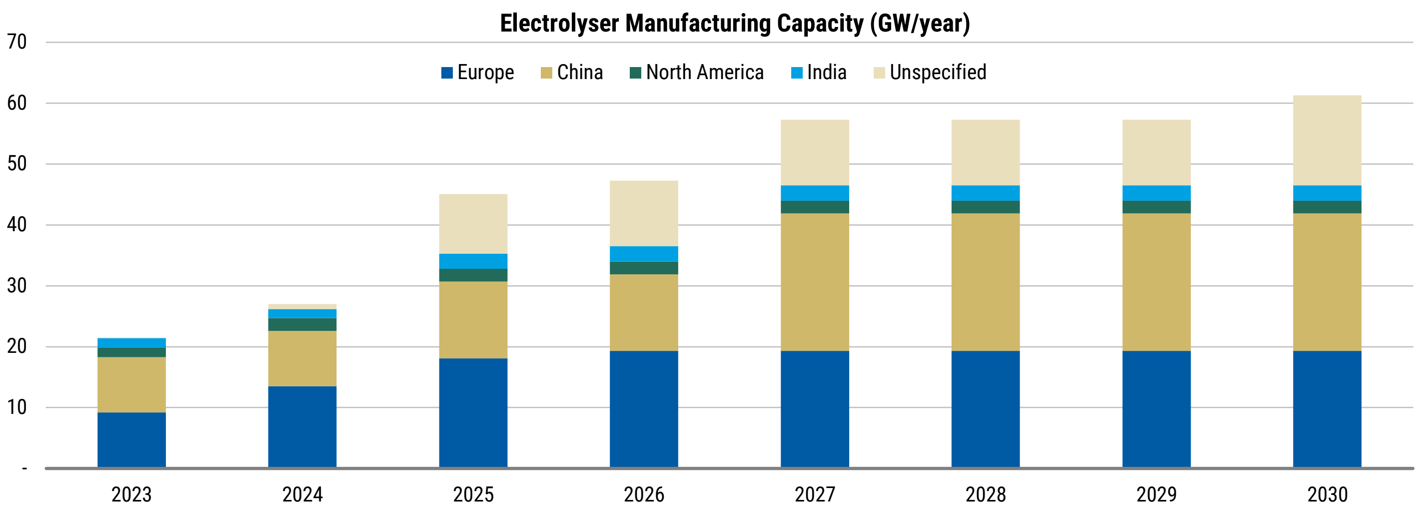
Source: Morgan Stanley Research estimates

Exhibit 32: Battery supply chain localisation – Chinese manufacturers remain dominant despite push to onshore supply chains



Source: Morgan Stanley Research estimates

Exhibit 33: Hydrogen electrolyser capacity will be driven by Europe and Asia, in line with the push for localisation



Source: IEA, Morgan Stanley Research

Exhibit 34: Substantial subsidies should be medium-term deflationary in the US and India and cost-competitive in Southeast Asia as factories ramp up utilisation

	US	China	Korea	India	South East Asia
Li-ion cell factory CAPEX (US$mn/GWh)	**130**	**60**	**80**	**70**	**100**
Asset Life (Yrs)	10	10	10	10	10
Localised Manufacturing Cost (US$/kwh)					
Depreciation	13	6.0	8.0	7.0	10.0
Labour Cost*	15.7	7.7	8.5	1.8	3.9
Water Cost*	0.2	0.1	0.1	0.1	0.1
Maintenance costs*	1.7	1.7	1.7	1.7	1.7
Renewable Electricity*	0.9	0.7	1.3	0.7	1.1
Material Cost*	99	83	91	91	91
Cost of Domestic Cell Production	**131**	**99**	**111**	**102**	**108**
Subsidies	-35			-10	-10
Net Cost of Production with Subsidies	**96**	**99**	**111**	**92**	**98**
Import Cost (US$/kwh)					
Import Duties (%)	25%			5%	
Net import Cost (ex freight)	**124**	**NA**	**NA**	**116**	**99**

** Standardised Production Assumptions and Scale*

Source: BNEF, US Department of Energy, IEA, Morgan Stanley Research estimates

Exhibit 35: Asia to remain the most competitive manufacturer of solar modules in 2030, while substantial federal support massively boosts the US's manufacturing edge, even as it relies on Asian imports for key components

	US	China	India	South East Asia
Solar Module Manufacturing Capital costs (US$ mn/GW)	**220**	**130**	**203**	**180**
Asset Life (Yrs)	10	10	10	10
Localised Manufacturing Cost (USc/w)				
Depreciation				
Labour Cost*	9.5	4.0	3.0	3.2
Energy*	2.5	4.0	4.0	4.0
Material Cost*	18.0	13.0	14.0	14.3
Cost of Domestic Production	**30.0**	**21.0**	**21.0**	**21.5**
Government Support	(12.0)		(2.2)	
Net Cost of Production with Subsidies	**18.0**	**21.0**	**18.8**	**21.5**
Import Cost (USc/w)				
Import Duties (%)	30%			
Net import Cost (ex freight)	**27.3**	**NA**	**21.0**	**21.5**

**Note: Standardised Production Assumptions and Scale*

Source: BNEF, US Department of Energy, IEA, Morgan Stanley Research estimates

Global Policy Support and Incentives

We estimate that total committed production-linked policy support announced globally is over US $500bn through 2030, with government subsidies making up a third of cost savings

The US, Europe, and India, and to some extent Japan, Australia, and ASEAN, have either put in place or are in the process of enacting substantial policy, financial and tax reforms to raise clean energy penetration and encourage reshoring. On our estimates, targeted production-linked policy measures and incentives alone tally over US$500bn so far. We believe these subsidies make up nearly a third of the cumulative savings. With ongoing and committed investments of >US$2trn seen since 2021, we believe the pace of clean energy investments can inflect as companies reshape their portfolios with favorable policy tailwinds. Most of these subsidies are in the US, while in Asia the subsidies are in the range of USc0.5-0.7c/kwh, i.e., 10% of the PPA prices in the region.

The US has taken the biggest and most concrete step with the landmark Inflation Reduction Act, offering equipment production related subsidies, incentives and tax breaks over the next decade that could approach or even exceed US$1trn to drive manufacturing investments across new solar, energy storage, green hydrogen, and carbon capture. For solar alone, the IRA delivers USc7-17/w of manufacturing cost subsidies.

India's accelerating focus on driving domestic manufacturing investments in solar panels and battery storage resulted in production-linked incentive schemes worth US$7-8bn in 2022-23, which have catalysed investments of US$25bn announced so far. For integrated solar manufacturing, India is providing USc2.7/kwh of production-linked support.

Europe has similar aggressive targets to develop its own renewable supply chain. While policy measures so far appear limited, Europe's green transformation is likely to cost €5trn and will likely necessitate an IRA-like policy framework.

Japan is set to raise US$40bn in sovereign bonds (US$150bn in total across clean power supply chains) to catalyse investments of US$0.5trn over the next decade across hydrogen, batteries and wind. **Australia's** 2023 budget outlay on clean energy stands at A$25bn.

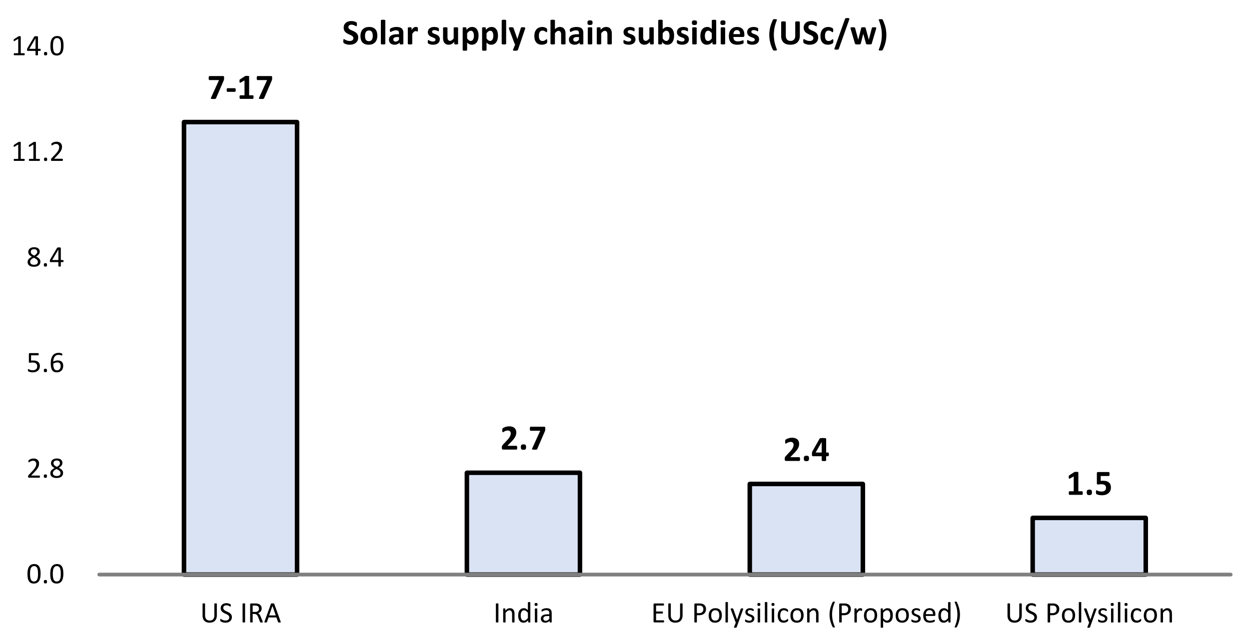
Lastly, our Morgan Stanley China utilities team estimates that **China's** renewable energy fund will see an annual outlay of **Rmb230-250bn** (US$32-35bn) through 2030 going to clean energy operators. However, the inflows into the fund have been limited to Rmb125bn p.a. (US$17-20bn p.a.).

Exhibit 36: Clean power has seen >US$2trn of ongoing and committed investments since 2021, and we think the pace can substantially accelerate as the policy framework becomes favorable

Est. Breakup (US$ bn)	Total Production-linked government support** (US$ bn)	Cost of Green transformation over 2030 (US$ trn)*	Ongoing and committed renewable Investments (US$ bn)	Details
	392	3-4	810	*Estimated production-linked subsidies and policy support over 2030*
		4-5	278	*Cost of EU's Green Transition estimated at around €5trn. We await details on specific government incentive/subsidy programs*
	125	4-5	654	*Average annual inflow into China's Renewable Energy fund at Rmb125bn (i.e. US$17-20bn)*
	8	0.5*	70	*Production-linked incentive scheme on solar module manufacturing, battery storage and green hydrogen at US$6-8bn currently.*
	40	0.5*	15*	*Government to raise US$150bn in sovereign bonds to catalyze clean energy investments worth US$1trn over the next decade*
	18		95	*Budgeted outlay of A$25bn on clean energy and renewables for 2023 (i.e. US$16-18bn). 30GW of offtake support by 2030*
	7	0.2	20	*IRENA estimates ASEAN would need investments of US$150-200bn on renewables alone over 2030*
	10		271	*Includes renewables investments in Middle East, Latin America, Carribean Islands among others. (List of subsidies/investment measures cited in the table are not exhaustive)*
Grand Total	600	~15.0	2,197	

**Cost of renewables alone, does not include downstream investments on grid upgrades, transmission etc.*
***Includes policy announcements till date, the list is not exhaustive*
Source: IRENA, government agencies, Ministry of Energy press releases, Morgan Stanley Research estimates

Exhibit 37: We estimate national production-linked support for solar investments globally works out to around USc5/W on average



Source: Company, Government policy releases, PIB, Morgan Stanley research estimates

North America: The US Inflation Reduction Act was passed in August 2022, providing federal funding that could approach or even exceed US$1trn (production linked support is estimated at US$0.4trn) to facilitate the clean energy transition. By extending existing and phased-down tax credits in addition to providing new clean tech tax credits, we believe the IRA legislation will greatly accelerate the deployment of clean energy across the US power sector and meaningfully improve the economics of various decarbonisation technologies that are on the cusp of being commercially viable. See more details in US IRA: Decade-Long Renewable Policy Support .

India – A constructive renewable policy framework: India targets 450GW of renewable energy capacity by 2030, of which solar is likely to be 280GW. This implies 25GW of solar capacity additions annually. India is significantly reliant on imports and domestic manufacturing capacity is currently inadequate. Government incentives to boost domestic manufacturing include: a) a production-linked incentive (PLI) scheme for module manufacturing, with incentives of US$3bn (Rs240bn); b) PLI for green hydrogen and electrolyser manufacturing of US$2bn (Rs200bn); c) solar manufacturing linked tenders and tenders with domestic content requirements; and d) basic customs duties of 25% on solar cells and 40% on modules effective April 2022.

Exhibit 38: US IRA tax incentives – A snapshot

Type	Applicable Facilities	Credit Value
MPTC	All	Varies by component
48C	Facility construction meets labor rules Facility construction does not meet labour rules	30% 6%
PTC*	Facilities <1MW and/or meet labor rules Facilies >=1MW that do not meet labor rules	2.6c/kWh** 0.3c/kWh**
ITC*	Facilities <1MW and/or meet labor rules Facilies >=1MW that do not meet labor rules	30% 6%
25D	All	30%
Domestic content bonus for ITC (+10 percentage points) or PTC (+10%)		
Energy community bonus for ITC (+10 percentage points) or PTC (+10%)		
+10%-20% low-income bonus for ITC only		

*Could be extended based on GHG levels
**Adjusted for Inflation
Source: NREL, Morgan Stanley research

Exhibit 39: India's federal support under the PLI scheme for manufacturing investments in energy transition initiatives works out to US$7-8bn

Industry	Outlay (US$ bn)	Projected Investments	Cabinet Approval Status	Application Process	Company details
High Efficiency Solar Modules	3.0	2.3	Done	Ended	Letters of award have been issued to the extent of funds alloted. New round of PLI scheme for solar manufacturing will have three schemes for different product categories. Second tranche approved
Advanced Chemistry Cells Battery Storage	2.4	6.0	Done	Ended	10 companies submitted their bids, four selected to received incentives worth INR180bn
Green Hydrogen	1.6		Done		
Electrolyzers	0.5		Done		
Total (New Energy Support)	**7.5**	**8.3**			

Source: IREDA, Morgan Stanley Research

Europe: The EU Solar Energy Strategy, as part of REPowerEU, aims to bring online over 320GW of newly installed solar photovoltaic capacity by 2025, nearly double today's level, and almost 600GW by 2030. We estimate the green transition as envisaged by the EU Green Deal and REPowerEU could cost as much as €5trn over 2021-30, while existing EU instruments could cover around €1.5trn of the total cost of the green transition.

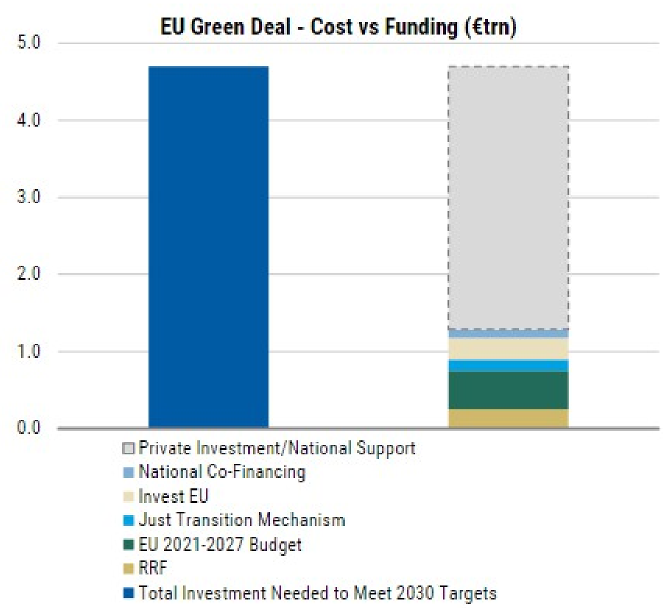
Limiting the capital outflows from Europe to the US that can be expected on the back of the IRA will be fundamental for Europe. Indeed, EU institutions have made clear that private capital will be pivotal to meeting the ambitious targets set by the original Green Deal and REPowerEU. It will likely be harder for Europe to rapidly mobilise the same amount of money as is available under the US IRA. Based on details available, we think the EU response could focus more around regulation, whereas the US announcement was focused more on tax credits and subsidies.

Southeast Asia: We expect renewables penetration to accelerate in the region, even as the region remains a significant cog in the global solar supply chain. While the region has ambitions to monetise its abundant resources and expand renewable penetration, we have yet to see any manufacturing or policy incentives on new energy investments, which even today are driven by corporate capital allocation decisions. At the margin, Thailand has announced new FiT tariffs and is simplifying the regulatory framework for renewable investments.

Australia: Australia has a range of state and federal incentives to achieve net zero by 2050, with an interim renewable electricity target of 82% by 2030. Finance initiatives include the Australian Renewable Energy Agency (A$2bn), the Clean Energy Finance Corporation (A$10bn plus the A$20bn Rewiring the Nation fund for transmission), and the National Reconstruction Fund (A$15bn, of which A$3bn could go to renewables and low-emission supply chains, e.g., components for wind turbines, batteries, solar panels, and hydrogen electrolysers, as well as modernising steel and aluminium manufacturing). It is also partnering with Singapore and Japan to strengthen trade and investments in clean energy.

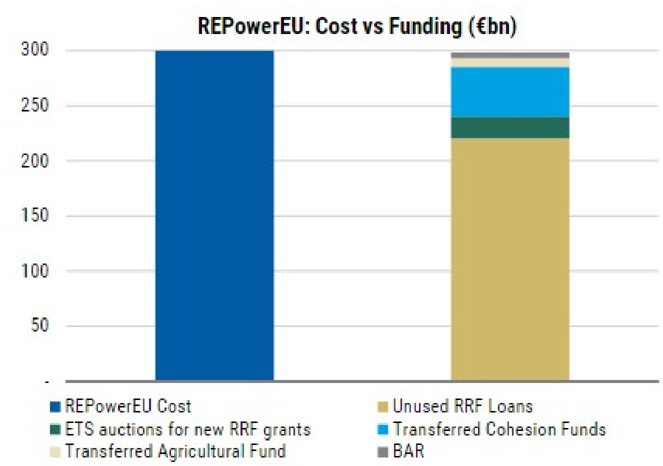
Japan: Japan's draft Green Transformation Act aims to accelerate Japan's decarbonisation to achieve a 46% reduction in carbon emissions by the turn of the decade (vs. 2013) and to make Japan carbon neutral by 2050. Its current form would see the government issue in total around US$150bn in Japanese Government Bonds (JGBs) starting this financial year to fund the initial wave of investments, with the aim of catalysing US$1trn of developments over the next 10 years. The package covers all aspects of the green transition: nuclear, renewables, grid upgrades, energy efficiency measures, electric vehicles, carbon taxes, an emissions trading scheme, and a border adjustment mechanism.

Exhibit 40: Costing and financing of the original EU Green Deal indicate a significant need for private investment/national support



Source: EC, Morgan Stanley Research estimates

Exhibit 41: REPowerEU relies mostly on the unused share of the RRF loans



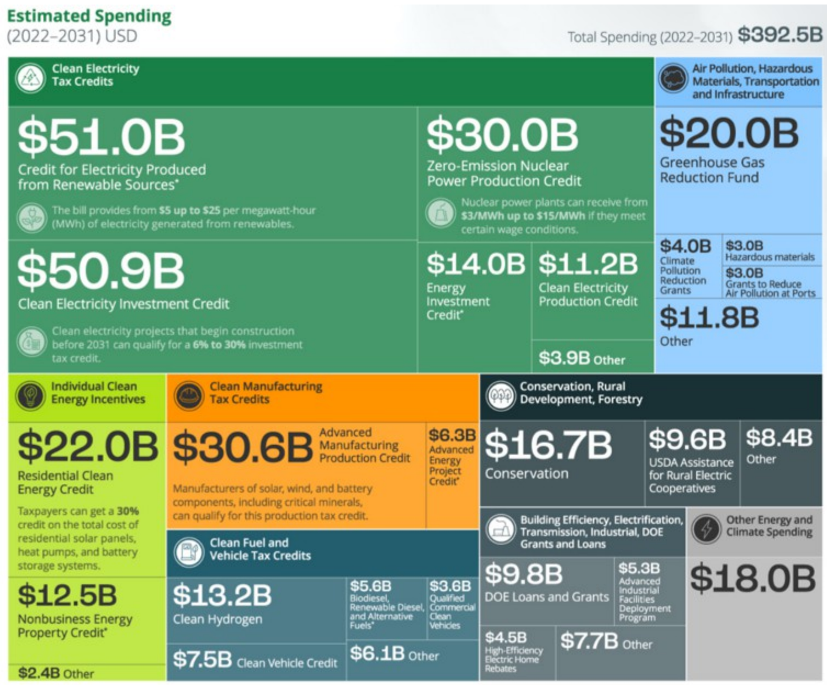
Source: EC, Morgan Stanley Research estimates

US IRA: Decade-Long Renewable Policy Support

The IRA: key legislation accelerating decarbonisation technologies in the US. The US Inflation Reduction Act provides an uncapped amount of federal funding to facilitate the clean energy transition domestically. By extending existing renewable tax credits and introducing new tax credits (hydrogen, battery storage, domestic manufacturing, etc.), the IRA accelerates the deployment of clean energy across the US power sector and meaningfully improves the economics of various decarbonisation technologies that were on the cusp of being commercially viable.

Key elements of the IRA. The IRA provides significant, wide-ranging support for decarbonisation technologies and domestic manufacturing, largely in the form of tax credits. As the legislation is currently written, the tax credits are in effect until the later of 2032 or until emissions from the US power sector fall by at least 75% from 2022 levels. From the perspective of our US stock coverage, the biggest beneficiaries of the IRA legislation are domestic manufacturers of clean energy technologies and green hydrogen-exposed names. Key provisions of IRA legislation include: **(1)** enhanced and extended tax credits for wind, solar and fuel cells; **(2)** a new standalone tax credit for energy storage; **(3)** enhanced tax credit for carbon capture and sequestration; **(4)** significant tax credits for a range of biofuels/sustainable aviation fuel; **(5)** a large tax credit for green and blue hydrogen; **(6)** a tax credit for nuclear power; **(7)** significant subsidies for domestic manufacturing of solar (including trackers), wind, offshore wind, batteries (and associated battery raw materials); **(8)** tax loss "transferability" and "direct pay" (which reduces the cost of monetising tax losses/credits); **(9)** significant tax credits for EVs; and **(10)** enhanced tax credits for domestic content, deployment in disadvantaged communities, and wage/apprenticeship requirements, among others.

Exhibit 42: Clean energy funding in the IRA



Source: Congressional Budget Office, National Public Utilities Council

Exhibit 43: ITC and PTC Values Over Time Under IRA

Summary of Investment Tax Credit (ITC) and Production Tax Credit (PTC) Values Over Time

			Start of Construction						
			2006 to 2019	2020 to 2021	2022	2023 to 2033	The later of 2034 (or two years after applicable year[a])	The later of 2035 (or three years after applicable year[a])	The later of 2036 (or four years after applicable year[a])
ITC	Full rate (if project meets labor requirements[b])	Base Credit	30%	26%	30%	30%	22.5%	15%	0%
		Domestic Content Bonus				10%	7.5%	5%	0%
		Energy Community Bonus				10%	7.5%	5%	0%
	Base rate (if project does not meet labor requirements[b])	Base Credit	30%	26%	6%	6%	4.5%	3%	0%
		Domestic Content Bonus				2%	1.5%	1%	0%
		Energy Community Bonus				2%	1.5%	1%	0%
	Low-income bonus (1.8 GW/yr cap)	<5 MW projects in LMI communities or Indian land				10%	10%	10%	10%
		Qualified low-income residential building project / Qualified low-income economic benefit project				20%	20%	20%	20%
PTC for 10 years ($2022)	Full rate (if project meets labor requirements[b])	Base Credit			2.75 ¢	2.75 ¢	2.0 ¢	1.3 ¢	0.0 ¢
		Domestic Content Bonus				0.3 ¢	0.2 ¢	0.1 ¢	0.0 ¢
		Energy Community Bonus				0.3 ¢	0.2 ¢	0.1 ¢	0.0 ¢
	Base rate (if project does not meet labor requirements[b])	Base Credit			0.55 ¢	0.55 ¢	0.4 ¢	0.3 ¢	0.0 ¢
		Domestic Content Bonus				0.1 ¢	0.0 ¢	0.0 ¢	0.0 ¢
		Energy Community Bonus				0.1 ¢	0.0 ¢	0.1 ¢	0.0 ¢

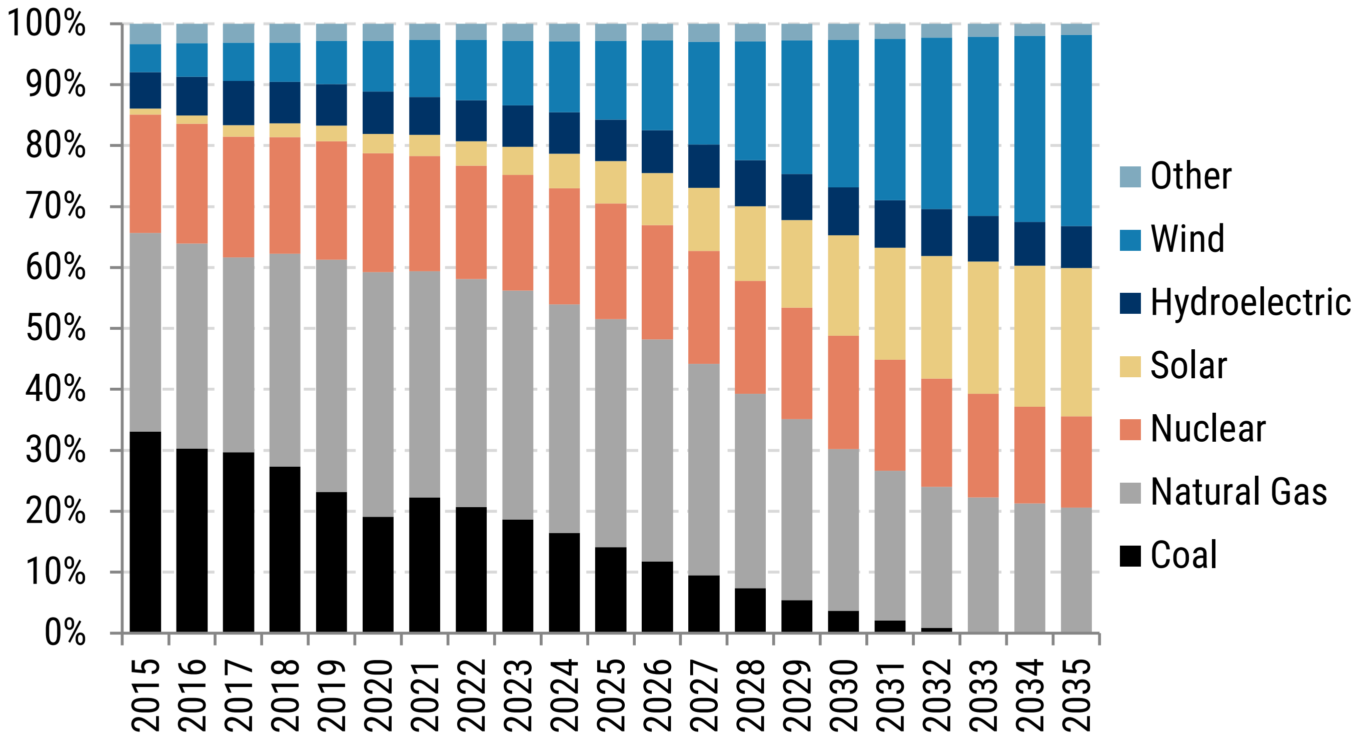
a "Applicable year" is defined as the later of (i) 2032 or (ii) the year the Treasury Secretary determines that there has been a 75% or more reduction in annual greenhouse gas emissions from the production of electricity in the United States as compared to the calendar year 2022.

b "Labor requirements" entail certain prevailing wage and apprenticeship conditions being met.

Source: Department of Energy

Decade-long benefits of the IRA propel significant growth for renewables, which we expect will lead to a significant shift in the US power mix by 2035. Aided by the IRA's extension of the investment tax credit (ITC) and production tax credit (PTC), renewable generating assets are in-the-money relative to fossil fuels in various regions of the US. Utilities, corporates, and residential consumers who are looking to decarbonise can benefit from cheap, deflationary costs of solar and wind. We expect strong demand for renewables over the next decade and significant growth in both solar (growing from 4% of US power generation in 2022 to 24% by 2035 on MSe) and wind installations in the US (growing from 10% of US power generation in 2022 to 31% by 2035 on MSe).

Exhibit 44: US generation fuel mix by source: Wind and solar to see significant increases in overall mix



Source: Morgan Stanley Research, S&P Capital IQ

Grid Changes Required to Enable to Energy Transition

While the transition to clean energy is in our view likely to be deflationary in many parts of the world, this is not universally the case. We analyse the conditions required for deflation, and assess a key factor that can drive both inflation/deflation as well as the pace of the energy transition: power grid changes/upgrades required to accommodate a greater share of renewable energy. In brief, the conditions required for deflation are: a significant spread between required per-unit power revenue for renewables relative to fossil fuel power plants and transmission upgrades that can be implemented with low permitting/legal risks. In practice, the most challenged regions, in terms of achieving a deflationary energy transition, would be areas with high population density (which can lead to challenges in effecting grid upgrades) and unfavorable solar/wind conditions. In the US, for example, the Northeast and California have seen above-average utility bill increases, while the Midwest and Southern US have lower bills and a greater potential to rapidly decarbonise while reducing utility customer bills. We provide case studies and technical analyses of power grid changes required to enable the energy transition.

Factors driving inflation vs. deflation

When assessing whether the transition to clean electricity is likely to be inflationary or deflationary, we would highlight the following key factors:

1. A low solar/wind Levelised Cost of Electricity (LCOE) relative to incumbent fossil fuel power plant costs. This is by far the most important factor, but not the only one to consider. As a contrast, we look at two locations in the US: in Texas, new wind LCOEs are significantly lower than coal and natural gas power plants, while in New England offshore wind has a LCOE that is above the cost to operate natural gas-fired power plants.

2. Transmission upgrades that are relatively modest, are low-cost, and that face low permitting/legal risks – and this factor has a close correlation with population density (high density throughout the entire region often raises challenges, but pockets of population density can often be managed).

3. Relatively low renewable penetration levels currently. Many utility management teams describe the capability to accommodate significant levels of renewables without drastic grid changes, but they also speak to "tipping points" at which the costs to upgrade the grid can rise substantially.

Energy transition deflation in the US Southwest Power Pool (SPP)

The Brattle Group conducted a study on behalf of SPP entitled "Unlocking the Queue with Grid-Enhancing Technologies," focused on the required grid upgrades to accommodate the growth in renewable in SPP, which is located in the Southwest US. This report was prepared for the WATT (Working for Advanced Transmission Technologies) Coalition with support from GridLab, EDF Renewables North America, NextEra Energy Resources, and Duke Energy Renewables. The WATT Coalition includes Ampacimon, Lindsey Manufacturing, LineVision, NewGrid, Smart Wires, and WindSim.

Key takeaways from this study:

1. There are multiple Grid Enhancing Technologies (GETs) that can boost grid reliability at very low cost. Brattle Group focused on three GETs, which are essentially operational grid management improvements, and which Brattle compares to "building a road to reduce congestion (long-term investment) and having a good map/GPS system to avoid congested roads (operational improvements)." The three GETs are: Advanced Power Flow Control, which "injects voltage in series with a facility to increase or decrease effective reactance, thereby pushing power off overloaded facilities or pulling power on to underutilised facilities," Dynamic Line Ratings (DLR), which "adjusts thermal ratings based on actual weather conditions including, at a minimum, ambient temperature and wind, in conjunction with real-time monitoring of resulting line behavior," and Topology Optimisation which "automatically finds reconfiguration to re-route flow around congested or overloaded facilities while meeting reliability criteria." Brattle Group highlights that "these technologies have matured over the past several decades, are commercially proven and actively operating on grids around the world." **The payback period for the US$90mn cost of these GETs in the SPP is around half a year – a very attractive return on investment.**

2. GETs allow for >2x growth in renewables deployment in the SPP without significant transmission upgrades. Under the SPP Base Case without GETs, Kansas and Oklahoma could integrated an additional 2.6GW of renewables without transmission upgrades, and with GETs that number climbs to 5.2GW. These numbers are significant relative to these states' total power generation capacity – for example, the delta in renewables penetration without requiring transmission in Oklahoma as a result of usage of GETs, at 2,470 MW, is 8% of the state's total generation capacity, on top of the 11% of the state's capacity comprised of renewables as per the most recent US Department of Energy assessment.

GETs enable more than twice the amount of additional new renewables to be integrated.

- Potential Renewables Considered: 9,430 MW
  - Based on queue projects with IA executed.
- Integrated Renewables (without further transmission upgrades)
  - Base Case: 2,580 MW
  - With GETs Case: 5,250 MW
  - Delta (With GETs Case – Base Case): 2,670 MW

RENEWABLE POTENTIAL ASSUMED FOR KANSAS AND OKLAHOMA

State	Wind	Solar	Total
Kansas	3,410	120	3,530
Oklahoma	5,760	140	5,900
Total	9,170	260	9,430

[Rounded to the nearest 10 MW]

~1.5 times the amount of wind SPP integrated in 2019 (1.8 GW).

ADDITIONAL RENEWABLES INTEGRATED

State	Base Case			With GETs Case			Delta (GETs - Base)		
	Wind	Solar	Total	Wind	Solar	Total	Wind	Solar	Total
Kansas	1,710	0	1,710	1,910	0	1,910	200	0	200
Oklahoma	770	100	870	3,200	140	3,340	2,430	40	2,470
Total	2,480	100	2,580	5,110	140	5,250	2,630	40	2,670

X2

[Rounded to the nearest 10 MW]

3. The net result is electricity price deflation: customers would save US$175mn in lower power costs from renewable energy annually, at a one-time capital cost for the GET equipment of US$90m. This is exactly the type of energy price deflation we would expect in regions with favorable renewable economics, such as the Southwestern US.

4. The Brattle Group extrapolated the benefits of GETs to the US nationwide, with the following potential benefits: (a) US$5.3bn in production cost savings (lower power costs from renewables), (b) "90 million tons of reduced carbon emission (more than enough to offset ALL NEW automobiles sold in the US a year), (c) US$1.5bn in local taxes and land lease benefits, (d) >330,000 short-term (first year) and nearly 20,000 long-term jobs, and (e) upfront capital costs of US$2.7bn (half-year payback), with ongoing costs equal to 6% of annual benefits from lower power production costs from renewables (US$300m/year).

Energy transition deflation in the Texas power market (ERCOT)

In October 2022, Joshua Rhodes, a professor at the University of Texas, published a report entitled "The Impact of Renewables in ERCOT." ERCOT is the power market that comprises most of the State of Texas. Dr. Rhodes quantified the impacts of renewables in ERCOT from 2010 to August 2022. The key findings of his analyses:

1. Renewables adoption in ERCOT reduced wholesale power costs by US$27.8bn between 2010 and August 2022.

2. Renewables can provide "a price hedge against the volatility of natural gas and coal prices in ERCOT, both of which were significantly more expensive in 2022 than the preceding years."

3. Emissions reductions from renewables deployment "have saved Texans between $10.2bn and $76.4bn in total in lower healthcare and other environmentally related costs."

Building on Dr. Rhodes' work, we developed an approximate payback assessment based on the likely cost of building the renewables capacity in ERCOT. As of August 2022, ERCOT had 30.4GW of wind power capacity and 8.6GW of solar capacity. The US DOE provides this analysis of wind power capital costs: "Wind turbine prices averaged US$800–US$950 per kilowatt (kW) in 2021. The average installed cost of wind projects in 2021 was US$1,500/kW, down more than 40% since the peak in 2010." Using an average between the high and low point of prices (though on a volumetric basis, costs would be towards the lower end, given that the biggest growth in wind power has been over the past few years), we would arrive at a capital cost for this Texas wind of US$60bn. Regarding solar, the US EIA estimates an average cost/kW for fixed tilt solar projects in the US of US$2,200 from 2014-19, implying a potential cost for Texas solar capacity of US$19bn, before factoring in the Investment Tax Credit (ITC) for solar.

Given Dr. Rhodes' analysis that in 2022, renewables were on track to exceed US$11bn in savings on power costs, the "cash yield" for Texas renewable customers would be 14%, before factoring in health and other benefits. That said, Texas power customers did not in fact pay for these renewables – in ERCOT, the cost of renewables construction is paid for by competitive renewable project developers, who hope to earn a sufficient return on investment by earning a margin between their costs (primarily financing costs) and the prevailing power price, which is often set, through a competitive bidding process, by natural gas-fired power plants in ERCOT. So from the perspective of Texas power customers, the full US$11bn in power price savings is realised without an offsetting capital outlay – this benefit does in fact flow to customers' "bottom lines".

Dynamics that can drive inflation from the move to clean electricity

In certain parts of the US, most notably the Northeast and Western US, utility customer bills have increased significantly over the past 10 years, during a period of rapid decarbonisation of the power sector in these regions. Currently, these regions have very low carbon emissions from the power sector, but they also have much higher utility bills relative to the US average.

For example, in California in April 2023, residential/commercial utility bills (in US$ per kWh) were US$0.295/0.215, well above the national average of US$0.161/-.122 – on a per unit basis, California residential/commercial customers were paying 82%/76% above the national average. In addition, the rate of increase in utility customer bills has been significantly more rapid in California relative to the national average; from 2013-20, the system average utility rate for the three largest California utilities (SCE, PG&E and SDG&E) increased by 16%/34%/47%, according to CPUC data, while the US average utility bill for all utility customers increased just 5% during this period, according to EIA data. Since 2020, California residential utility bills have also increased at a much more rapid rate relative to the national average; for the 12 months from April 2022 to April 2023, California residential utility rates increased by 19%, while the average US residential rate increased by 9%.

The energy transition in Texas is instructive in terms of the differences relative to California. As summarised by the US Energy Information Administration (EIA):

"Texas produces more electricity than any other state, generating almost twice as much as second-place Florida. Natural gas-fired power plants supplied about half the electricity generated in Texas in 2022. Natural gas fuels more electricity generation in Texas than in any other state and accounts for 15% of all U.S. natural gas-fired generation. Wind is the second-largest source of in-state generation in Texas. In 2022, wind supplied one-fifth of Texas' in-state utility-scale (1 megawatt or larger) generation, and it provided more in-state power than coal for the third year in a row. Because of the increase in wind power and the retirement of more than 7,400 megawatts of coal-fired generating capacity, coal-fired power plants supplied 16% of state generation in 2022, down from a 36% share in 2011...Renewable resources provided about one-fourth of in-state electricity net generation in Texas in 2022. The state accounted for about 15% of the nation's total electricity generation from all renewable sources and about 29% of the nation's total electricity generation from all non-hydroelectric renewable sources. In 2022, Texas led the nation in utility-scale wind-powered electricity generation, producing more than one-fourth of the U.S. total. In 2011, Texas was the first, and until 2020 the only, state to reach 10,000 megawatts of wind generating capacity. By February 2023, Texas had nearly 40,000 megawatts of wind capacity, which was more than one-fourth of the state's utility-scale generating capacity and almost three fourths of its total renewable generating capacity, including from small-scale (less than 1 megawatt) solar installations. Texas ranks sixth in the nation in solar power potential. In 2022, the state was the country's second-largest producer, after California, of solar power. Solar PV capacity at the state's large- and small-scale facilities rose to more than 13,500 megawatts in early 2023. Solar energy accounted for about 5% of the state's total electricity generation in 2022. Small-scale solar facilities provided about one-eighth of that total."

The following is EIA's summary of the California electricity system:

"In 2022, California was the nation's fourth-largest electricity producer and accounted for about 5% of all U.S. utility-scale (1-megawatt and larger) power generation. Renewable resources, including hydropower and small-scale (less than 1-megawatt) customer-sited solar photovoltaic (PV) systems, supplied about half of California's total in-state electricity generation. In 2022, natural gas-fired power plants provided 42% of the state's total net generation. Nuclear power's share of California's total electricity generation was about 8%, which was less than half the power nuclear supplied in 2011. The decrease resulted from the shutdown of the San Onofre nuclear power plant in January 2012...California is second in the nation, after Texas, in total electricity generation from renewable resources. The state is the nation's top producer of electricity from solar energy and geothermal resources...California has the nation's second-largest conventional hydroelectric generating capacity, after Washington, and it is consistently among the nation's top four hydropower producers. Hydropower's contribution is highly variable and is dependent on rain and snowfall. Even though California is prone to drought, 2021 was

the driest year in nearly a century and in-state hydroelectric power supplied about 7% to California's utility-scale net generation that year. Hydroelectric power's contribution increased slightly in 2022, supplying 8% of California's total in-state generation. Non-hydroelectric renewable generation, especially solar and wind energy, offset declines in the state's hydroelectric and nuclear generation. In 2022, non-hydroelectric renewable resources provided 42% of California's total in-state electricity generation. Coal fuels only a small amount of California's in-state net generation, all of it from one industrial cogeneration plant. A California law, enacted in 2006, limits new long-term financial investments in electricity generation based on greenhouse gas emissions. As a result, essentially all imports of coal-fired generation from other states are expected to end by 2026. California imports more electricity than any other state and typically receives between one-fifth and one-third of its electricity supply from outside of the state. In 2022, in-state utility-scale electricity generation equaled about four-fifths of California's electricity sales, and the rest of the state's supply came from out of state...Wildfires in California and surrounding states threaten both imports of electricity and transmission within the state."

The historical customer utility bill trajectories in Texas and California have been very different, notwithstanding the rapid growth in renewables in the two states. For example, residential AEP Texas-Central customers served by retail provider Reliant Energy paid a rate of US$0.109/kWh in March 2020 (assuming monthly usage of 1,000 kWh), while in March 2013, the average Reliant Energy rate was US$0.102, representing a total rate increase of 7% and well below the US national average. In contrast, from 2013 to 2020, the system average utility rate for the three largest California utilities (SCE, PG&E and SDG&E) increased by 16%/34%/47%, according to CPUC data, respectively.

While there are many drivers of utility bill inflation, a few of the key differences we see between Texas and California that can help to explain the differential in utility bill inflation are:

1. Very low wind power costs in Texas. Portions of Texas have outstanding wind conditions, and the costs to acquire land and develop wind projects are generally lower in Texas than California.

2. Larger scale renewable projects in Texas. The larger the MW output of a renewables project, generally the lower are the per-unit power costs. As recently noted by PV Magazine, "Texas is a dominant state for utility-scale solar project construction, with 28 projects totaling 6.7GW in capacity, with about 240MW as an average project size. The state's largest active project is 500MW." In contrast, in California, as of 1Q23, the state had 41GW of solar assets installed across 1.8mn projects, implying an average project size of 23kW, according to SEIA data. The same SEIA statistic for Texas would equal an average project size of 76kW, 3x the average project size in California.

3. Lower transmission costs in Texas. Much of the Texas electric transmission system is above ground, while a growing portion of California transmission construction is being completed underground, resulting in higher costs.

4. Lower land and real estate costs in Texas. These costs can be a material portion of total renewable project costs, and can also drive differences in power grid management/maintenance costs.

While we view the above factors as important drivers of the different utility rate trajectories between the two states, there are other drivers of the different trajectories for utility bills between the two states, such as the cost of wildfire damage and risk mitigation in California, Pacific Northwest hydropower conditions, the fuel mix in the two states, and the delivered cost of natural gas, among others.

The Cost of Solar

Solar Deflation = Efficiencies + Federal Support

Asia will spearhead the deflation in solar costs, with a combination of commodity and component oversupply, higher efficiencies as new technologies gather scale, and supportive policy framework driving local investments. IRA-linked federal support will drive the next leg of costs savings in the US. Europe is unlikely to be significantly disinflationary, in our view. LONGi is seeing a breakthrough on HPBC (hybrid passivated back contact) cell technology and large-scale production. HPBC will help drive down solar power prices for distributed users, an area where multiple EMs are incrementally focussed on.

"Improving cell conversion efficiency and reducing the cost of electricity remain the perpetual theme driving the development of the photovoltaic industry." (LONGi CEO)

Asia: Oversupply + Technologies + Efficiencies: We estimate levelised cost of solar to decline from US$51/MWh in 2023 to US$27/MWh in Asia by 2030. The first leg of cost savings will come from polysilicon oversupply, which is already in play in 2023, followed by rapidly evolving component oversupply, as reshoring investments fructify by 2025, while companies continue to derive significant efficiencies from existing and new technologies. The latter half of the decade should also see lower usage of key raw materials, higher wafer efficiencies, and tailwinds from lower energy costs as module efficiencies continue to track higher. We reflect these cost savings both in our module manufacturing capex, which declines by nearly a fifth (see Exhibit 21), and operating costs, which halve by 2030.

Key to this will be efficiency gains in established technologies like TOPCon/HJT, manufacturing efficiencies, and breakthroughs in new technologies like Perovskite/IBC by 2030. MS estimates that TOPCon will reach cost parity with PERC by end-2023 and HJT will reach cost parity with TOPCon by end-2024.

Other drivers include larger and thinner wafer sizes, reduced degradation, and reliable alternatives to high cost materials like silver.

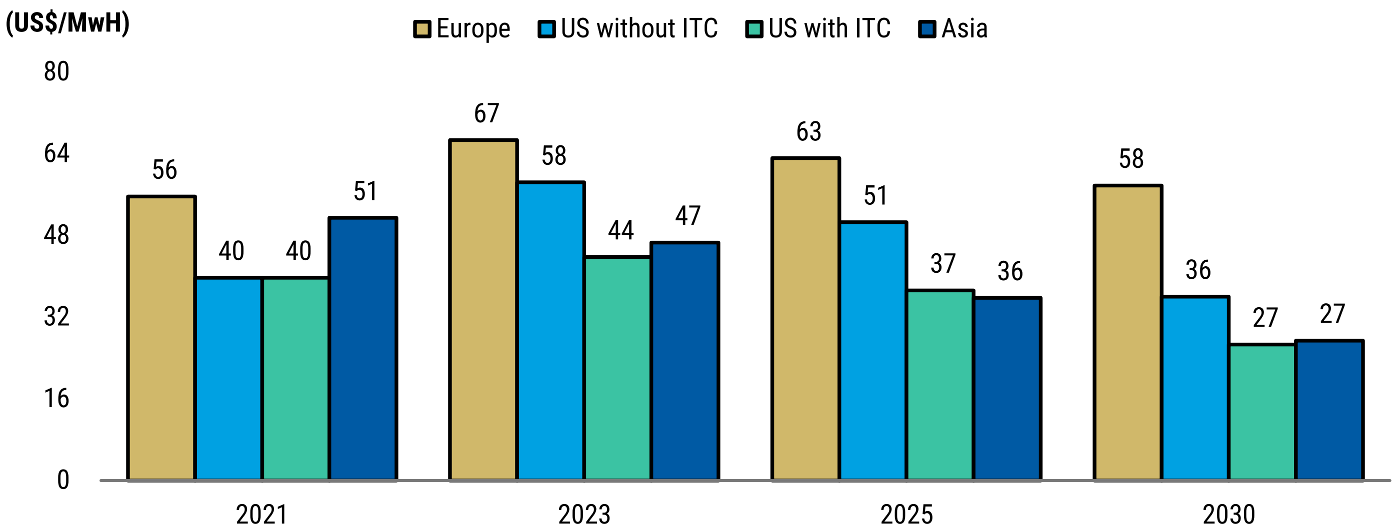
US: IRA significantly improves domestic competitiveness: We estimate the levelised cost of solar will decline from US$44/MWh in 2023 to US$27/MWh (with federal support of USc7-17/w) and US$36/MWh (without federal support) by 2030. Production subsidies will play a key role in deflating manufacturing costs. YTD, the US has seen over US$100bn in clean energy announcements, which are poised to take module manufacturing capacity from below 10GW today to >50GW by 2030. We estimate US solar LCOE reaching parity with Asia by 2030 as costs decline by 40% in our base case (with federal credit). We estimate solar module costs to decline by 30% over 2030, led both by ongoing domestic supply chain investments and ensuing oversupply in solar components. The second leg of deflation will come from lower non-module costs, such as inverters and lower installation costs, which will also decline by a third, by our estimates.

Europe: Not a significant deflator: We estimate Europe's levelised cost of solar will see the slowest deflation, falling to US$58/MWh by 2030. Investments to set up 25GW of module manufacturing capacity by 2025-26 are already underway, but are unlikely to significantly lower Europe's reliance on Asian solar imports, in our view. While Europe will benefit from the global deflation in solar technologies, we think the absence of significant government support and a higher cost of production for domestic components will limit significant deflation in the region.

(Note: all LCOE computations are in DC terms)

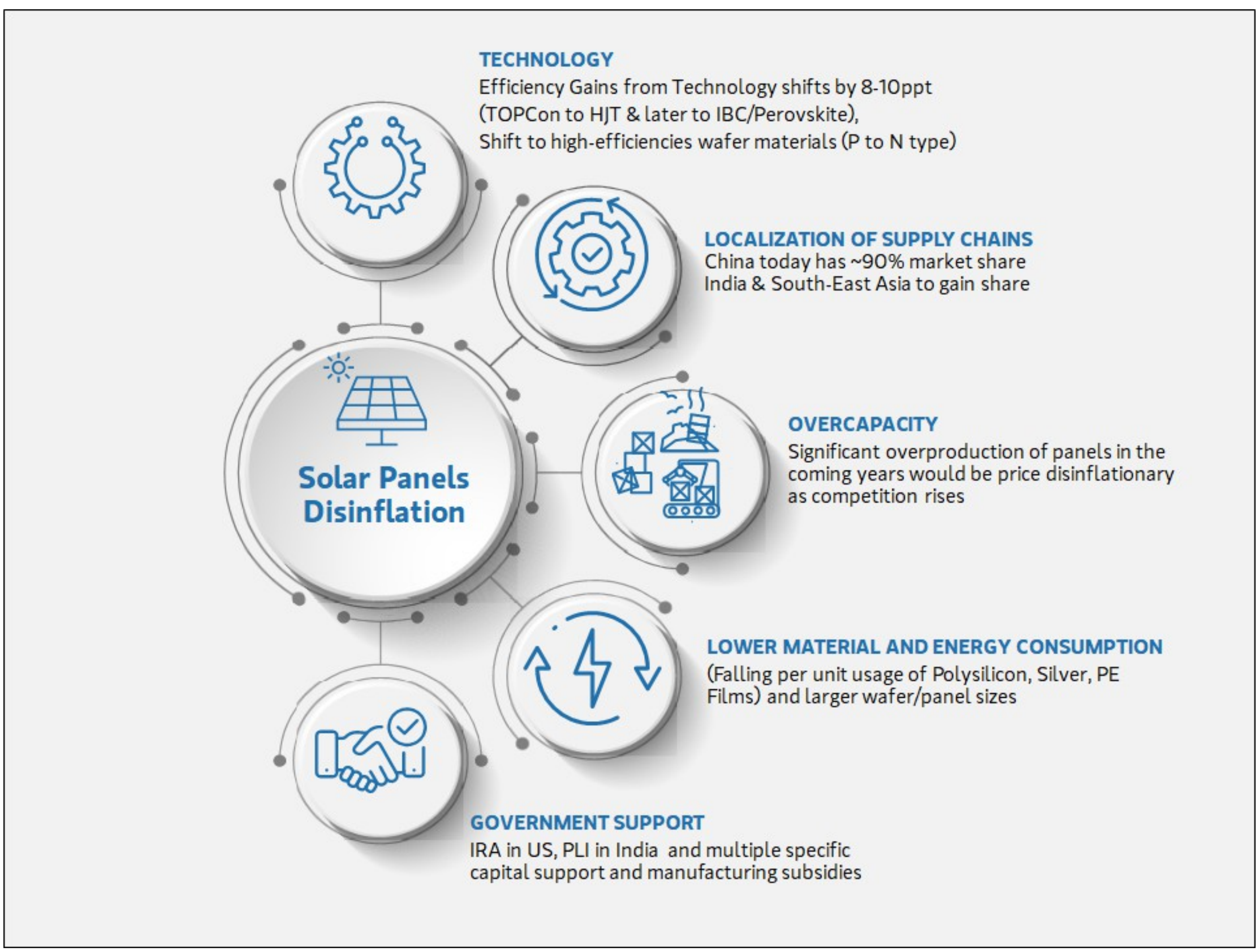
The policy angle: We have seen unprecedented government support for new energy investments, particularly for renewables in countries like the US, India and more recently in Europe. We estimate the IRA offers a cumulative subsidy of USc7-17/W, likely making US panels as competitive if not more competitive than China by 2030 (see Exhibit 35). Even countries like India are accelerating these incentives in a bid to encourage domestic manufacturing investments and job creation. Considering the policy initiatives announced so far globally, we estimate an average ~USc5/w of subsidy support, which will be key as companies accelerate the cost deflation in solar.

Exhibit 45: US and Asia will see solar LCOEs decline 40% over the next decade, driven first by well-supplied commodity markets, followed by technological scale, higher efficiencies, component oversupply and federal support



Source: BNEF, Morgan Stanley Research estimates

Exhibit 46: Solar: A five-pronged approach to cost deflation over 2030 with technology, localisation and overcapacity aided by government support and production efficiencies



Source: Morgan Stanley Research

Solar: Radiating Savings

Efficiencies, Technology and Subsidies

Solar manufacturing cost deflation is likely to play out in every single component of the supply chain. Key drivers include: i) The commodity oversupply, i.e., polysilicon; (ii) process and manufacturing efficiencies, i.e., reduced wafer sizes and lower material consumption; (iii) component oversupply as global solar investments fructify over the next decade; (iv) higher conversion efficiencies; and (v) federal support and subsidies.

LONGi announced new 33.5% efficiency perovskite/crystalline silicon tandem solar cells based on commercial CZ silicon wafers at the world's leading trade fair for the solar industry, Intersolar 2023.

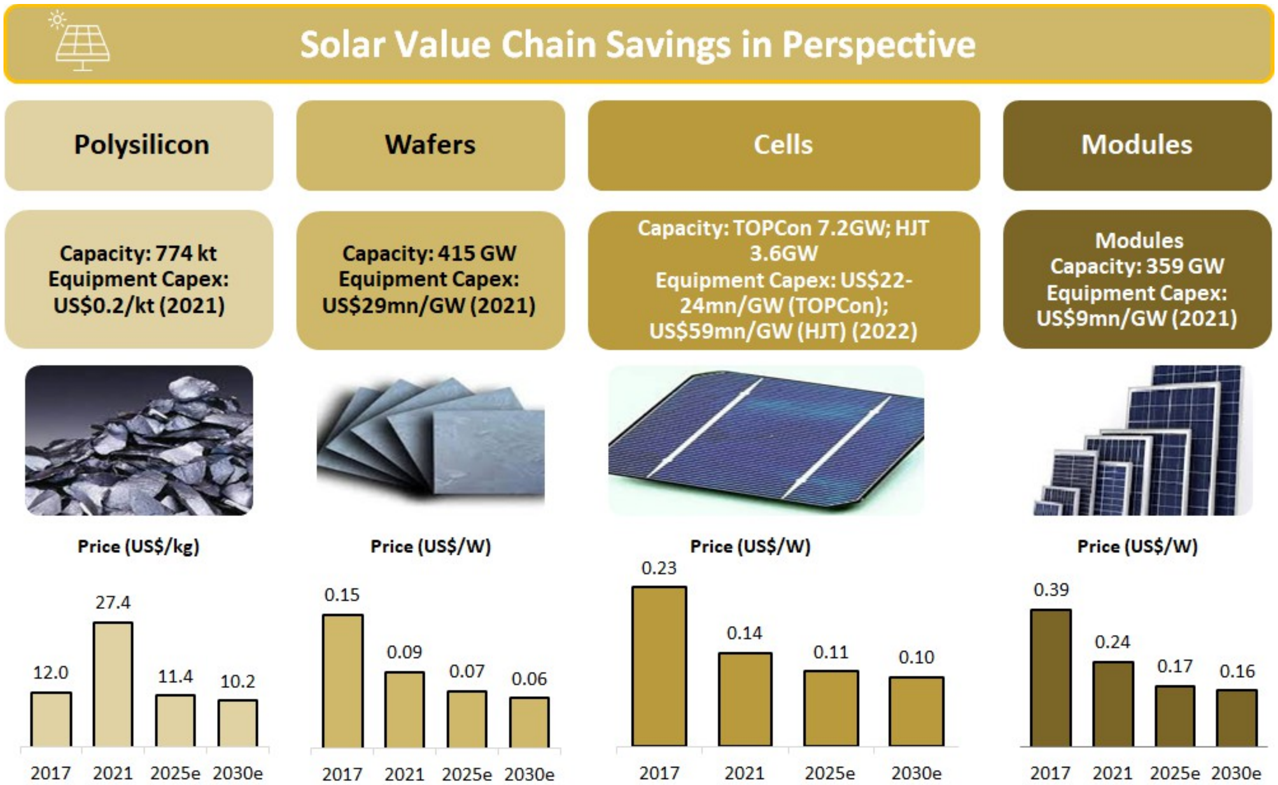
Solar panels are key to decarbonisation as they drive the adoption of batteries and green hydrogen, and are the most affordable way to help transition. Technology iterations over the past two decades have consistently helped lower costs with China developing supply chains and globally power generators benefitting from cheaper solar modules. We are already in the midst of the first two drivers of cost reduction, i.e., the ongoing polysilicon oversupply (which has driven polysilicon prices down by 70% YTD vs. end 2022) and advances being made in process efficiencies (Chinese incumbents are trialling new processes in plating, wafer cutting and packaging, which are showing promise in lowering material usage and wafer thickness without impacting conversion efficiencies).

Rising wafer size and reduced polysilicon usage: M10 (182mm) and G12 (210mm) accounted for 60% and 24% of wafer supply in 2022, up from 27% and 13% in 2021, respectively; the 182/210mm sizes should account for 96% of wafer supply in 2023. As wafer sizes rise, the efficiency of the panels improves as well. Gaoce, a key player in wafer-cutting business, believes it can reduce silicon consumption at larger wafer sizes when cutting, and save costs, thereby contributing to its advantages in cutting equipment and technologies as well. These technological leaps, among several others, are being diffused from China to the rest of the world, which is importing Chinese equipment to setup their own local supply chains.

Supply chain investments: We estimate investments worth >US$100bn are currently in execution globally in setting up localised solar chain manufacturing hubs in India, the US and Europe, as well as in China. These investments, once ready, will likely drive 3.2x overcapacity in wafers, 2.3x overcapacity in cells and 2.4x overcapacity in modules by 2025, per our estimates. Overall, we see solar installations to lag module capacity by ~2x (Exhibit 53).

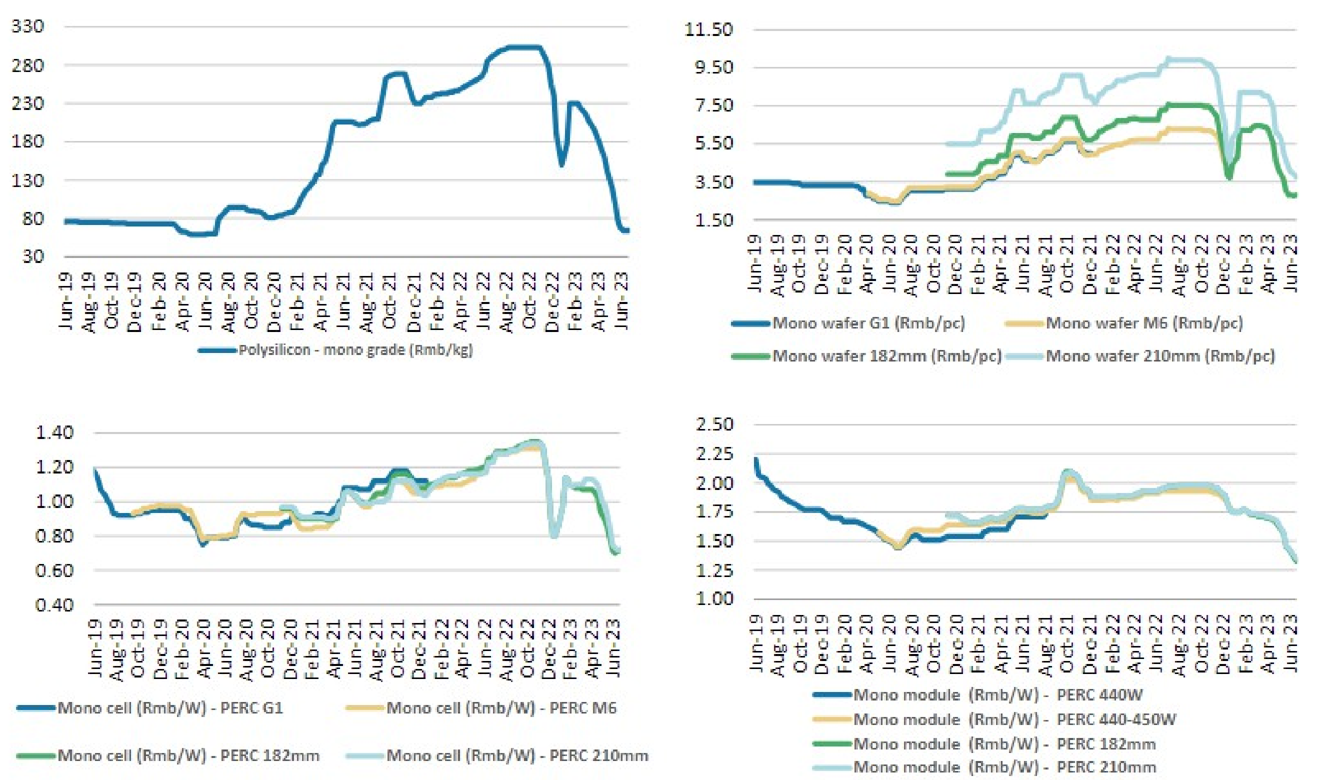
Panel efficiencies have increased: Panel cost declines over the past decade have been well flagged, however, panel efficiency increases have been slow from 10% efficiency in 2010 to 22-24% in 2022. The largest, most advanced modules on the market today offer up to almost 700 W under standard testing conditions, more than double the 250-300 W of panels used in 2010. Continued increases in wafer size and cell technology advances, including better wafer types, are expected to drive power output even higher in the future. With more efficiencies in existing TOPCon/HJT technologies and breakthroughs in new technologies, such as IBC/Perovskite technologies in future (see Exhibit 50), we expect panel efficiencies can continue to improve, possibly hitting >30% by 2030. Maxwell expects HJT cell conversion efficiency to reach 26% by end-2023 and reach cost parity with TOPCon by end-2024.

Exhibit 47: Solar value chain – Putting the 40% value chain cost deflation through 2030 into perspective



Source: Company data, Morgan Stanley Research (e) estimates

Exhibit 48: China solar product prices have declined quickly in the last few months. Significant deflation due to over capacity ahead, as prices touch near cash costs and overall fossil fuel based energy prices fall



Source: Morgan Stanley Research

Solar: Upcoming Technology Improvements

Multiple Technologies for Efficiency Setup

The continuous improvements in TOPCon/HJT modules, breakthroughs in production technologies and further leaps in nascent alternatives such as perovskite are key to the solar cost deflation from Asia, as well as around the globe. Incumbents are evaluating multiple routes, trialling new processes and transforming industry best practises, and we see multiple avenues of cost reduction taking concrete shape through 2030.

Mass production and adoption of HJT in 2023: HJT reached cost parity with PERC by end-2022 and we expect it to reach cost parity with TOPCon by end-2024 (with penetration in total cell capacity growing from 2% in 2022 to becoming a key technology by 2030). Today, we are seeing more cost reductions across TOPCon and HJT at each step of the value chain, which will continue to drive costs lower in the next 1-2 years. These include HJT's low temperature processing environment, lower consumption of polysilicon and silver (or usage of silver-coated copper), larger and thinner wafers, as well as advances in soldering and plating technologies. While some of these are more easily applied to HJT, TOPCon is also seeing cost declines. We expect TOPCon and HJT to become the dominant technologies by 2030 (vs. PERC in 2022), which should improve global solar panel efficiencies to the high twenties (vs. 22-24% currently).

1) Lower material consumption: (i) **Granular polysilicon:** Solar wafers made from granular silicon are of lower cost, but have higher oxygen containment, vs. one made with the traditional Siemens process. HJT's low temperature processing environment has a higher tolerance for wafer oxygen containment than N-type TOPCon cells. (ii) **Silver-coated copper**: Silver accounts for approximately 60% of the non-wafer cost and 5–10% of the module manufacturing cost. By applying silver-coated copper (more easily applicable to HJT), silver consumption can be lowered to <10mg/w in mass production in 2023. (iii) Researchers from the Fraunhofer Institute have developed a new metallisation technique for bifacial silicon HJT cells that reveals an impressive reduction of the average wet silver paste laydown by 60–70%.

2) The shift to N-type: Penetration of larger, thinner and higher efficiency n-type cells is rising in 2023. **What is the difference?** The incumbent p-type refers to the fact that the cell is built on a positively charged (hence p-type) silicon base, i.e., the wafer is doped with boron. The top of the wafer is then negatively doped (n-type) with phosphorous. This helps form the p-n junction that will enable the flow of electricity in the cell. N-type solar cells are built the other way around, with the n-type doped side serving as the basis of the solar cell.

Key advantages of N-type wafer: Higher efficiency and absence of light induced degradation (in the absence of boron-oxygen defect to wafer efficiency), and consequently lower costs.

3) Multiple new technologies: We are seeing significant breakthroughs as companies explore multiple new technologies in the solar value chain (Exhibit 50). Technology iteration is the key driver of solar cost reduction and we see continuous technology improvements, not only in HJT but also encouraging technologies such as IBC and perovskite, as well material cost reductions in today's dominant TOPCon technology. (The above mentioned technologies have much higher panel efficiencies approaching 30%, vs. PERC which is tracking at 22-24% efficiency.)

4) New technology & processes: (i) HJT wafers at 110 & 120μm thick have been validated in mass production, with further cost reductions likely at scale. Incumbents like Gaoce are nearing mass production of 80μm wafers while achieving a trial run of 60μm wafers later in the year. (ii) **OBB stringer**, an advanced soldering technology and equipment, adapts to thinner wafers and silver-coated copper to improve conversion efficiency. By applying OBB, HJT modules could further improve unit power output with less shaded area and lower sliver consumption. In addition, companies like Autowell are introducing new equipment within crystal growing furnace that would lower oxygen containment in polysilicon ingots, thus improving cell conversion efficiency by 0.1%. These are currently in small to middle scale trials, with results expected later this year.

The key risks: The rapid technological strides and cost reductions in solar are not without risks. (i) China will likely remain the largest player in the global solar value chain, even if global investments fructify. As such, local production hubs may be unable to match China's competitiveness in the absence of government support. (ii) Supply security of critical raw materials (e.g., silver) is a conundrum that the industry continues to grapple with, especially in light of the rapidly increasing penetration of solar PV modules. (iii) New technologies (such as perovskite), which promise better efficiencies, still face challenges of durability and rapid degradation, and still require substantial work prior to mass adoption. Furthermore, with limited synergies with existing technologies and assets, the solar industry is likely to see multiple iterations of higher cost capex deployment over the next decade (see Exhibit 50).

The Technologies

What's driving TOPCon costs lower? TOPCon is currently the most extensively used technology for solar cells after PERC. N-type TOPCon currently has a clear edge in mass manufacturing efficiency, cost control, and market share. TOPCon is also easily adaptable to the existing PERC technology, where PERC production lines can be easily converted to produce TOPCon with only a few additional steps and at relatively lower costs. Furthermore, the process continues to see improvements in metallisation techniques and falling wafer sizes, which have and will play a key role in cost declines expected through the decade.

Heterojunction solar cells: A combination of crystalline silicon and amorphousthin-film silicon. The top layer of amorphous silicon catches sunlight before it hits the crystalline layer, the middle layer turns out most of the sunlight into electricity and the last layer of crystalline silicon captures the remaining photons that surpass the first two layers. We believe HJT penetration is rising, and expect HJT to reach cost parity with PERC by end-2023 and TOPCon by end-2024.

Interdigitated back contact: Traditional solar cells achieve energy conversion by placing front contacts in the cell. This means photons that reach the surface of the cell must be absorbed at that moment to release electrons and produce electricity. If they are not absorbed they are transmitted or reflected. This can be considered a loss. In IBC, instead of placing the contacts in the front of the cell, they are placed on its rear side. This allows them to achieve higher efficiency due to reduced shading on the front of the cell, while at the same time electron-hole pairs generated by the absorbed light can still be collected on the rear side of the cell.

Perovskite solar cells – Overcoming the challenges could leapfrog efficiency for solar panels: A perovskite solar cell is a type of solar cell which includes a perovskite structured compound as the light-harvesting active layer. Perovskite materials are cheap to produce and relatively simple to manufacture. Perovskites possess intrinsic properties like a broad absorption spectrum, fast charge separation, long transport distance of electrons and holes, and a long carrier separation lifetime among others. Perovskite PVs hold promise for high efficiencies, low potential material and reduced processing costs. A big advantage perovskite PVs have over conventional solar technology is that they can react to various different wavelengths of light, which lets them convert more of the sunlight that reaches them into electricity. However, the key challenge has been the efficiency drop at high temperature and humidity.

Mellow Energy, a perovskite solar module manufacturer in China, has announced that its first large-area (30 cm × 30 cm) perovskite solar module has rolled off the pilot production line, while Longi achieved 33.5% efficiency for silicon-perovskite tandem solar cells.

Exhibit 49: Stacking up the solar technologies: PERC vs. TOPCon vs. HJT

Metrics	PERC	TOPCon	HJT
Bifaciality	75.0%	80.0%	Above 90%, with potential to reach 95% and higher
Silver consumption (mg/pc)	90	115	127
No. of Steps	8-11 Steps	10 Steps	4 Steps
Energy Intensity	High	High	Relatively Lower
Compatibility with Exisiting PERC set-up		High	Requires significant investments
Tolerance to contamination			
Light Induced Degradation	Low	Low	High
Oxygen Containment	Low	Low	High
Potential for Cost Reduction			
Silver Usage Reduction / Other Alternatives	Low	Medium	High
Polysilicon	Low	Medium	High
Lower Wafer Thickness	Low	Medium	High
Financial Metrics			
Cell Equipment Capex (Rmb mn)	120	150-170	400

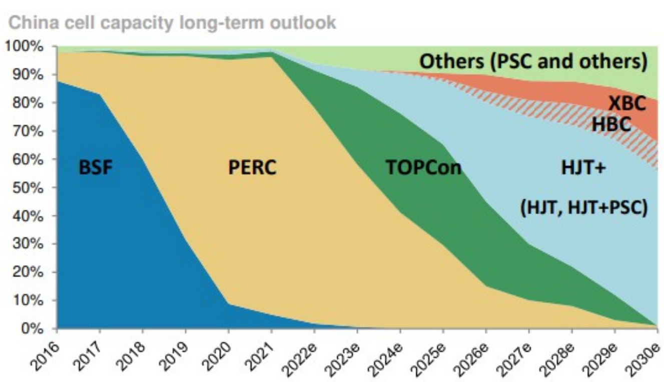
*Note: Color code from Red to green implies Least preferred to Most preferred
Source: Company data, Morgan Stanley research estimates

Exhibit 50: A snapshot – PERC vs. TOPCon vs. HJT vs. XBC vs. perovskite

Metrics	PERC	TOPCon	HJT	XBC	Perovskite
Conversion Efficiency in mass production	23.2%	24-25%	24.5-24.8%	IBC: 24-25%, ABC: 25.5%, HPBC: 25%	Still in Trial
Bifaciality	75.0%	80.0%	Above 90%, with potential to reach 95% and higher	80.0%	
Temperature Coefficient	-0.38%/°C	-0.285%/°C	-0.2%/°C	-0.29%/°C	
Life Span (Years)	25-30	30	>30	30	>30
Silver consumption (mg/pc)	90	115	127	Expected to be lower than TOPCon and HJT as XBC only has busbars on one side	
Cost Reduction	Less room due to 8-11 production steps, processing above 400°C and use of thick layered wafers	Less room for cost reduction, but compatible with existing PERC infrastructure	More room due to lower no. of production steps, and further conversion efficiency improvement to 30%+ with Perovskite tandem	Room for cost reduction by integration with other tech route to lower equipment capex and manufacturing complexity	Room for cost reduction as the upper limit of conversion efficiency (30%+) is higher than mono-polysilicon cell (29%)
Non-wafer cost (Usc/w) - 2022 end	2.4-2.9	3.7-3.9	4.6-4.7		
PID (Potential-induced Degradation) in module	2.5% in first year	1.5% in first year	0%	0%	
Current Challenges in increasing penetration	Conversion efficiency in mass production close to its theoretical limit	Potential to further improve conversion efficiency	Higher cell manufacturing cost due to higher silver cost in metallization process	Lower theoretical limit of conversion efficiency	High equipment capex, more difficult to achieve higher conversion efficiency on larger cells

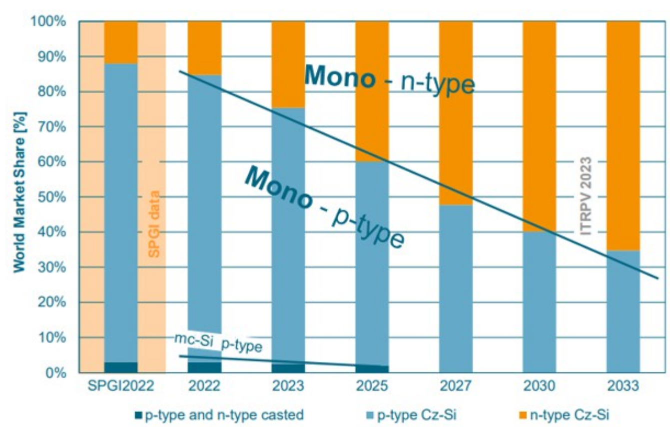
Source: Morgan Stanley Research estimates

Exhibit 51: HJT to be the mainstream high-efficiency solar cell technology long term, in our view



Source: CPIA, Morgan Stanley Research. E = Morgan Stanley Research estimates

Exhibit 52: Higher efficiency N-Type wafers are already dominating the order wins for China's component manufacturers



Source: ITRPV

Solar: How Are Supply Chains Evolving?

The New Landscape is Not Priced In

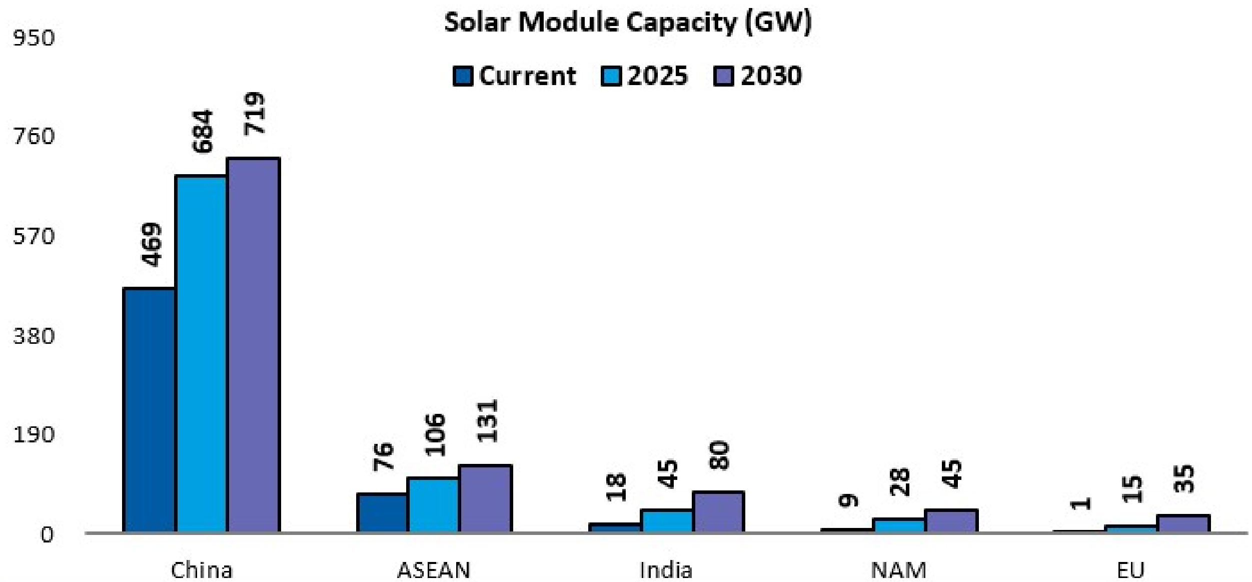
The previous decade saw near total dominance by China in the global solar supply chain. We see solar value chains becoming more localised as investments accelerate in India, ASEAN and the US, in addition to expansion in China. Despite the substantial additions in the pipeline, we believe China will still account for ~2/3 of the solar manufacturing value chain in 2030.

The solar trade in perspective: We estimate that the current solar supply chain is heavily dominated by China: polysilicon (~80%), ingots and wafers (>90%), cells (>80%) and modules (>75%) (Exhibit 54). China's solar exports grew 64% to US$52 billion in 2022 despite global trade tensions, according to latest analysis from Wood Mackenzie. In the last five years, the European Union has imported 84% of its installed solar PV requirements, the United States 77% and India 75%. Modules produced in these areas depend 60-80% on imported PV cells. Near term, we could see import dependence rise as supply investments materialise. While market share for domestic components will certainly rise over 2030, we estimate the US and Europe will still rely on imports in 2030, while India likely becomes a net exporter.

The slew of capacity announcements across North America, Europe, and India for solar component manufacturing (we have tallied >100GW of manufacturing capacity so far) is a clear effort to lower the global over reliance on China and Southeast Asia. Based on our assessment of these announcements made in India, Europe and North America, the bulk of investments focus on expanding module manufacturing capacities, with only half of the proposed projects likely to be fully integrated from polysilicon and or wafers/cells. This implies that countries like India/US will likely continue to rely on Chinese/Southeast Asian imports for their remaining component parts or even polysilicon. RIL is growing its integration into polysilicon by 2026, while Hanwa in the US has restarted its polysilicon line.

These investments, in our view, will increase the global overcapacity in solar component manufacturing, although the overcapacity will likely remain concentrated in China, Southeast Asia and India. Even if all of the proposed reshoring investments were to eventuate across the globe, China's dominance in the solar value chain is likely to remain, even as we estimate market share ex-China in global solar manufacturing rises to nearly a third by the end of the decade.

Exhibit 53: China and India will see substantial module manufacturing overcapacity over the next decade, while North America and Europe still rely on Asia for their component supplies

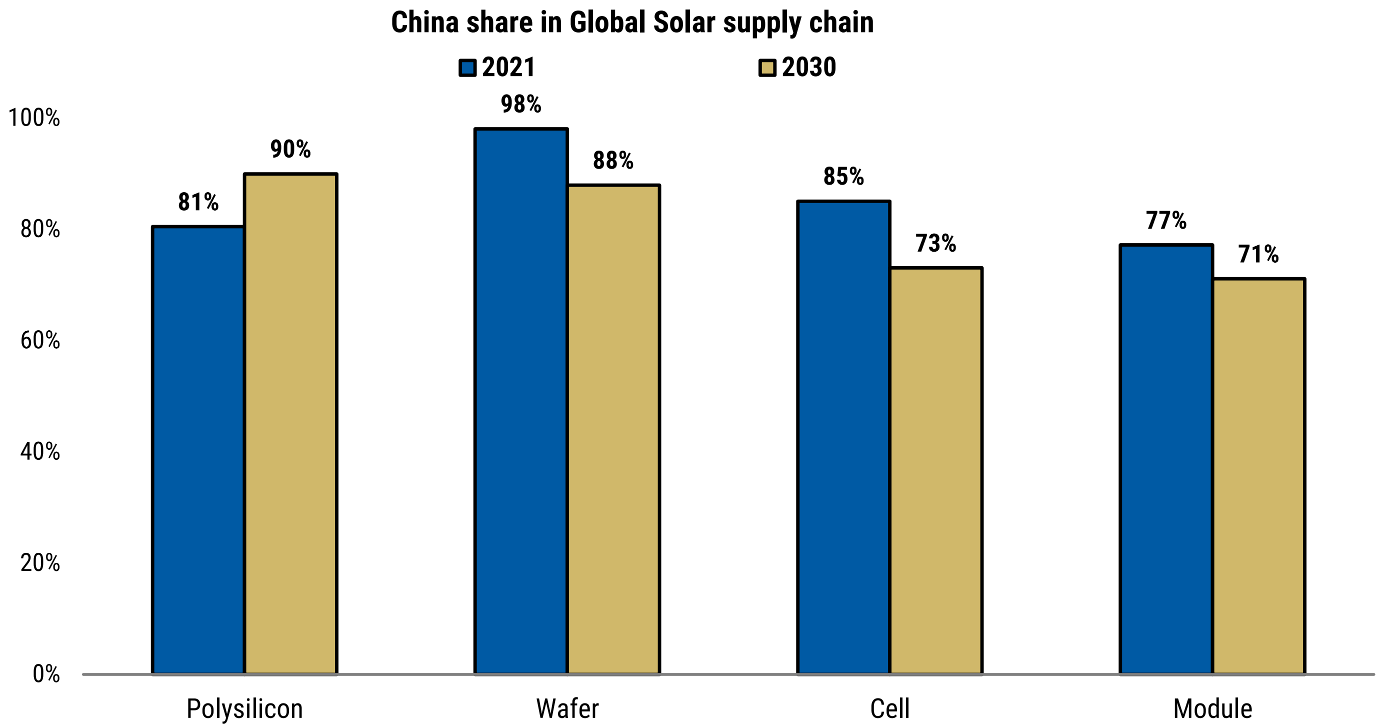


Solar Modules: Global Supply-Demand Balance (GW)

	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
China	477	557	564	571	578	585	592	599
India	10	19	28	32	37	43	50	55
US	(2)	(5)	(7)	(11)	(13)	(13)	(13)	(15)
Europe	(17)	(15)	(11)	(8)	(7)	(7)	(6)	(2)
SEA/RoW	24	29	33	35	36	36	33	30
Global	**491**	**585**	**607**	**619**	**631**	**644**	**656**	**667**

Source: Bloomberg, Morgan Stanley Research (e) estimates

Exhibit 54: China dominates the global solar supply chain across components, but we see ex-China market share rising by 2030, as upcoming investments take shape



Source: CPIA, Morgan Stanley Research

Asia to remain the global supplier: We have seen substantial solar manufacturing investments in the US, Europe and India. This is in addition to expansions underway in China. Proposed expansions in Europe appear to be vertically integrated, while those in the US and India imply 60-70% integration. Putting all of this together, we think the US and Europe will still heavily rely on Chinese/Indian/Southeast Asia supplies to meet their annual solar installation targets even in 2025 and 2030. Today, we estimate the solar module manufacturing industry is oversupplied by ~2x. Despite the likely acceleration in solar installations globally, oversupply conditions are unlikely to narrow significantly even by 2030, as capacity additions outpace solar penetration. Below we present a breakdown of solar self sufficiency by geography.

China: China will continue to dominate the global solar supply chain in 2025 (vs. 2022) as it raises polysilicon capacity by 3x, wafer and cell capacity by 60%, and module capacity by 45%. This implies an integrated capacity addition of 220GW by 2025. The larger players (i.e., JA Solar, Longi, etc.) continue to make substantial investments and even smaller players are rapidly deploying capacities at a time when solar technologies are rapidly evolving (the solar supply chain saw US$50bn of investments by China between 2011 and 2020, per IEA).

India: India imports 80% of its cells/panels from China. However, it is planning to add 25GW of integrated module capacity that should bring it to self-sufficiency by 2025-26 as these investments materialise. We expect these to fructify over the next 3 years, entailing an investment of US$25bn announced on the back of the government's US$3bn PLI scheme. While these investments are largely happening on modules, we believe the dependence on China for the imports of cell/wafers may still remain. We estimate these investments will also lead to 0.1mn in local job creation. Nearly 15GW of upcoming capacity will be fully integrated into polysilicon, while the remaining PLI-led investments will add downstream capacity.

Southeast Asia: Vietnam and Malaysia are the second and third largest manufacturers of solar modules after China, serving as a base for Chinese manufacturers diversifying their operations in Southeast Asia to overcome US import restrictions. The region has installed module manufacturing capacity of 80GW p.a. with a significant reliance on China for wafer imports and 15% integration into polysilicon, by our estimates. These capacities are largely concentrated in Malaysia and Vietnam. We believe the region will continue to see cell/module additions of 5-8GW p.a. until 2025-26 (largely focused in Vietnam, Malaysia and Thailand), before the pace of growth slows into 2030.

North America: As of 2022, US solar module manufacturing capacity was ~8.5 GW, but we estimate an incremental 19 GW will come online by 2025, driving total capacity to 27.5 GW (compared to US solar installation of 40 GW by 2025). The US Solar Association (SEIA) published a roadmap, which targets 50GW of manufacturing capacity by 2030. In 2021, vs. actual US solar installation of 23.6GW, as much as 26GW solar modules were imported, of which SE Asia accounted for 80%, or 21GW. We see imports playing a key role in US solar adoption, even by 2025 and possibly 2030.

Europe: Europe today is almost entirely reliant on Chinese imports. The recently launched Solar Photovoltaic Industry Alliance aims to develop a European solar-PV ecosystem that will secure and diversify supplies of solar PV products. Europe is envisaging a major ramp-up of solar-photovoltaic based electricity. As part of its solar strategy, the region has announced a 750GW target of installed solar PV capacity by 2030 – up from 171GW of installed capacity in 2022. This represents a considerable step up in annual installations, going from some 23GW in 2021 to around 70GW in the second half of this decade.

A number of companies have already come forward with future plans to develop manufacturing capabilities, with announced capacities of 25GW of modules, 21GW of cells and 20GW of wafer capacity by 2025 and investments totaling US$10bn.

Energy Storage: The Beta in Energy Transition

The Backbone of a Renewable Grid

As the cost of renewables gets cheaper and becomes a bigger part of the energy grid, the need for energy storage rises to reduce volatility in supply and ensure grid reliability. In our view, energy storage in the form of both batteries and green hydrogen could play a role in ensuring grid reliability as renewables penetration increases. The cost of battery energy storage systems (BESS) forms about half of the total cost of supplying green electrons for a renewable grid and, hence, the 30-50% cost savings here from the shift in technology to cheaper LFP based cells, sodium ion cells and metal air batteries is an important part of accelerating the adoption of low carbon solutions. We expect BESS installed capacity to increase from 48GWh in 2023 to 227GWh by 2030, supporting 2% of 2030 global renewable demand. The cost of energy storage LCOEs should reduce by 20% by 2025 and 30% by 2030

"Significant system-flexibility technologies – both short duration and long duration – will need to be deployed quickly to provide the necessary flexibility solutions in line with the future needs of the system and the gradual phase-out of fossil-fuel generation" (European Commission)

Energy storage reduces congestion and grid-investment costs, particularly in areas with favourable renewable-generation potential.

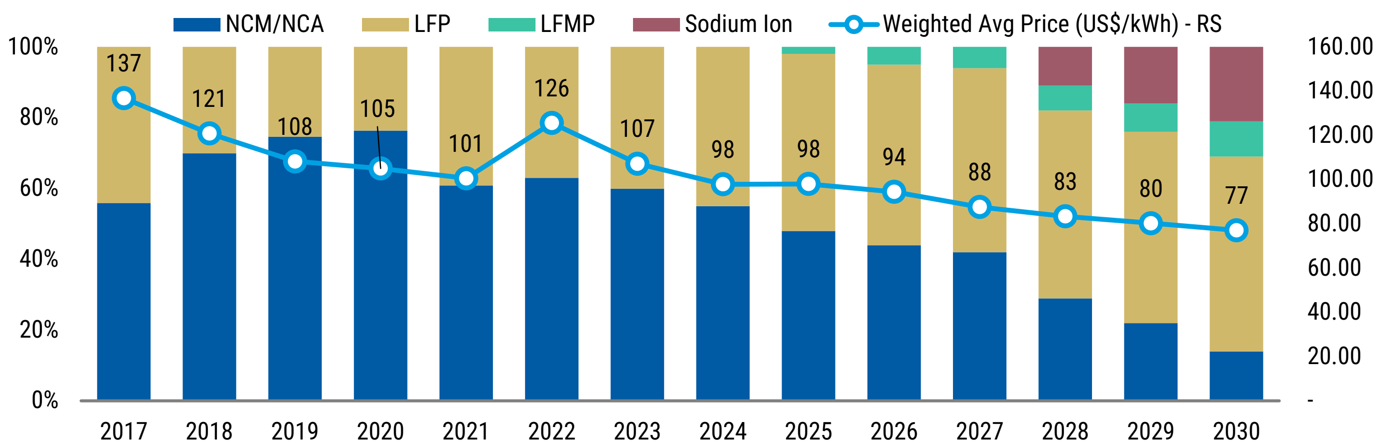
Grid-scale batteries are projected to account for the majority of storage growth worldwide. Batteries are typically employed for sub-hourly, hourly and daily balancing. Total installed grid-scale battery storage capacity stood at close to 16GW at the end of 2021, most of which was added over the course of the previous five years. The US, China and Europe led the market, each registering gigawatt-scale additions with 6GW adds in 2021. We estimate about 2-4 hours of battery storage usage to work along with gas to stabilise the grid, but at very high renewables penetration levels, the grid will need longer duration (multi-day) resources, which could be long duration storage such as metal-air batteries - or natural gas-fired power plants could serve this role. In liberalised electricity markets, measures to increase incentives for the deployment of flexible power resources, enabling a rapid response to fluctuations in supply and demand, could help improve the business case for grid-scale storage the most.

Battery storage is the most expensive part of a clean power grid and currently has the highest LCOE: The battery technology shift has helped lower LCOEs by 25-40% globally for storage, but remains 3x that of solar in terms producer economics. Hence, further cost reductions may be needed for a broader deployment and for that – similar to what happened in the wind and solar industry – policy support and subsidies may be needed. We also note that batteries do not address the question of seasonal storage, for which other costly solutions may have to be found (one of the main issues of solar power being that it produces at low load factors in winter when European power demand is high).

Cheaper chemistries: ESS battery cell technologies are still largely dependent on the EV supply chain as demand for ESS is only 5% of the EV battery demand. Unlike EV batteries, energy storage batteries do not have a limitation of size, hence they offer a bigger landscape for companies to deflate cost using newer and cheaper battery chemistries with lower energy density, (Exhibit 55) e.g., sodium ion and LFP. Sodium ion is about 30% cheaper than LFP which is 15% lower vs. NCM Li-ion cells as both are less reliant on rare earth minerals – a key cost element in Li-ion cells. Multiple corporates like Reliance Industries have announced plans to build ESS manufacturing facilities on technologies on metal air and sodium ion. Even CATL is looking to expand its innovation in sodium ion, see expert call notes. While a lot of these remain unproven, we believe the direction of travel to lower costs is evident.

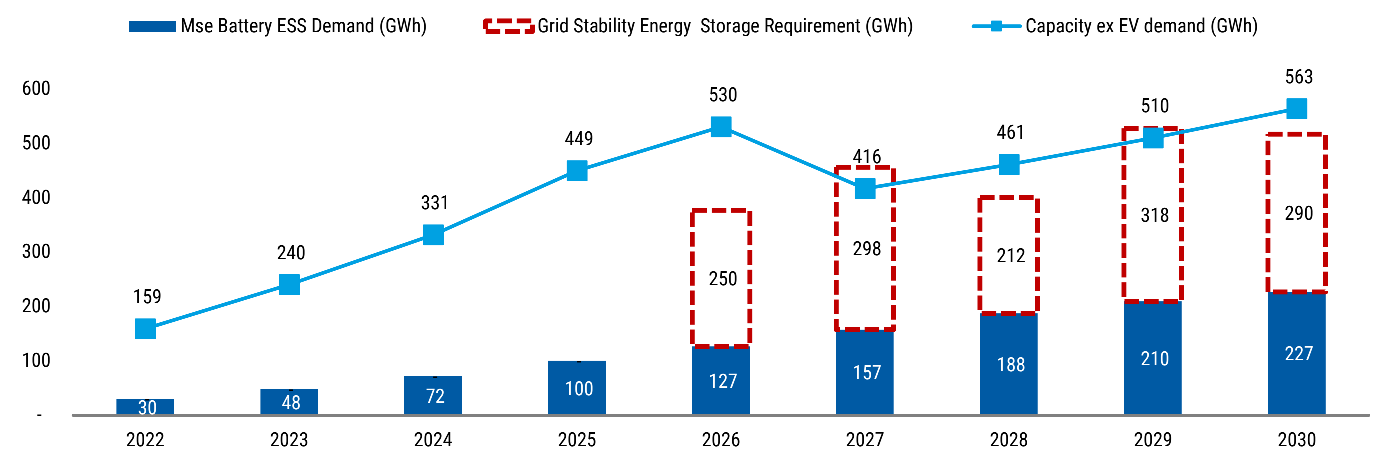
The supply chain: Less inflationary than the market assumes: Some of this reduction in costs will however be negated by a shift in supply chains to local production like the US, where capex/GWh is 2x vs Asia. However, government subsidies and production-linked incentives, such as the US IRA and India PLI, should help lower the impact of localisation in supply chains (Exhibit 34). Eventually over the medium term, the localisation in supply chains should bring working capital and other opex benefits for power generators in the US, India and Southeast Asia where the cost of production with subsidies could be 15% more cost competitive than importing battery cells.

Exhibit 55: The shift in battery mix towards LFPs and subsequently sodium ion could drive costs 30% lower and increase adoption



Source: Morgan Stanley Research estimates

Exhibit 56: The energy storage oversupply in context: Lower costs are needed to drive ESS adoption which remains below grid stabilisation requirements

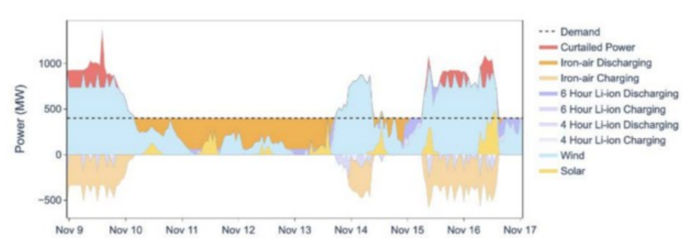


Source: BNEF, IEA, Morgan Stanley Research estimates

What are the implications of LDES? We see significant potential for cheap Long Duration Energy Systems (LDES) providing firm, reliable power at low costs. Utilities with low customer bills and favorable economics could use LDES to 'generate' power while paired with renewable-generating assets as an economically-feasible alternative to new natural gas fired power plants.

A few potential implications of very cheap long duration storage: (1) added incentive for renewable developers to add LDES to new projects at low costs; (2) increasing grid reliability with storage's ability to mitigate around intermittency of power assets, as seen in Exhibit 57; (3) potentially lowering customer costs and increasing utility growth all while rapidly expanding on decarbonisation efforts; and (4) potential for utilities to lose commercial and industrial (C&I) customers to distributed energy providers who can combine their offerings with LDES for a reliable off-grid solution at a rate below the utility.

Exhibit 57: Long Duration Energy Storage such as iron-air batteries can help to stabilise the grid to meet periods of low wind & sun resource



Source: Form Energy, Great River Energy, University of Minnesota

The Cost of Electricity Storage

Chemistry Change + Oversupply + Subsidies = Global Cost Deflation

Battery Energy Storage Systems (BESS) are at an inflection point with 40% cost savings ahead as technological breakthroughs and increasing adoption coincide with an oversupply driven by government incentives and a supply localisation push. Asia and the US should be the biggest beneficiaries with LCOE at US$100/kWh by 2030 due to new technology adoption in Asia and substantial production government support in the US. Europe should see a slower deflation with LCOEs at US$175/kWh due to limited subsidies. We see pockets of cell manufacturers benefiting from production linked government support; particularly Korean manufacturers with 500GWh of committed capacity in the US.

CATL on battery storage technology.. "...working on electrochemical energy storage solutions, with the aim of increasing the cell life to a record high of 18,000 cycles – thus expanding the scale of a single energy storage power station to 1GWh and rivaling the pumped storage level by cost per kilowatt hour and energy storage capacity."

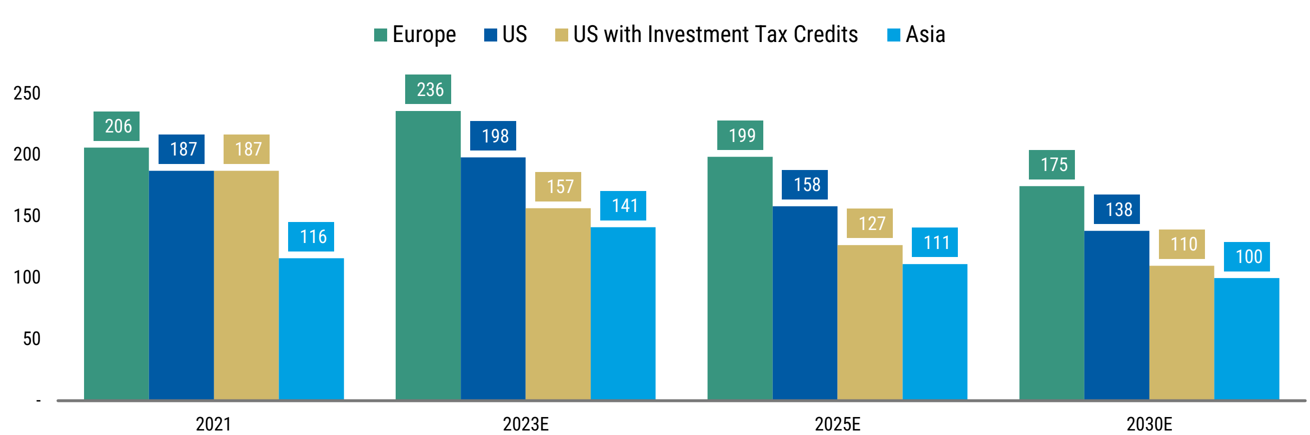
We see deflation in storage costs globally, driven primarily by technological advances in cell costs and the expansion of non-cell component manufacturing capacity. The deflationary cost of storage is more prominent in Asia and the US, with LCOEs declining by 30% in 2030 (relative to 2023) to US$100/kWh in our base case and over 50% in our bull case with metal air batteries. We expect storage costs in Europe to decline 25% vs. 2023 on inflationary pressures from supply chain localisation without subsidies.

While lithium-ion storage is currently the dominant technology, we see one emerging technology as having the potential to be far more advantageous in terms of power grid stabilisation as renewables penetration rises: metal-air energy storage. In the US, a private company (Form Energy) is building its first factory to manufacture iron-air energy storage, and the capital cost of this form of battery could be 1/10th that of lithium-ion batteries – see our note here outlining the economics of this important technology.

Asia: Oversupplied market keeps capital costs down

We expect the standalone levelised cost of storage to decline from US$141/kwh to about US$100/kwh by 2030, driven by manufacturing scale and technological advancements. Asia's BESS are currently cheaper than the rest of the world as they are predominantly based on cheaper LFP battery technology compared to BESS systems in the US and Europe which utilise more expensive NCM/NCA cells. Asia's advantage also lies in over 1TWh of manufacturing capacity and raw material availability which keeps the market for batteries well supplied despite the strong growth in demand and even more so with planned supply chain localisations in the US and Europe freeing up capacity in Asia (Exhibit 59). Asia's earlier adoption of Na-ion cells should also help to reduce costs by 20% and increase producer cashflow visibility, removing the impact of lithium price volatility.

Exhibit 58: We expect global cost deflation in electricity storage costs, however, the cost of storage in Europe remains 80% above the US and Asia due to the absence of substantial government support



Source: BNEF, Morgan Stanley Research (E) estimates

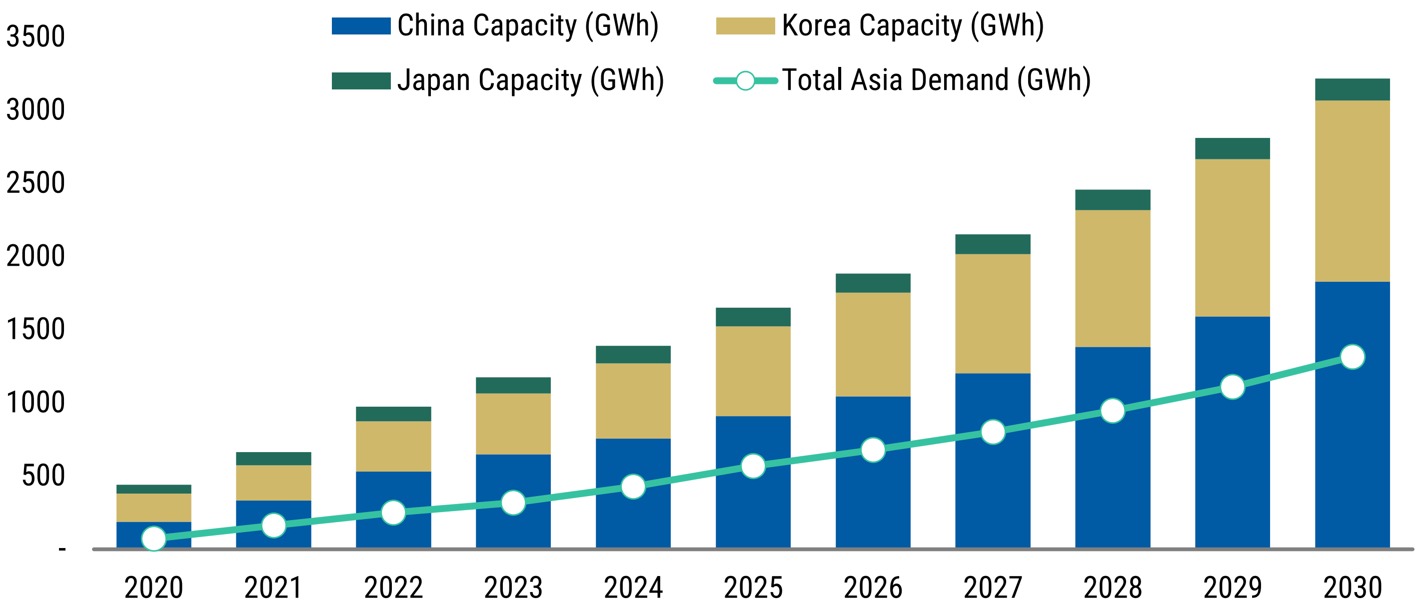
US: Cost deflation led by subsidies, which will drive greater scale and lower costs

We expect standalone levelised cost of storage to decline from US$198/kWh (without tax credits) to US$138/kWh by 2030 without Investment tax credits (ITCs). With tax credits, we expect storage costs to be as low as US$110/kwh by 2030 (Exhibit 60), competitive with storage projects in Asia. The decline will be mainly attributed to lower capital costs as LFP cell adoption in ESS applications increases commensurate to EV applications from 7% in 2023 to 27% in 2030. We also expect high ITC subsidies at 30% of capital costs to greatly reduce the overall cost of storage.

Europe: Limited deflation, awaiting subsidies

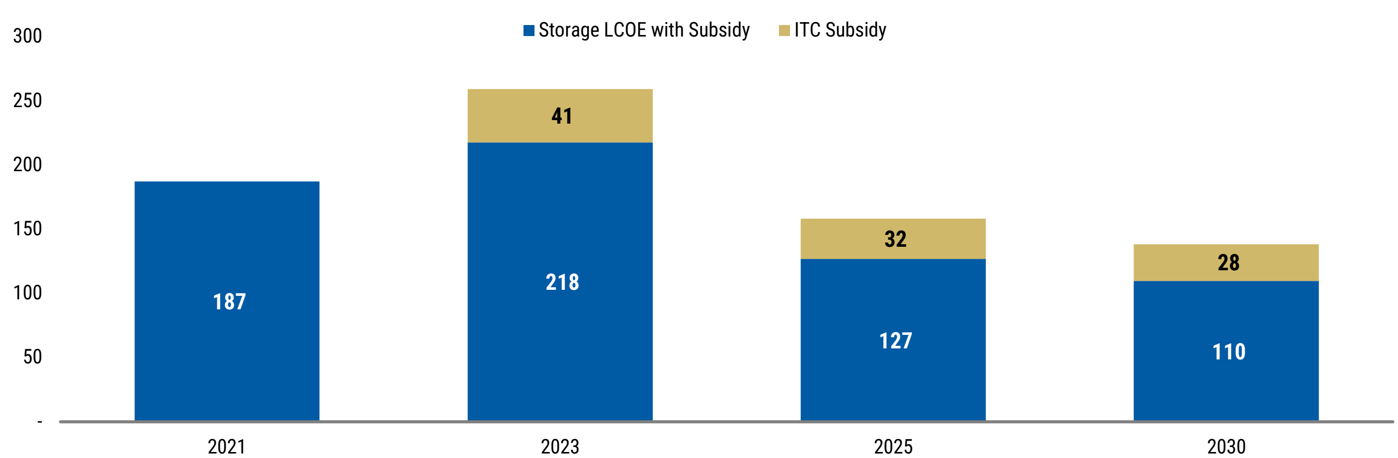
We estimate the standalone levelised cost of storage will decline from US$236/kWh to US$175/kWh by 2030, as a 10% capital cost decline is met with limited deflation in green electricity due to higher onshore and solar generation costs, as well as the inflationary forces of supply chain localisation on energy security concerns. For now, we see the lack of meaningful subsidies in Europe as key to its uncompetitive cost of storage vs. Asia and the US. Having said that, the European Union has been working on a response to the US Inflation Reduction Act, from which potential new support mechanisms for new clean technologies could come out and mitigate the cost gap with other regions.

Exhibit 59: Oversupply in Asia is exacerbated by supply localisation in the US, which should lower overall costs



Source: Morgan Stanley Research estimates

Exhibit 60: US levelised cost of storage is highly competitive with its 30% investment tax credits



Source: BNEF, Morgan Stanley Research estimates

Energy Storage Batteries: The Technology Upside

Underappreciated Advances

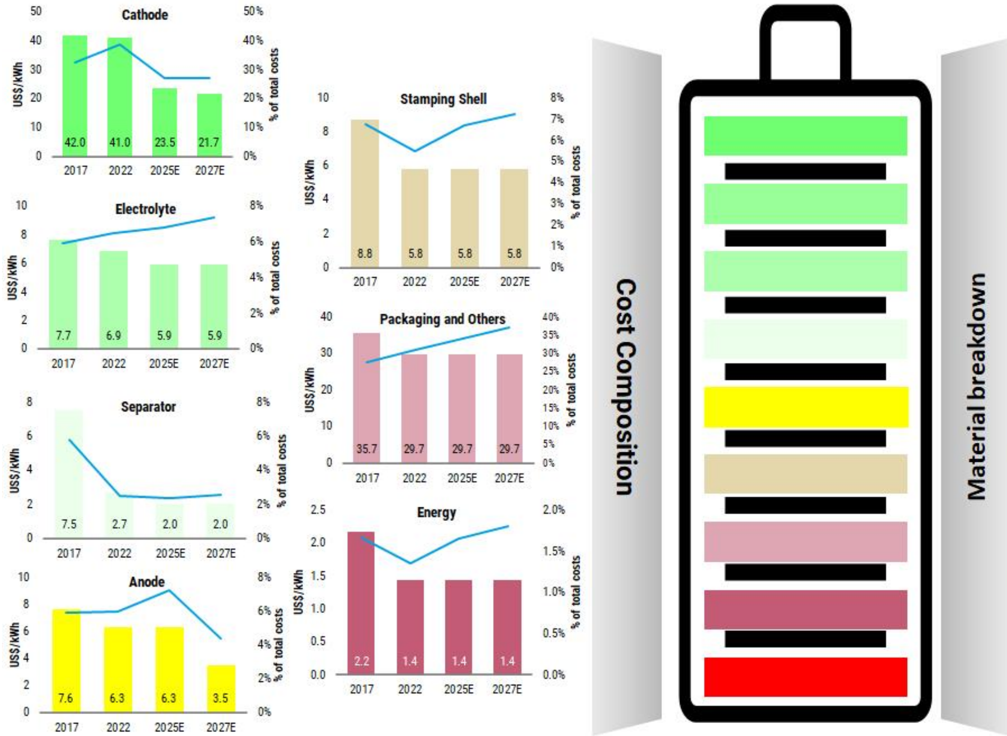
Battery technology is at an inflection point for energy storage with multiple contenders that avoid the use of rare earth materials – a key cost bottleneck for the incumbent lithium(Li) ion cell. Cheaper Sodium-ion cells have reached commercial development and implementation in China, and are where LFP cells were 5 years ago. Metal air batteries, which could cost 1/10th of Li-ion, have made significant breakthroughs in rechargability and are beginning commercial production in 2024. We're also seeing the increasing adoption of LFP cells globally, which avoid nickel and cobalt, as the technology has overcome energy density limitations for EV usage (Exhibit 61).

Exhibit 61: Technological advancements in cell manufacturing and faster Na-ion adoption could reduce costs 20-30% beyond our base case of US$77/kwh by 2030

2022	Initiative	How costs are lower	2025e Impact vs 2022	2025e	2030e Impact vs 2022	2030e
US$126 /kwh			-US$28/kwh	US$98 /kwh	-US$49/kwh	US$77 /kwh
	Cathode					
	Sodium Ion Cathode	Cheaper battery chemistry	NA		-US$10/kwh (-20%)	
	Li-ion Cathode	Greater LFP Adoption / material cost deflation	-US$30/kwh (-23%)		-US$30/kwh (-12%)	
	Anode					
	Silicon Anode	Higher energy density	NA		-US$3/kwh (-2%)	
	Manufacturing					
	Supply Localization	Integrated supply chain	+US$2/kwh (+2%)		-US$4/kwh (-3%)	
	Dry Electrode Manufacturing	Reduced energy costs from drying process	NA		-US$2/kwh (-2%)	

Source: Morgan Stanley Research estimates

Exhibit 62: The lithium-ion cathode represents 40% of costs and significant scope for deflation as cell chemistry improves with the likes of Na-ion technology



Cathode		
Materials	Lithium	0.10 kg/kWh
	Iron	0.82 kg/kWh
	Phosphate	0.45 kg/kWh
	Oxygen	0.95 kg/kWh
Electrolyte		
Materials	Lithium Salt	0.11 kg/kWh
	Organic solution	0.99 kg/kWh
Separator		
Material	Polyethlyene	15.71 sqm/kWh 0.17kg /kWh
Anode		
Materials	Graphite	0.61 kg/kWh
	Copper foil	0.40 kg/kWh
Packaging & Others		
Materials	Nickel, Steel, Polyethylene, PVC	0.16 kg /kWh
Energy		
Material	Electricity	39kwh

Source: Company data, Morgan Stanley Research (E) estimates

Improvement in Li-ion technology

Li-ion battery technology has made significant improvements in cathode chemistry, cell design and capacity growth, which led the 10x decline in cell costs over the last decade (Exhibit 63). We expect the mainstreaming of LFP technology, manufacturing efficiencies and silicon anodes could further reduce Li-ion (LFP) cell cost in the next decade (Exhibit 64) and reduce costs by US$13/Kwh. Although not new, LFP cathode technology has matured to the point where cell energy densities have become sufficient for EV commercialisation (>250wh/kg) and ESS home applications. With 80% adoption in China and Tesla transitioning into LFP batteries, we expect its current 35% market share globally to rise to 60% by 2030, supported by over 500GWh of new LFP production capacity, which should drive greater LFP technology adoption for ESS applications. With the likes of Samsung SDI and LG Energy, which have ESS products based on NCA and NCM technology, respectively, to develop ESS modules based on cheaper LFP-based cells.

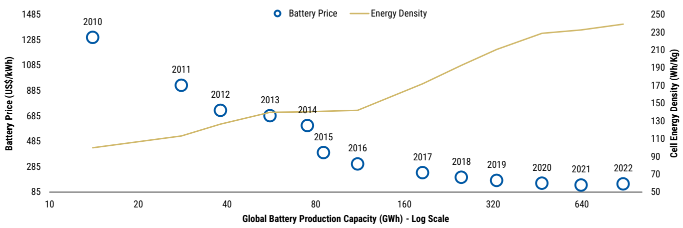
LFP vs. NCM Cathode: LFP batteries don't contain nickel and cobalt unlike NMC and NCA cells, resulting in US$10/kwh cheaper cathode material costs. Its 20% thermal efficiency and 50% longer life cycle are also key advantages that lower lifetime cell costs over NCM batteries. Manufacturers are also exploring the addition of manganese to LFP cathodes to form LFMP cells, which are reported to achieve energy densities of NCM cells (250Wh/kg vs LFP at 200Wh/kg) while only 5-10% more expensive. We estimate LFP production costs at US$80/kwh by 2025, 10% lower than NCM cells, reducing global battery costs by US$10/kwh vs. 2022 as adoption increases.

Manufacturing efficiencies: With cell production capacity tripling to 6TWh by 2027, increasing equipment availability, supply chain integration and GWh scale efficiencies, we see capital costs and operational costs declining by US$3/kwh. Improvements with the 'powder into film' dry electrode manufacturing process uses 40% less energy and 15% less solvents.

Silicon anodes: Although 10% more expensive than graphite to produce on our estimates, silicon anodes have 10x higher energy density over current graphite anodes which could theoretically increase overall cell level energy density by 25%, minimising the 30% energy density gap between cheaper LFP cathodes over NMC-based cells.

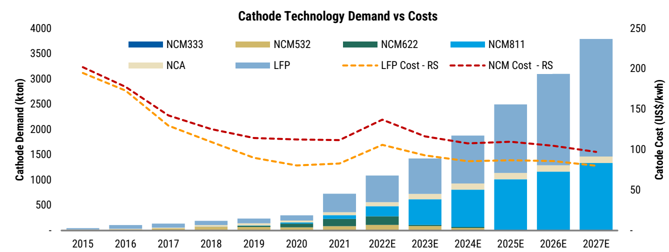
We are beginning to see large scale commercialisation of silicon anodes with new giga-scale silicon anode production plants and expect the technology to see widespread adoption in the later half of this decade. We expect silicon anodes to contribute US$3/Kwh of savings by 2030.

Exhibit 63: Capacity growth and cell density improvements resulted in the cost decline of the past decade...



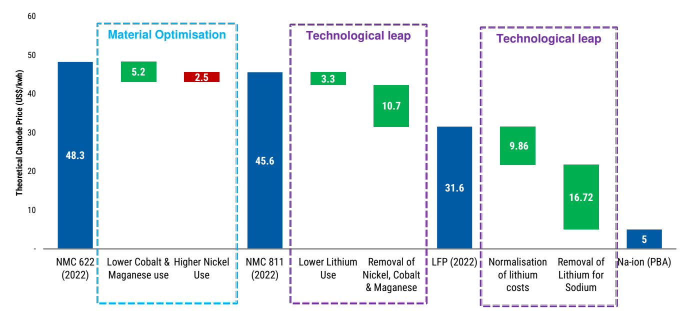
Source: Company data, Morgan Stanley Research estimates

Exhibit 64: ...which should increase LFP manufacturing capacity and adoption



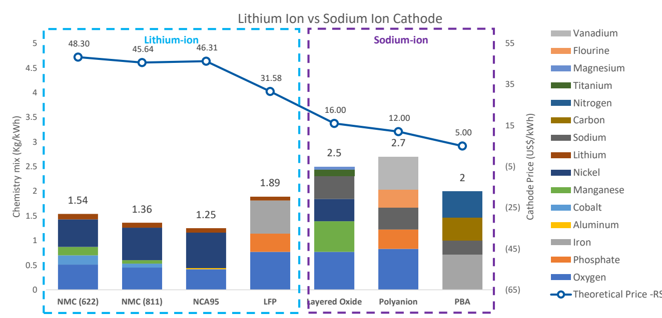
Source: Company data, Morgan Stanley Research (E) estimates

Exhibit 65: Material efficiencies contributed to cost declines historically, but technological leaps in cell chemistry made the most difference...



Source: Company data, Morgan Stanley Research estimates

Exhibit 66: ...as cathode chemistry technology improves with the use of less rare earth materials



Source: BNEF, Wood Mackenzie, Morgan Stanley Research estimates

Breakthrough in Battery Cell Technology

The majority of ESS battery architectures today leverage 4-hour or 6-hour lithium-ion technologies, but interest has been growing in long-duration energy storage (LDES), which stores energy for more prolonged periods (10+ hours and potentially even multiple days). LDES can store energy in a number of ways – mechanical, electrochemical, chemical, or thermal – but innovations in LDES to reach cost-competitive scale are still relatively new. To see increased adoption, the technology has to prove that it's capable of storing and deploying prolonged hours of energy at a significantly cheaper capital cost compared to lithium-ion chemistries in the range of US$100/kWh-US$200/kWh.

Sodium-ion: The next LFP? Sodium-ion (Na-ion) batteries can provide the next significant technological leap in battery cost reductions with the replacement of expensive lithium for abundant sodium, which we estimate would reduce cell costs to around US$57/kwh. The announcement by CATL and BYD that they will mass produce Na-ion batteries and install them in EVs by 4Q23 is a key trigger for the commercialisation of Na-ion technology, in our view, and should see adoption in ESS from 2025. Key cathode suppliers have also announced production facilities will be ready this year, with Ronbay planing to reach 36,000t/yr of layered oxide Na-ion cathode production and Hunan Changyuan Lico completing a 1,000mt/year production line to support commercialisation by cell manufacturers.

Na-ion = Li-ion five years ago: Lithium performance was originally similar to nickel, but the capacity-to-storage energy using lithium has tripled through the optimisation of cell design, and the same may happen now with sodium batteries (Exhibit 67), including the possibility of solid-state (solvent-free) sodium batteries and innovative seawater batteries that would produce fresh water (desalinisation) as a byproduct on top of chlorine and CO2 trapping.

Sodium-ion: Cheaper cathode. Na-ion cathode chemistries replace expensive lithium, nickel and cobalt with sodium, iron and magnesium, which are in abundance. Prussian Blue Analogue (PBA) is a leading candidate to be the dominant Na-ion cathode chemistry, costing about US$4/kwh to produce – one-fifth the cost of an LFP cathode. The availability of sodium sourced from the sea or inland mines near final EV markets adds to its cost advantage in the move to localise supply chains.

Sodium-ion: Less electrolyte. We expect electrolyte costs to fall 10% due to the better conductivity of sodium, leading to a lower concentration of electrolyte, as well as the shift away from expensive lithium-based LiPF6 salts used in most Li-ion cells.

Sodium-ion: Cheaper anode collectors. Because sodium-ion does not react with aluminum (unlike lithium-ion), copper collectors can be replaced by cheaper aluminum collectors in Na-ion anodes, slightly offsetting the roughly 30% more expensive hard carbon anode needed in Na-ion cells.

Sodium-ion: Low cost of switching. Manufacturers expect only a 10-15% increase in capital costs to retrofit existing manufacturing lines to produce Na-ion cells, which should increase the rate of switching and commercialisation as the technology matures.

Limitations to Na-ion adoption: PBA has a relatively open crystalline structure, which is more conducive to the intercalation and extraction of sodium ions, but its stability and cycle performance still need to be improved to match the energy density and lifecycle of LFP cells. These limitations, however, can be overcome with a hybrid battery pack, which combines lithium and sodium in the same battery. CATL's Ni-ion/Li-ion one pack could be a game-changer for sodium, opening a range of additional uses. We also see headwinds to Na-ion adoption should lithium prices return to trough levels, disincentivising R&D in alternative storage technologies.

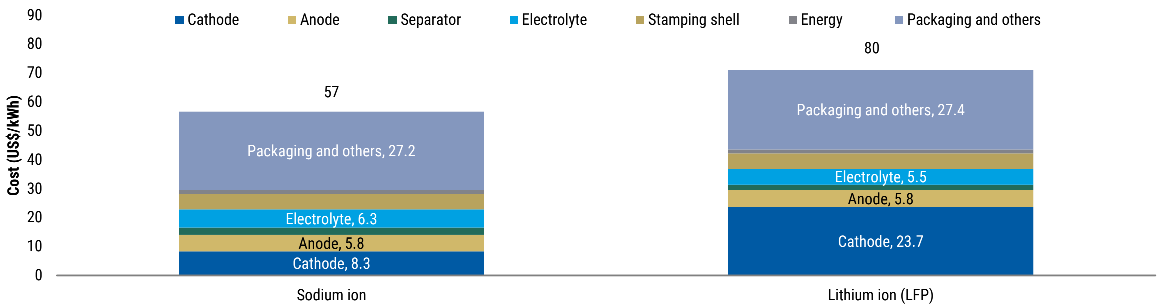
Metal air batteries: A paradigm shift. The application of air as a cathode significantly reduces costs over Li-ion cells. Although promising, metal air batteries have yet to reach an inflection point for wide-scale commercialisation and will more likely see adoption in the 2030s. The cost advantage comes with trade-offs in terms of low energy density, cycle rate, discharge rate, and lower round trip efficiency, hence these cells would be more suitable for ESS applications. Form Energy (unlisted) aims to deliver a 3MW output/acre ESS system (50% less than current ESS) using rechargeable iron air batteries produced at its US$760mn factory in West Virginia from 2024 at a cost that we estimate could be below US$20/kWh (one-fifth to one-tenth the cost of current Li-ion cells).

Metal air: The breakthrough. The metal-air system comprises a porous air cathode, a metal anode and an electrolyte. Air cathodes utilise oxygen from the air to oxidise the metal anode, releasing electrons in the process.

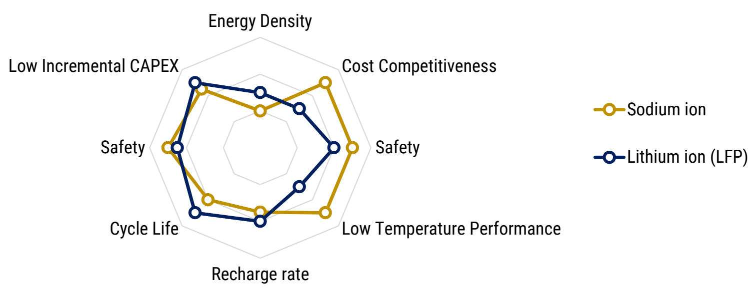
Exhibit 67: Sodium-ion technology is beginning to look like LFP cell technology five years ago.

Technologies	Sodium Ion (PBA)	Lithium Ion (LFP)
Cost (2030e) (US$/kWh)	57	80
Key Materials	Sodium salt, Prussian Blue Analogues, aluminium, hard carbon	Lithium, Iron phoshate, aluminium, graphite, copper
Energy Density (Wh/Kg)	140-160	160-200
Cycle Life (cycles)	2,000-4,000	3,000-5,000
End-Use Case	ESS, 2/3 wheeler EV currently dominated by low density lead acid battery, lower end 4 wheeler EV	All EVs, ESS

Cost Brekdown



Key Characteristics



Source: CATL, BNEF, Morgan Stanley Research estimates

Exhibit 68: Global players will introduce prototypes ready for commercial manufacturing as early as 2H23

	Asia			Europe			US
Players	**HiNA**	**Reliance (RIL.NS)***	**CATL (300750.SZ)**	**TIAMAT**	**ALTRIS**	**LiNA Energy**	**Natron Energy**
Capacity Commitments	1GWh production opened in 2022, with expansion to 5GWh planned for 2024	5GWh production starting in 2024 plans to scale to 50GWh by 2027	Aims to start production in 2023	5GWh production by 2025, producing high discharge rate cells	GWh Prussian blue cathode factory planned for 2023 with 25GWh capacity by 2025	Plans for Gigafactory production by 2026	To produce high discharge rate Prussian blue Cells with ~50MWh capacity
Technology	Layered transition metal oxide	Layered transition metal oxide	Blue Prussian	Polyanionic materials	Blue Prussian	Nickel-iron chloride	Blue Prussian
Estimated cell cost (US$/kWh)**	NA	103	75	106	80	43	55
Energy Density (Wh/Kg)	145	160	160, targets 200	NA	160	195	NA
Cycle Life	4,500	4,000	~4,500	5,000	NA	4,500	NA
Charge Rate	5C	2C	~5C	20C	NA	NA	20C
Potential Target Market	EV	2/3 Wheeler EV & ESS	EV & ESS	Industrial backup power	NA	ESS	Industrial backup power

***: includes Li-ion battery production**
****: Morgan Stanley Research Estimates**

Source: Company data, BNEF, Morgan Stanley Research estimates

Downstreaming savings in ESS

Our base case mainstreaming of LFP cells by 2025 and Na-ion cells by 2030 could drive cheaper cell costs and improved thermal efficiencies. Combined with manufacturing scale, cheaper inverters and longer duration systems, we could see the cost of ESS systems fall more than US$100/kwh (Exhibit 69), slightly offset by a 5-10% margin normalisation by developers.

Lower thermal requirements: Na-ion and LFP cells exhibit wider operating temperature ranges and 20% higher thermal runaway temperatures. This reduces the need for advanced and costly liquid cooling systems, which could reduce the cost of racks and cooling by 30%.

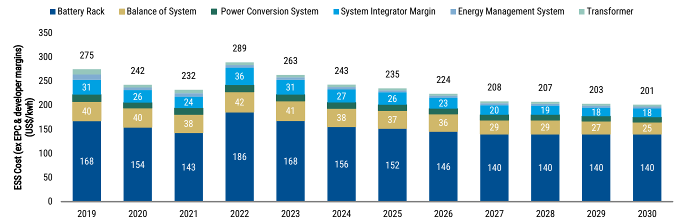
Margin expansion: ESS developer margins have seen a steady 10% decline over the past five years as contractors compete for projects (Exhibit 70); we see this trend reversing in the long run, which could slightly offset overall system cost savings.

Synergies with solar: ESS power conversion systems and solar inverters share similar characteristics and could be integrated in a single system, lowering overall system costs. We expect solar inverter manufacturers such as Sungrow and Huawei to launch more ESS products to be used in hybrid solar + energy storage projects which are starting to see strong adoption. This could potentially reduce costs by US$30/kW.

Longer duration systems: System cost per kwh declines as system duration increases due to economies of scale which negate additional battery management systems (Exhibit 71). The shift towards longer duration 6-8 hour systems used as baseload capacities compared to the current 1-4 hour systems designed for emergency dispatch could reduce overall system costs, which remain underappreciated.

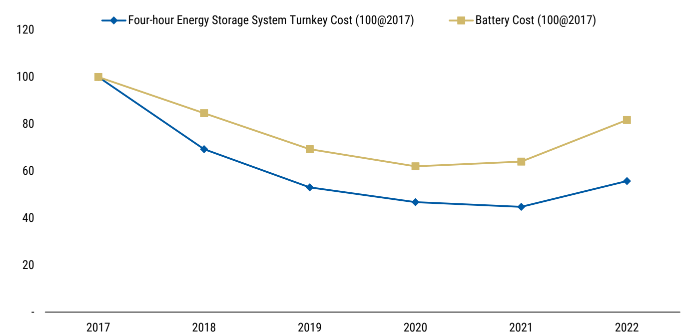
Manufacturing scale: BNEF estimates that ESS battery racks are currently 10% more expensive to produce than EV battery packs as they lack economies of scale and volume order price negotiations. We believe costs should decline further from scale benefits as installed capacity grows. Currently only CATL and BYD have dedicated production lines for ESS batteries. Samsung SDI and LGES have started exploring dedicated production in ESS batteries, especially in the US, where demand is expected to be high.

Exhibit 69: Cost savings at the cell level, coupled with more efficient systems, should lower total system costs



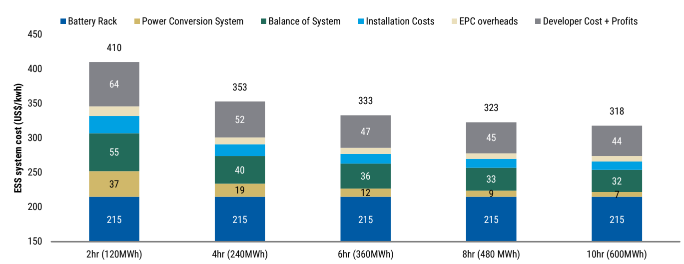
Source: BNEF, Morgan Stanley Research estimates

Exhibit 70: ESS turnkey system costs have declined faster than the cost of batteries as developers squeeze margins to win contracts



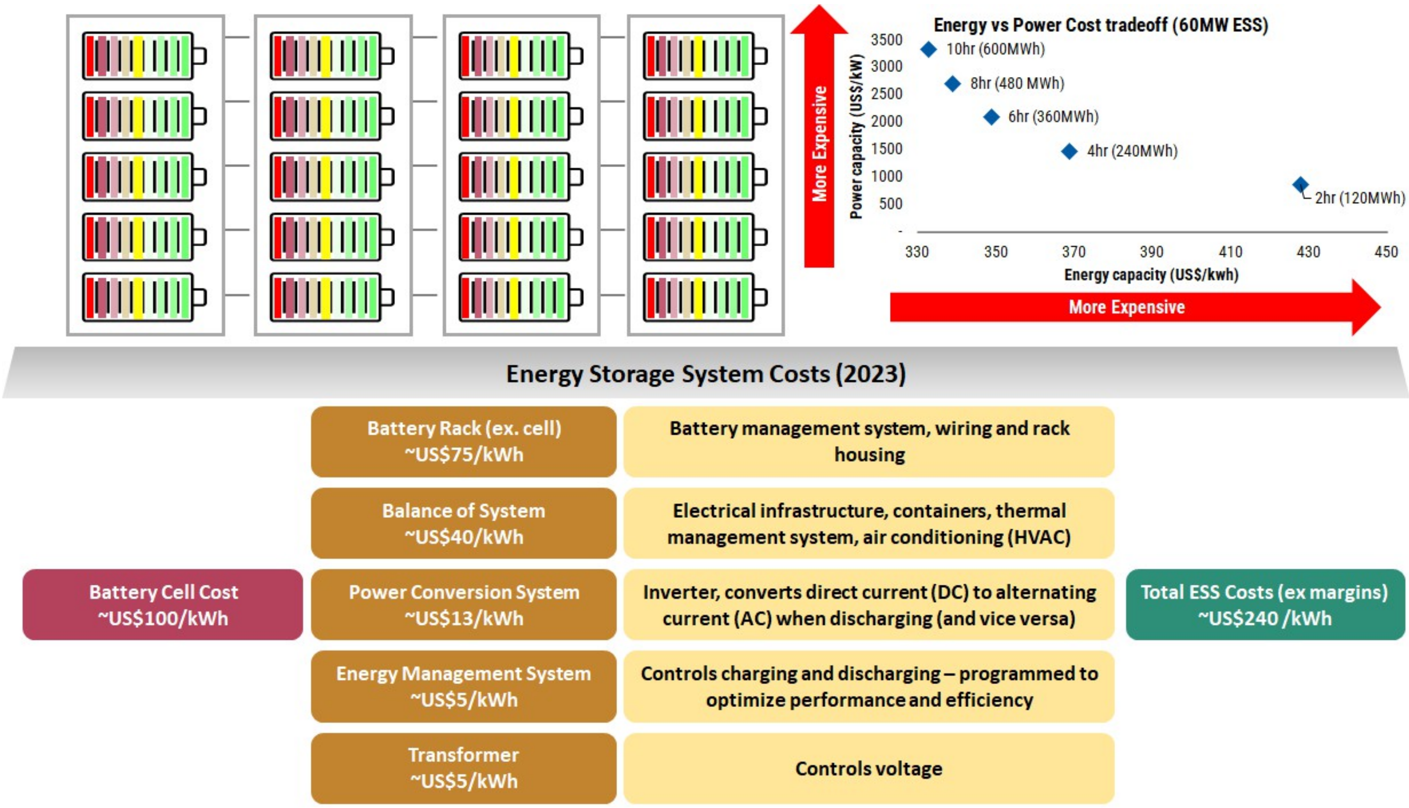
Source: BNEF, Morgan Stanley Research

Exhibit 71: Long duration systems are less expensive to install and could be the key to lowering the cost of electricity storage



Source: NREL, Morgan Stanley Research

Exhibit 72: Battery cells contribute about 40% of total system costs with significant scope for deflation with the introduction of Na-ion technology and greater LFP adoption



Source: Company data, NREL, BNEF, Morgan Stanley Research estimates

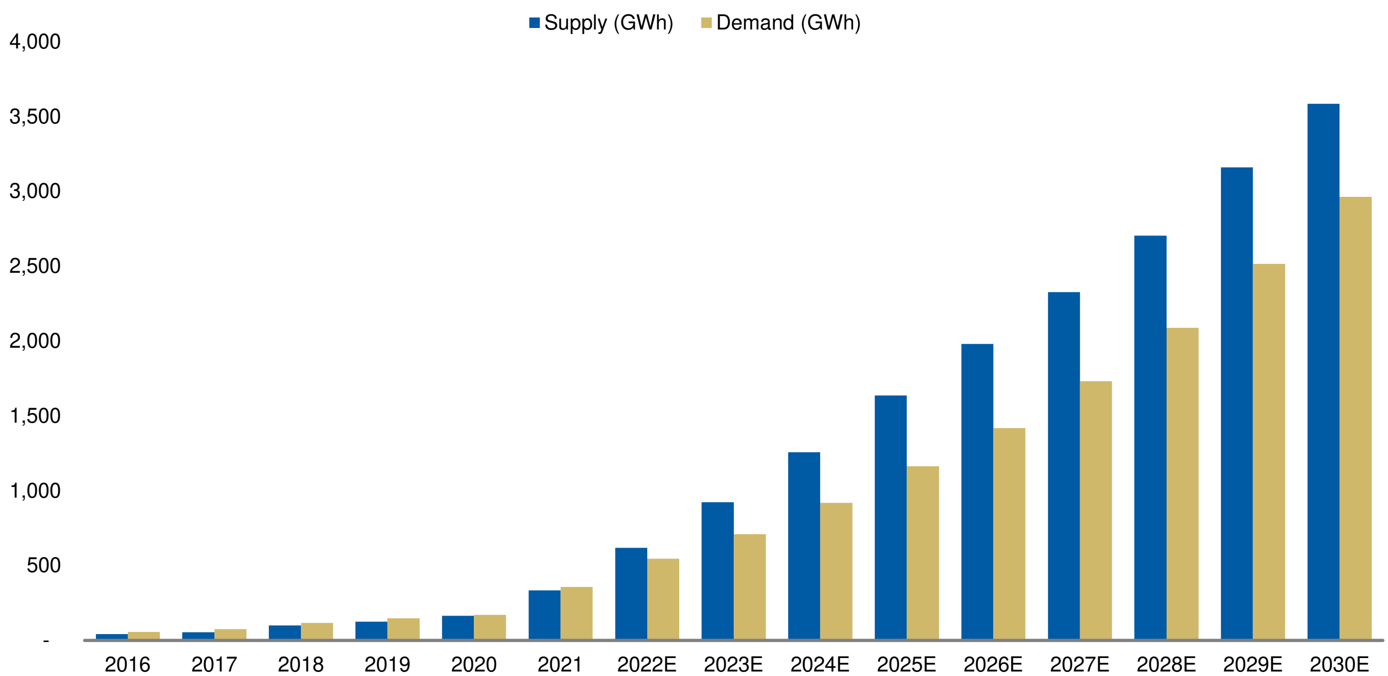
Energy Storage Batteries: The Supply

Distributed supply; cost inflationary near term

The expansion in global battery production capacity is on pace to keep demand well supplied into 2030 (Exhibit 73) with 5TWh of new capacity driven by the localisation of supply chains as nations seek to reduce battery production dependence away from China with over US$30bn of investments in the US, Europe and Southeast Asia committed by LG Energy, SK Innovation, and Samsung SDI.

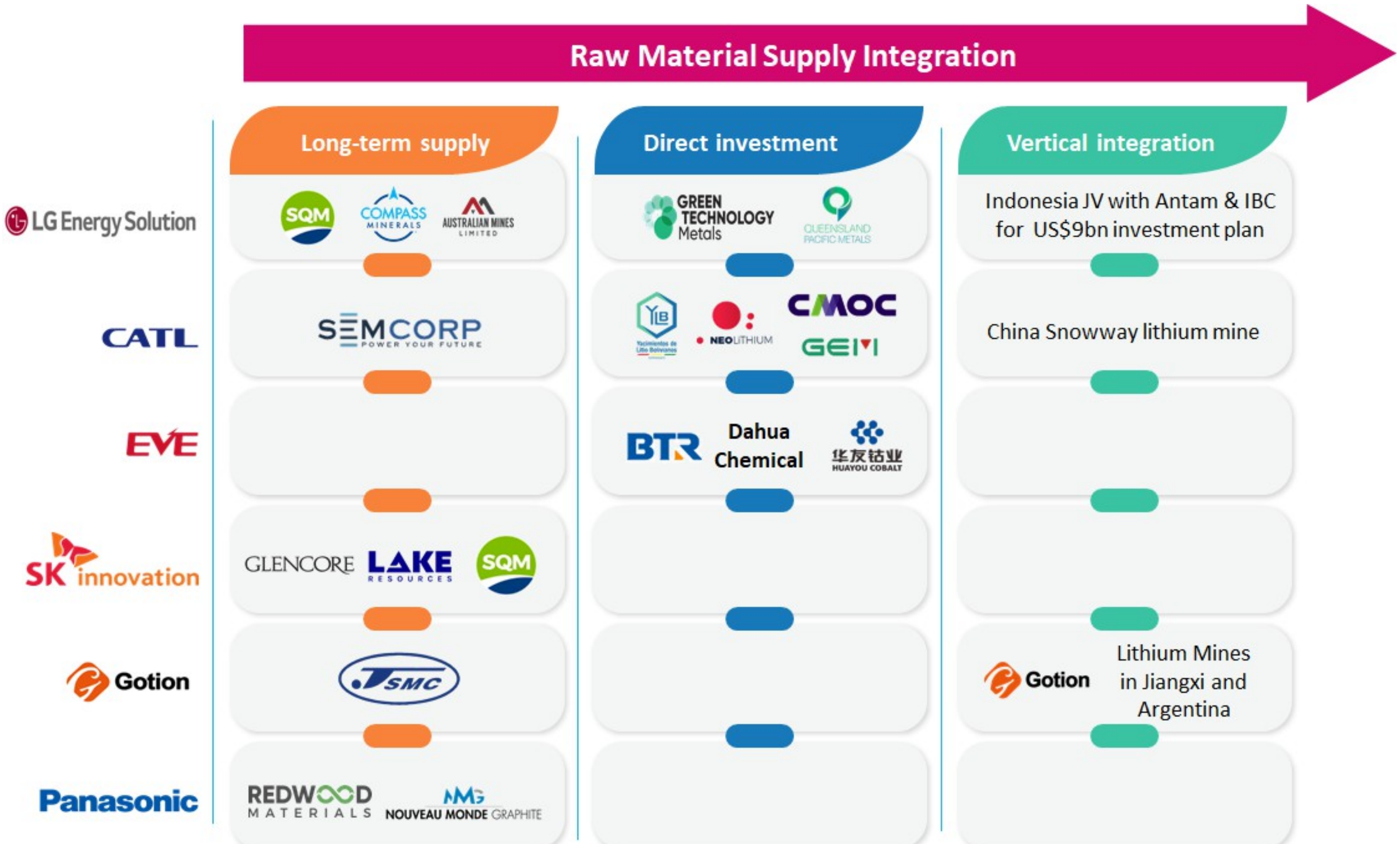
We expect the global supply chain to become increasingly integrated (Exhibit 75) with domestic production of key components and battery cells, which would lower costs in the long run as production matures and material supply stabilises. The shift to Na-ion tech also aids in the deflation of localisation as key materials such as sodium can be sourced from the sea and inland mines located all over the globe, including final EV markets. In the short run we expect localisation to be cost inflationary on higher capital outlays and slow production utilisation as the market remains oversupplied.

Exhibit 73: Localisation of supply chains should keep overall Li-ion cell value chain well supplied, eventually driving costs lower



Source: Company data, Morgan Stanley Research (E) Estimates

Exhibit 74: Key manufacturers have signed long-term material contracts improving material supply visibility and price certainty



Source: Company data, BNEF, Morgan Stanley Research

Exhibit 75: We estimate the committed manufacturing capacity of various components is insufficient in most countries to create fully integrated supply chains

Country	India	China	Korea	Japan	ASEAN	North America	Europe
Capacity Plans (GWh)							
2030e Cathode	10	1,757	494	106	141	735	661
2030e Anode	170	3,466	239	0	78	269	298
2030e Seperator	23	2,754	108	285	0	149	236
2030e Electrolyte	32	3,048	68	0	0	306	82
2030e Cell	50	5,918	145	209	80	810	666
Integrated Suply Chain Score	4	5	3	1	4	4	3
Raw Material Availability Score	2	5	2	2	4	4	1

Source: Company data, Morgan Stanley Research estimates

Stacking up integrated supply chains and manufacturing costs

North America: The US currently imports 90% of its battery volumes from China, and we forecast domestic additions of 400GWh with respect to integrated cell production capacity (Exhibit 76), reducing dependence by 80% across the value chain. While the US IRA has pledged US$31bn in subsidies to localise the value chain, our bottom-up estimate of component capacity indicates the US will remain dependent on China and Asia for separator capacity, as investment in this area has been lacking. Overall we estimate only 150GWh (20%) of cell capacity will be fully integrated with 750GWh (85%) of capacity supported by key domestic cathode material processing.

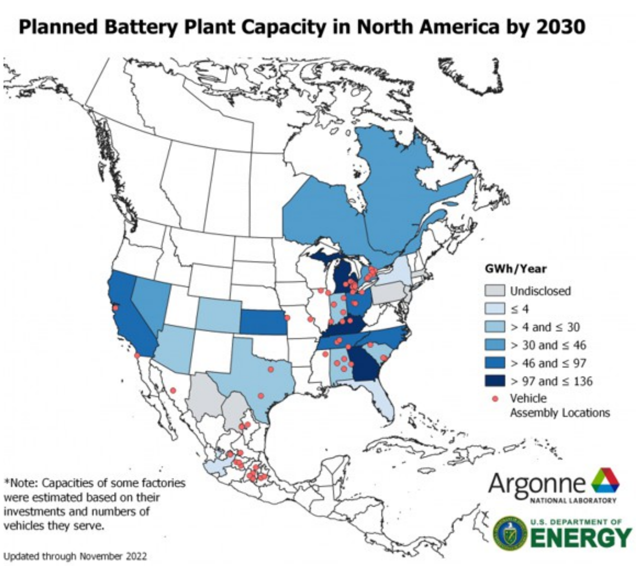
Europe: New capacity investment has slowed significantly, with major producers who were looking to diversify production out of Asia being lured away from Europe by the US's IRA subsidies. Europe currently imports 80% of its annual battery demand from China and plans to end its reliance by 2027. It plans to add 300GWh of integrated cell production capacity, reducing dependence by 75% across the value chain. The EU has pledged US$7bn in subsidies to date to localise production, and may launch its version of the US IRA this year, potentially doubling planned subsidies. Our bottom-up estimate of component capacity indicates Europe will still remain dependent on China and Asia for anode, electrolyte and separator capacity.

Overall, we estimate nearly 100GWh (15%) of capacity will be fully integrated from individual component processing and potentially 650GWh (95%) of capacity supported by critical domestic cathode material processing.

Southeast Asia: The region currently has minimal cell manufacturing capacity despite significant raw material resources. Policy pushes in Indonesia and Thailand, as well as export bans on nickel by Indonesia, have driven significant investment by key manufacturers LGES, CATL and Samsung SDI into the region to develop an integrated supply chain (Exhibit 77). Local players such as Energy Absolute, GPSC and VinES have also committed to cell manufacturing capacity. Investments in Indonesia total US$10bn to date, with capacity commitments of 30GWh (50% of ASEAN manufacturing capacity by 2025). Indonesia's target of 140GWh of cell production should allow it to support the region's demand for batteries by 2030. Localisation of several components, however, remains limited with firms committing largely to cathode and anode material investments with a 70GWh gap of electrolyte and separator capacity. Southeast Asia will likely import electrolytes and separator materials from China and India given the scale of manufacturing and low value add of these components.

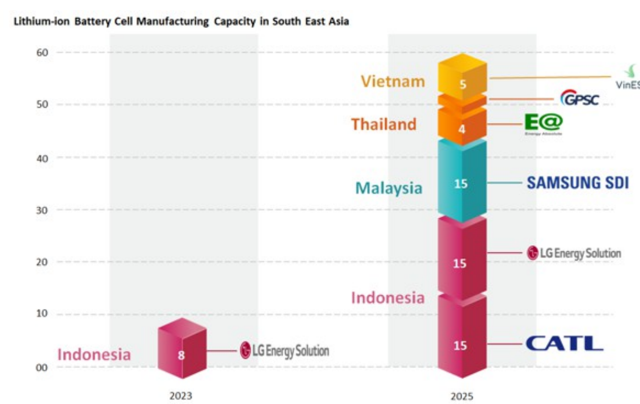
South Korea and Japan: Local battery value chains are highly integrated, importing mainly electrolytes, as the availability of LiPF6 is limited domestically. Japan and Korea plan 1TWh of cell manufacturing capacity by 2030, supported by 0.8TWh of planned domestic cathode production capacity. Although they currently meet 5% of global cell and cathode material demand, we see both nations contributing less as their domestic manufacturers focus on overseas expansion. Korean and Japanese manufacturers are leveraging the global policy push to expand capacity, namely in the US, Europe and China. The Korean government has also committed US$5.3bn of financing support for domestic manufacturers to expand capacity in the US.

Exhibit 76: Planned battery capacity in North America nears 1TWh/yr



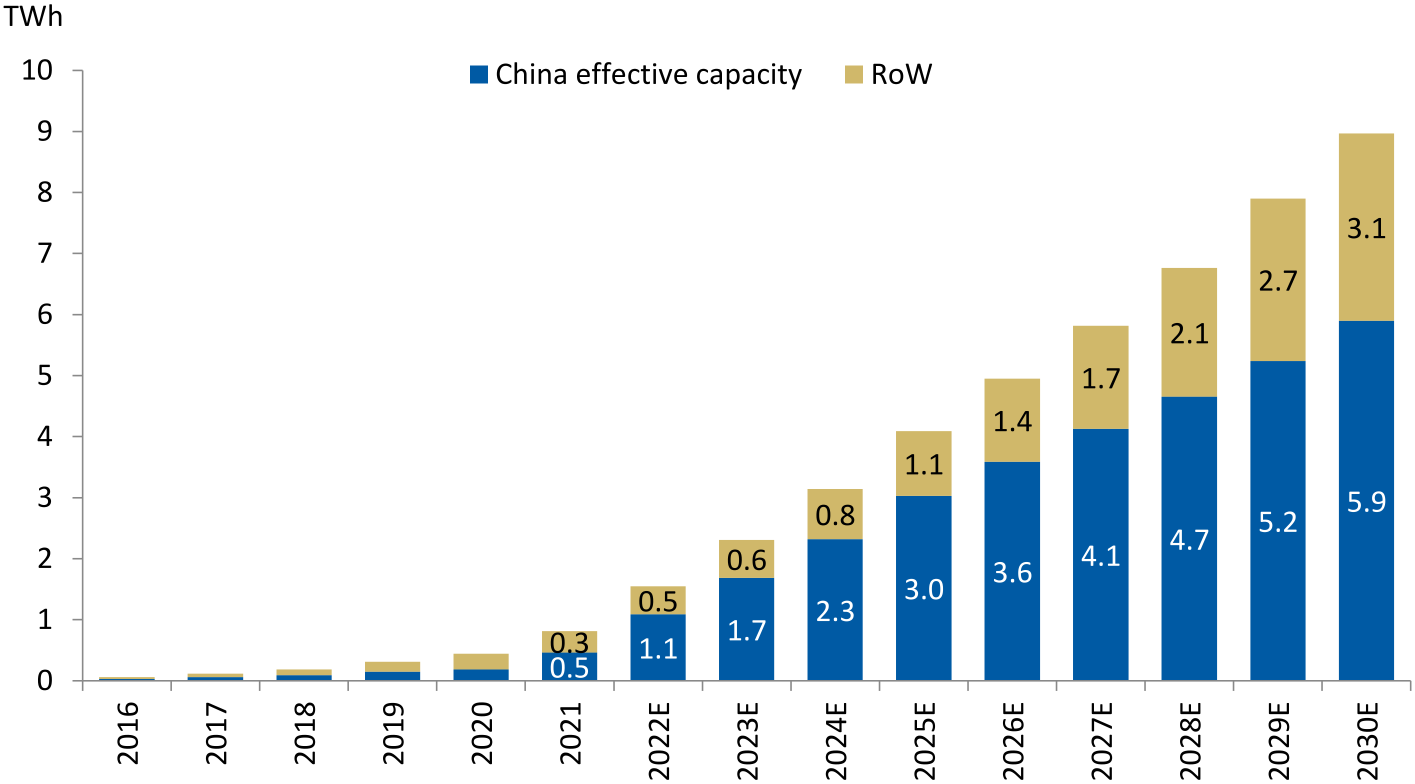
Source: Argonne National Laboratory, US DOE

Exhibit 77: Lithium-ion battery cell manufacturing capacity in Southeast Asia will be done mainly though global partnerships



Source: BNEF, Morgan Stanley Research

Exhibit 78: The value chain is shifting away from China due to supply localisation



Source: Company data, Morgan Stanley Research estimates

China: The country currently supplies 80% of the world's Li-ion batteries and has the most integrated supply chain as years of policy support bear fruit. Chinese battery players have benefited from US $20bn in subsidies, creating 1TWh of integrated capacity with unparalleled scale and cost efficiency, with plans to reach 5TWh by 2030. Chinese manufacturers, faced with the threat of supply chain localisation globally driven by energy security in a multipolar world, have expanded globally with Gotion and CATL investing over US$10bn of capacity in the US, Europe and Southeast Asia. Despite efforts globally to localise supply chains we expect Chinese battery component exports to continue filling the gaps in multiple segments.

India: India aims to become a battery manufacturing player, with the government announcing an initial capacity target of 50GWh with subsidies totaling US$2.4bn under the PLI scheme having a requirement of 60% domestic value add. As India lacks battery raw materials (40% of costs), successful bidders Ola, Rajesh Exports and Reliance would have to fully integrate component manufacturing locally in order for battery cells to qualify for subsidies. We see India as slightly behind the curve with insufficient investment commitments in cathode production capacity. Reliance has invested in Lithium Werks (LFP technology) and Faradion (Na-ion technology) to bridge the capability gap and could look to commercially mass produce cathode materials for the domestic market to fill the current 20GWh+ gap.

Policy Support & Capital Costs

Exhibit 79: Policy support drives capacity increases as production-linked incentives reduce payback period and improve ROCEs of battery manufacturers

Policies	US	Europe	Japan	Korea	India	Indonesia	Thailand
Key Schemes	Inflation Reduction Act	Important Project of Common European Interest (IPCEI)	METI subsidies	Loans & Tax Credits	Production Linked Incentive	Export ban	EV battery production incentive package
Electrode Active Materials	10%		50%				
Cells	US$ 35/kWh						
Modules	US$ 10/kWh				~US$ 9.8/kWh		US$ 11-23/kWh
Modules that do not use cells	US$ 45/kWh						
Other Financing				25%			
Total Subsidies (US$bn)	**30.6**	**6.71**	**3.4**	**5.3**	**2.4**	**NA**	**0.7**
Capex Costs (US$mn/GWh)	130.0	100.0	100.0	80.0	70.0	110.0	86.7
Capex Costs (W. 3 years of subsidies) (US$mn/GWh)	**91.0**	**89.6**	**67.9**	**80.0**	**60.3**	**110.0**	**86.7**

Source: Morgan Stanley Research

US Inflation Reduction Act

Since its introduction in late 2022, the US IRA has attracted over 100GWh of new production cell capacity investment. We see further capacity investments continuing to increase as cell production costs post subsidies could reach US$96mn/GWh, below even Chinese factories at about US$99mn/GWh. Qualified manufacturers are able to get subsidies on:

- **Electrode active materials,** 10%
- **Cells,** US$35/kWh
- **Modules that do not use cells,** US$45/kWh
- **Critical materials,** 10%

European IPCEI (Important Project of Common European Interest)

Member states will provide up to US$6.7bn in funding in the coming years and are expected to unlock an additional US$15bn in private investment. The incentives will focus on battery innovation and technological advancements in raw material mining and electrode chemistry rather than the mass production of batteries. We expect the EU to launch its version of the IRA, which could budget for battery production subsidies.

Indonesia's strategy

Indonesia has the world's largest nickel reserves and is seeking to shore up 20 years of growth with a manufacturing drive, shifting the dynamics from a commodity supplier to a value-added manufacturing hub. Indonesia's differentiated approach to advance its battery ambitions include an export ban on raw nickel ore and setting up the state-owned Indonesia Battery Corporation (IBC), which co-invests in battery projects across the country. Since 2020, foreign buyers of Indonesian nickel must now invest in domestic smelters and process the raw material locally. To date, Indonesia has attracted US$15bn of investment under consortiums led by LGES and CATL in partnership with local mining companies and IBC. Indonesia plans to install 140GWh of battery production capacity by 2030.

India's Production-Linked Incentives

Around 110GWh worth of proposals were submitted for a 50GWh Advanced Chemistry Cell (ACC) scheme with US$2.5bn in subsidies. This indicates the strong investment interest of local players despite the current lack of domestic capacity. Among the successful bidders, key names included Reliance New Energy Solar Limited (5GWh), Ola Electric Mobility Private Limited (20GWh), and Rajesh Exports Limited (5GWh). Key terms for successful bidders:

- **Within two years:** Minimum 5GWh capacity, at least 25% domestic value addition and investment minimum of US$31mn/GWh.
- **Within five years:** Minimum 60% domestic value addition.
- **The incentive will be disbursed over a period of five years** on the basis of energy efficiency, sales, battery life cycle, and localisation levels.

South Korea's financial support

South Korea will provide US$5.3bn in financial support for its battery makers seeking to expand capacity in North America. Support includes lowering lending rates and insurance premiums by 20%, and providing more loans and tax credits. LGES, SKI and Samsung SDI have heavily invested in US-based production facilities and should benefit from a double dose of subsides from South Korea and the US IRA.

Japan's METI subsidies

Japan announced US$2.6bn in subsidies aimed at ensuring a stable battery supply chain in the country. A facility should be capable of producing more than 3 GWh/yr of EV batteries and more than 300 MWh/yr of storage batteries to qualify for the subsidies. US$1bn of subsidies have been allocated to a >20GWh battery production plant by Honda and GS Yuasa with a total investment of US$3.1bn.

Thailand Battery Incentive Package

Battery manufacturers with less than 8GWh capacity will receive a subsidy of between US$11 and US$18 per kWh, while a factory of 8GWh or more will receive between US$18 and US$23 per kWh. The subsidies should help reduce the prices of batteries and increase EV and ESS adoption. The ministry has seen several foreign investors inquire about the subsidy package.

Hydrogen: Underappreciated Alpha

Hydrogen is seen by many as an effective solution to decarbonising polluting industrial sectors. Many countries have made this energy vector a central element of their energy transition strategy with a view to drastically reducing industrial emissions, storing electricity and propelling the mobility of tomorrow.

Hydrogen is an old technology and has seen two boom and bust cycles (Exhibit 83) and hence there is a lot of experience by industry players on using the fuel, but what was lacking is the scale so that it can be more competitive vs. alternatives like gas, coal and oil. Apart from the falling cost of renewables, we believe three factors will reduce the cost of green hydrogen in the coming years. This combined with the potential for blue hydrogen (using CCUS) and IRA/other government subsidies could reasonably make hydrogen competitive vs. LNG. We believe hydrogen's evolution has potential to follow a path similar to LNG adoption 40 years ago. While there are still challenges to green H2 adoption, such as the availability of desalinated water and transport costs, we believe industrial adoption will drive lower costs for green hydrogen. Hence multiple countries like US and India are adopting a cluster/Hub model to raise adoption of green hydrogen

1) Improving electrical efficiency for alkaline electrolysers. While alkaline electrolysers are considered to be the most mature technology (Exhibit 81), they still have the potential to see further increases in electrical efficiency. Current estimates for electrical efficiency are 65%, which we believe can reach 80%. In the past few years, new electrolyser designs have reported very high efficiency, such as Hysata's capillary technology (80% efficiency on a low heating value basis) and Sunfire's high-temperature electrolysers (84% efficiency on a low heating value basis). An increase in electrical efficiency from 65% to 70% would help drive down the cost of hydrogen by about US$0.44/kg.

Measures which are being undertaken to improve efficiency include reducing diaphragm thickness, redesigning catalyst compositions, increasing the limit for operating temperatures, and introducing new porous transport layers.

2) Improvements in technological design for Proton Exchange Membrane (PEM) electrolysers. Given the high cost of rare earth materials (platinum and iridium are key components in the membrane or separator, accounting for around 20% of stack costs) (Exhibit 83), the technological push has been to find ways to reduce the amount of rare earth materials required by reducing the thickness of the membrane. Studies so far indicate that technological improvements can lead to a reduction of platinum and iridium use by a factor of 3-5x. The reduction in stack costs will help to drive down the overall cost of hydrogen by US$0.03/kg, we estimate.

3) Increasing scale of manufacturing for electrolysers and increasing electrolyser capacity size should lead to significant economies of scale and reductions in cost. Electrolyser manufacturing capacity is expected to scale from 8GW in 2021 to 65GW in 2030 while electrolyser capacity is expected to scale from MW terms to GW terms. Consequently, we think the capital costs for electrolysers can decline to US$0.3mn/MW for alkaline electrolysers and to US$0.5mn/MW for PEM electrolysers. The corresponding decline in capital costs helps to lower the overall cost of hydrogen by US$1.48/kg.

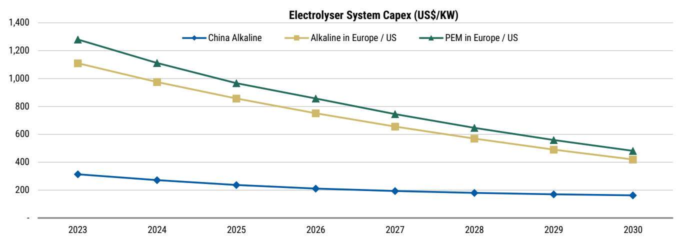
Hydrogen transport: Currently in the exploratory stage with proof of concept the goal thus far. Given the low volumetric density of hydrogen and its low boiling point (-253°C), we think the practical near-term commercial steps for its transportation will center around piped transportation and conversion to ammonia (Exhibit 84), which has higher volumetric density, making shipping more cost effective. In addition, ammonia already has a significant global supply chain given its role as a feedstock for fertiliser and industrial chemicals production.

Hydrogen Council studies so far indicate that for distances up to 500km, retrofitted pipelines can reach a cost level of US$0.1/kg of H2. Retrofitting distribution pipelines has an estimated capex of US$0.1-0.2mn/km compared to capex of US$0.3-0.7mn/km for new pipelines. For ammonification, cost estimates indicate a level of US$0.8/kg of H2 can be achieved.

Green hydrogen adoption pace: Over the last two years green hydrogen's adoption pace has accelerated from announcements of targets/intentions in 2020 to having successful prototypes and conducting pilot studies, to discussions on commercial scale adoption in 2023. For instance, Hyzon Motors, a global supplier of zero emission Fuel Cell Electric Vehicle (FCEV) trucks, with an order book of US$60mn (March 2022) has commenced commercial trials in Europe under commercial agreements in CY1Q23. At a volume of 1,000 FCEV trucks, Hyzon estimates the total cost of ownership (TCOE) is 25% above diesel trucks without subsidies, at US$1.02/km, while with subsidies an FCEV truck is largely on parity with a diesel truck's TCOE of US$0.81/km.

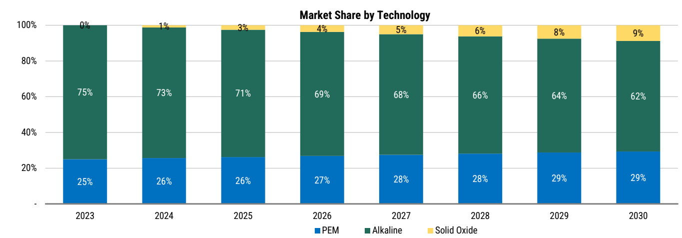
Oil India (OILI) commissioned a green hydrogen pilot plant in April 2022 with a 500kW solar plant and a 100kW Anion Exchange Membrane (AEM) electrolyser array, producing 10kg/day green hydrogen in Assam. The pilot was a success, and the company estimates it will take 2-3 years to start commercial-scale operations. In fact, the US power sector will see four or five minor green hydrogen projects, with hydrogen generating capacity ranging from 10-60kg/day, come online this year. One of the companies, Air Products (via a JV with ACWA Power named NEOM Green Hydrogen), was awarded an EPC contract for a commercial 600 tonnes per day green hydrogen project in February.

Exhibit 80: Electrolyser system costs are expected to come down meaningfully with China continuing to be the lowest cost



Source: BNEF, Morgan Stanley Research

Exhibit 81: Alkaline electrolyser technology expected to remain the dominant technology form



Source: Morgan Stanley Research estimates

Exhibit 82: Overview of electrolyser technologies

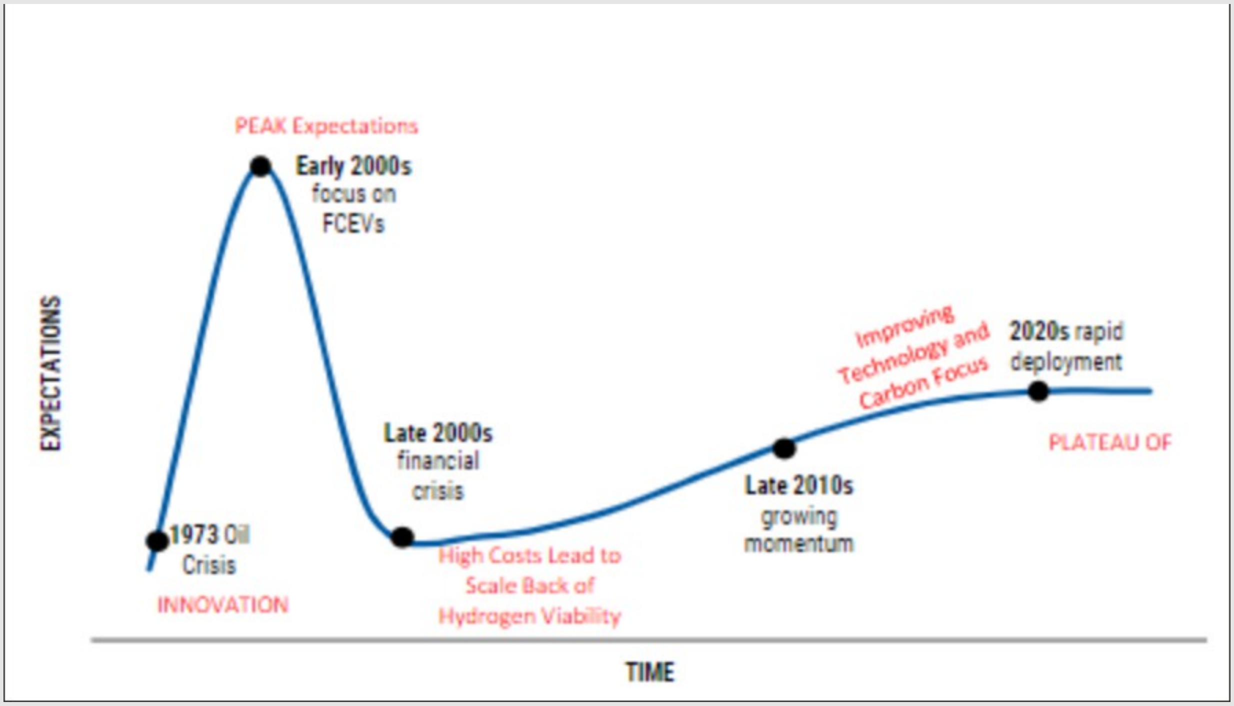
	Unit	Alkaline	PEM
Space Requirement	m2/Kwe	0.095	0.048
Water Requirement	Litre/kWH	9	9
Electricity Requirement	kWh/kgH2	50	55
Electrode		Asbestos & Nickel	Iridium & Platinum
Output Pressure	bar	1-30	30-80
Electrical Efficiency		66%	58%
Capital Cost	US$/KWe	500-1400	100-1800
Lifetime	years	20-30	10-20
Start-Up Time	min	>30 min	<30 min
Flexibility		Low	High

Source: Morgan Stanley Research

Green Hydrogen's Boom and Bust Cycles

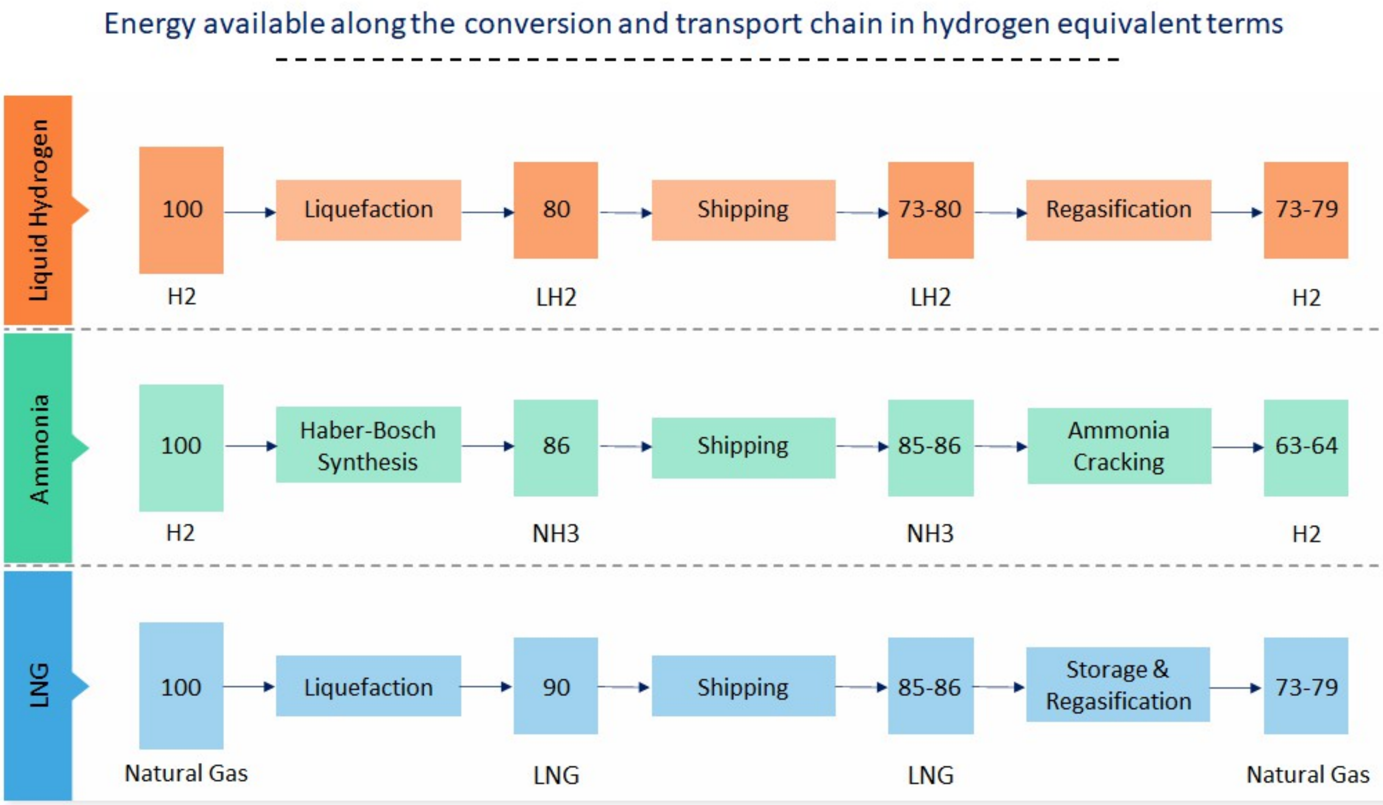
Over the past few decades, the world has experienced no less than two major hydrogen demand booms, both of which fizzled out due to cost competitiveness. However, we see that changing as the cost to produce becomes competitive vs. natural gas and green H2 finds application in heavy industries.

Exhibit **83**: Hydrogen cycle: A more sustainable plateau is underway after two boom cycles in the 1970s and 2000s



Source: IRENA, Morgan Stanley Research

Exhibit 84: LNG and hydrogen transportation economics: We believe a cluster model of various heavy industries and producers to build a green H2 ecosystem will help lower initial adoption costs



Source: IEA, Morgan Stanley Research

Exhibit 85: Economics of an alkaline electrolyser

Alkaline-based LCOH (€/kg)			Cost of electricity (€/MWh)																
Total upfront capex (€mn/MW)		2.28	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
0.8	0.3	0.3	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.2	3.5	3.7	4.0	4.2	4.5	4.7	5.0
1.3	0.5	0.45	1.5	1.7	2.0	2.2	2.5	2.7	3.0	3.2	3.5	3.7	4.0	4.2	4.5	4.7	5.0	5.2	5.5
1.7	0.6	0.6	2.0	2.2	2.5	2.7	3.0	3.2	3.5	3.7	4.0	4.2	4.5	4.7	5.0	5.2	5.5	5.7	6.0
2.1	0.8	0.75	2.5	2.7	3.0	3.2	3.5	3.7	4.0	4.2	4.5	4.7	5.0	5.2	5.5	5.7	6.0	6.2	6.5
2.5	0.9	0.9	3.0	3.2	3.5	3.7	4.0	4.2	4.5	4.7	5.0	5.2	5.5	5.7	6.0	6.2	6.5	6.7	7.0
2.9	1.1	1.05	3.4	3.7	3.9	4.2	4.4	4.7	4.9	5.2	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4
3.4	1.2	1.2	3.9	4.2	4.4	4.7	4.9	5.2	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	7.9
3.8	1.4	1.35	4.4	4.7	4.9	5.2	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	7.9	8.2	8.4
4.2	1.5	1.5	4.9	5.2	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	7.9	8.2	8.4	8.7	8.9
4.6	1.7	1.65	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.2	7.4	7.7	7.9	8.2	8.4	8.7	8.9	9.2	9.4
Context								Current average US wind/solar LCOE							Current average EU wind/solar LCOE				

- EU Grey Hydrogen cost at 2025 TTF price (€3.3/kg)
- EU Grey Hydrogen cost at 2025 TTF price + MS 2025e CO2 price (€130/t)
- EU Grey Hydrogen cost at 2025 TTF price + MS 2030e CO2 price (€140/t)

Source: Morgan Stanley Research

The Cost of Green Hydrogen

Green Hydrogen Producer Cost Deflation = Electrical Efficiencies & Design Improvements

Asia will spearhead the deflation in green hydrogen, driven by cheaper and more efficient electrolysers and the lower cost of green electrons. Substantial production subsidies in the US should bring the cost of production close to Asia, but we think US$3/kg of green H2 subsidies will make exports very competitive and enable the scale benefits that can then start the virtuous cycle of cost deflation and adoption. The lack of subsidies and higher cost of green electrons in Europe is a key hurdle for limited cost savings.

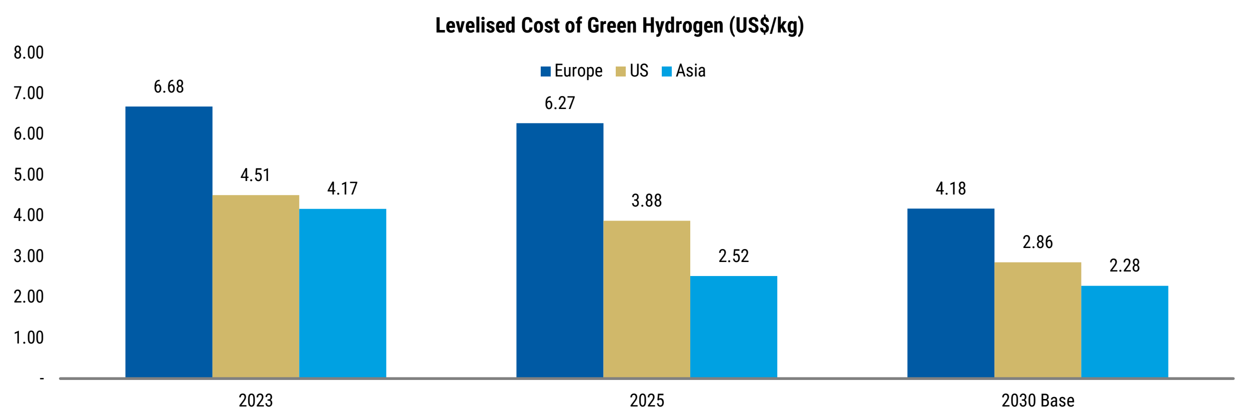
"Scale and automation achieved at the gigafactory will allow Plug to lower our electrolyser costs by as much as 60 to 70 percent in the next several years" – Plug Power

Asia: Government Push + Technologies + Cheaper Input Costs: We estimate the levelised cost of hydrogen will decline from US$4.17/kg in 2023 to US$2.28/kg in Asia by 2030. The first leg of cost savings will come from increasing electrical efficiency through design improvements, followed by electrolyser manufacturing scale through 2030. The latter half of the decade should also see producers leveraging lower solar equipment costs. We reflect these cost savings in both our electrolyser manufacturing capex, which declines 40%, and electrical efficiency, which increases from 60% to 75% between 2023 and 2030. Scale adoption in the industrial sector, especially refining and fertilisers, we believe, is key to help scale the adoption of green hydrogen. We also see hydrogen hubs helping to scale adoption as transporting hydrogen raises overall costs.

US: IRA drives supply chain investments: We estimate the levelised cost of hydrogen production will decline from US$4.51/kg in 2023 (without federal credits) to US$2.86/kg, by 2030. The main drivers of lower hydrogen production costs include **(i)** improved electrolyzer efficiency, **(ii)** falling cost of renewables, and **(iii)** the IRA, which provides up to $3/kg of tax credit subsidy for clean hydrogen producers.

Europe: Higher cost of green electrons: We estimate the cost of hydrogen will decline from US$6.68/kg in 2023 to US$4.18/kg by 2030 as electrolyser capex declines from US$2.2mn/MW to US$1.1mn/MW on manufacturing scale and design advancements. The higher cost of green electrons in Europe vs. the rest of the world is key to its much higher cost of production. Having said that, our calculations for the cost of green hydrogen are based on the average cost of green electricity in Europe, while we reckon large projects may initially be developed in locations with strong renewable resources and thus benefit from significantly lower costs than the headline numbers we present here. We also note that the upcoming EU renewable hydrogen pilot auction (to be run in the autumn, with results potentially around mid-2024) could lead to subsidies for green hydrogen production, which could help the economics in the region.

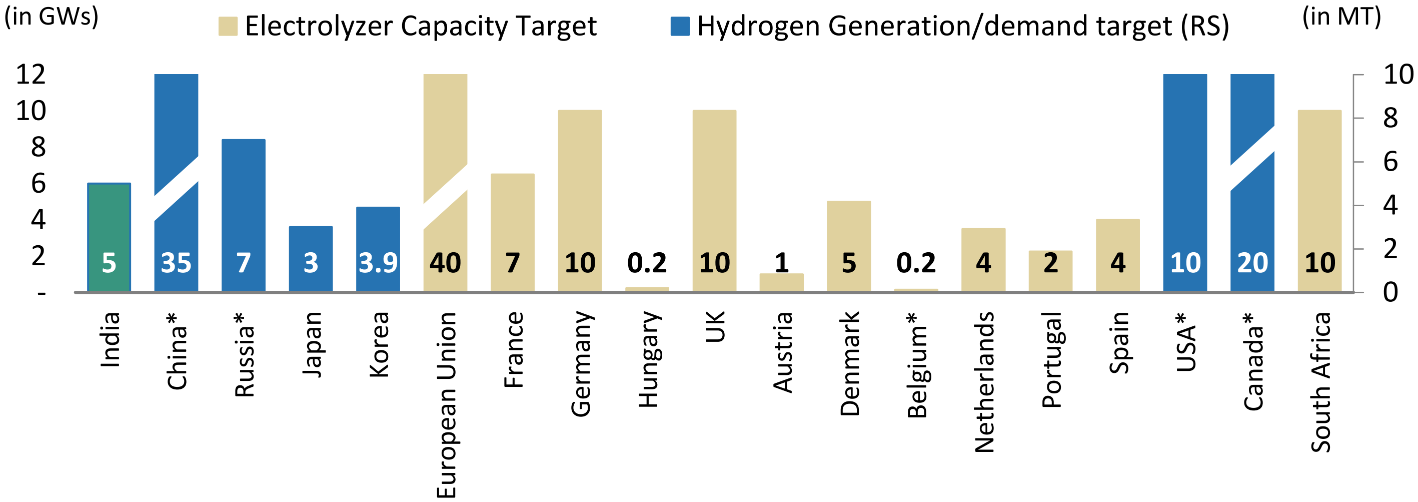
Exhibit 86: Globally we expect green H2 cost declines, led by Asia and the US



* US and Asia calculations based on Alkaline electrolysers and Europe based on PEM electrolysers
Source: Morgan Stanley Research estimates

Green Hydrogen: Evolving Supply Chains for Demand and Production

Exhibit 87: Hydrogen targets by country (2030)



Source: IEA, Niti Ayog, Morgan Stanley Research. Note: *China and Russia timelines are for 2035, *USA for 2031, *Belgium for 2026, Canada by 2050

We see significant supply chains being developed locally for low carbon hydrogen (Exhibit 87) as countries with access to cheaper renewables, especially solar, grow the manufacturing and distribution supply chains, while renewable/conventional energy players expand their returns by growing more downstream and decarbonising operations, respectively. The manufacturing supply chain for green H2, especially electrolysers and the downstream demand value chain, is evolving a lot quicker than expectations across heavy industries, though less on the mobility side.

Developing local chains also helps lower the transportation cost for green hydrogen, which currently is a key bottleneck to the adoption of green hydrogen by industry. Hence, countries like India and the US are not only developing manufacturing supply chains but are also promoting the development of green hydrogen hubs where consumers of green hydrogen like refineries, fertilisers, steel and conventional power producers (which can blend green H2) come together and H2 can be transported via pipelines at lower cost. Other forms of incentives like zero transmission charges are being given to renewable electricity produced for green hydrogen to reduce the cost of green H2 production and transportation.

Supply chains in the US/Europe: Attractive economics for green hydrogen in the US following the passage of the IRA have multiple implications. One of which is that the US could start setting up green ammonia export hubs on the East Coast to serve European markets and on the West Coast to serve Asia (Japan and South Korea). In Europe, the focus on shifting away from Russian natural gas is expected to drive growth in green hydrogen. Interestingly, offshore hydrogen production has emerged as a likely form factor for hydrogen production in Europe. Recently we saw similar announcements by US government to support (with $7bn in funding) regional clean H2 Hubs.

Supply chains in Korea/Singapore and Middle East: Singapore corporates have entered partnerships to explore the transportation of green H2/ammonia from Australia and the Middle East in line with the government's push to have low-carbon hydrogen potentially support up to 50% of power needs by 2050. Korean corporates have similarly signed agreements for the import of low-carbon hydrogen/ ammonia from Australia, Middle East and Chile.

India's 'Hydrogen Valley' approach: This is a defined geographical area where hydrogen serves more than one end sector or application in mobility, industry, and energy. This typically covers all the necessary steps in the hydrogen value chain, from production (and often even dedicated renewable electricity production) to subsequent storage, and its transport and distribution to various off-takers.

Demand is shaping up for green H2. We believe heavy industries will be the first to adopt green H2 and provide the base level volumes needed to support adoption and lower costs. Companies that already have the experience and infrastructure to handle hydrogen will be first adopters, and these include refineries and fertilisers, followed by steel manufacturers.

Fertilisers: Fertilisers like urea have higher demand for hydrogen and ammonia, hence they should be able to provide the scale along with refiners to lower the cost of green hydrogen and raise adoption. We did see fertiliser prices using green hydrogen being priced at a premium to normal urea prices. The governments of India and China are mandating the use of green hydrogen in the fertiliser sector to quickly raise adoption of new and existing capacities.

Refining: The industry is one of the largest end markets for hydrogen, at around 40mnt/year. As a result, oil majors already have a foothold in the production, use and distribution of hydrogen. Several oil majors are already actively developing large, centralised, clean hydrogen production facilities.

Steelmaking via H2-DRI-EAF (which stands for Hydrogen-based Direct Reduced Iron with Electric Arc Furnace) looks most viable today, costing mills about US$1,200/tonne of capacity. In Europe alone, adoption would require mills to incur US$130bn in direct capex (0.8x of market cap post 50% grants), and would require: an 8% increase in power generation, >5mt in green hydrogen capacity (with insignificant production today), and would theoretically require 120mt of direct reduction-grade pellets – double the current global supply. **Given the scale of the global steel industry, any meaningful shift towards green steel production** could have a significant impact on global hydrogen demand, though demand may initially be for blue hydrogen (carbon capture based) and then green hydrogen. Europe's inability to supply enough green hydrogen domestically may boost the seaborne hydrogen trade as well.

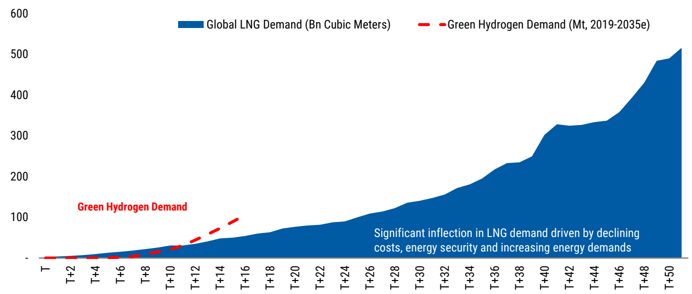
Hydrogen Today = LNG in the 1970s

We see similarities between the situation of LNG in the 1970s and hydrogen today (Exhibit 90), both in terms of challenges to adoption as well as drivers for adoption (Exhibit 88). In the 1970s, supply chains for LNG were considered expensive to develop and transportation unviable – similar to the debates we see in green hydrogen/ammonia today. The adoption curve was slow and government incentives supported the demand growth. In 1970s, the oil shock drove a focus on LNG, while we believe the 2022 energy shortages have raised the focus on alternative fuels like green H2, such that dependence on imported energy reduces.

The scale of adoption really picked up when power plants shifted from diesel and coal towards LNG, and we are starting to see a slow but similar trend in adoption of green H2 in the power sector – the big consumer of gas today. Adoption of green H2 with other industrial applications, however, could see a faster ramp-up. As a technology, green hydrogen has gone through two boom and bust cycles and, hence, the ability and experience for the industry to enhance adoption looks more certain, though we fully appreciate the technology here is not like Moore's law in integrated circuits.

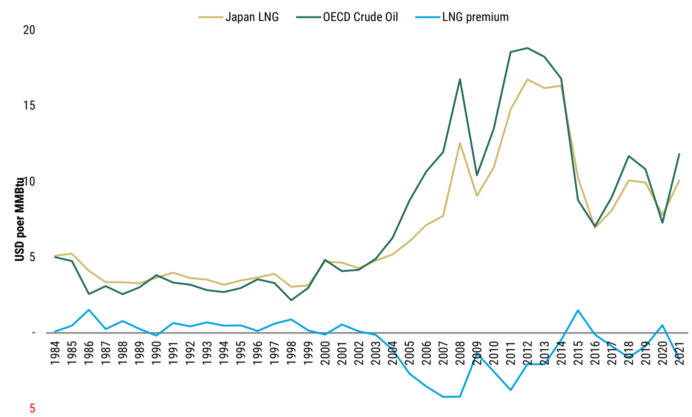
The key risks: LNG has a volumetric energy density advantage compared to new fuels. Liquid hydrogen, ammonia and methanol have 34%, 51% and 63% of the volumetric energy density of LNG, respectively. In other words, it takes about two cubic meters of ammonia to match the energy output of one cubic meter of LNG. To achieve the same sailing distance, fuel tanks for liquid hydrogen would need to be at least three times the volume of those for LNG as a consequence of the large amounts of insulation required. For ammonia, the tank size ratio is approximately two to one compared with LNG and in the case of methanol, tank sizes are equivalent.

Exhibit 88: Global LNG demand – Potential for green hydrogen to follow a similar path



Source: BP Statistics, IEA, International Gas Union, Statista, Morgan Stanley Research estimates

Exhibit 89: LNG had been more expensive relative to oil until the trend reversed in the 2000s



Source: BP Statistics

Exhibit 90: LNG (1970s) vs. hydrogen today: Similar challenges in adoption for industrial applications

	LNG (1970s)	Hydrogen
Challenges to Adoption		
Infrastructure Challenge	- Specialized shipping vessels, storage and regasification facilities required - Significant land also required for onshore regasification	- Electrolyser manufacutring costs remain high - Lack of transport infrastructure with liquification, hydrogen carriers such as Ammonia and pipelines being explored - Significnat loss of energy when hydrogen is shipped in liquid form and regasified
Cost Challenge	- Pricing premium with low oil prices in the 1970s providing a challenging pricing environment - Pipeline supplies of natural gas for various geographies also were more economical, particularly in Europe	- Pricing premium for green hydrogen given high capex and electrolyser manufacturing costs - Existing costs of grey hydrogen are significantly lower than green hydrogen
Safety Concerns	- LNG is highly flammable and uncontrolled releases could lead to explosions, resulting in concerns over transportation	- Hydrogen also posseses explosion risks and has lower ignition energy vs gasoline or natural gas

Source: Morgan Stanley Research

Exhibit 91: Countries are ramping up in hydrogen acceptability and securing supply contracts

	Singapore	Malaysia	Thailand	India	China	Korea	Japan	Australia	US	Europe
Imports/ Exports	Net Importer Semcorp plans to import Hydrogen in 5 years with Japanese JV. Keppel working with Woodside Petroleum to import Liquid Hydrogen from Australia	Net Exporter		Net Exporter MoU signed between Greenko and Keppel to explore hydrogen exports by 2025-26	Net Exporter	Net Importer	Net Importer	Net Exporter	Net Exporter	Net Importer
Hydrogen Production		SEDC Energy & Sumitomo Corp to develop 1k ton H2 production facility by 2023. SEB operates a 130KG Green Hydrogen Plant and has plans with Korea for 7k ton green H2 facility. Petronas produces blue hydrogen as a byproduct of its LNG production process, plans to explore commercial production of green hydrogen	EGAT to explore hydrogen production in Thailand BIG (largest H2 producer in thailand) developed a 12k ton Hydrogen production plant	Reliance Industries targets green hydrogen production at US$1/kg by 2030 Adani Enterprises targets 1mtpa green hydrogen production capacity by 2030 ACME invests US$6.2bn in Karnataka to set up green hydrogen and ammonia plant. Initial targeted capacity 1.2mtpa	Shell starts up hydrogen electrolyser in China with 20 MW production capacity with plans to scale to 60M, Shanghai Electric Power to develop Hydrogen plant. Beijing Hypower Energy to Develop worlds largest H2 station with 5 tonnes a day capacity (600 H2 fuel cell vehicles) China Petrochem to develop largest Green H2 facility (20k tons)	Lotte Chemical to invest $3.7bn in the hydrogen economy aims for $2.5bn sales and 10% Operating margin	Mitsubishi Takasago Hydrogen Park planned for 2025, construction in 2023	Origin Energy MoU with Kawasaki on a 300MW/36.5k tons green hydrogen facility for export expected mid 2020s APA trial of hydrogen pipeline. Woodside to build a $1billion Hydrogen plant in Perth FFI Plans for 5.4GW solar and Wind projects and first electrolyser		E.ON and Fortescue signed MoU to ship upto 5mtpa of green hydrogen to Europe by 2030
Power Producers	Keppel Infrastructure, Mitsubishi Power and Jurong Engineering to build Keppel Sakra Cogen Plant to be run on hydrogen by 2026	Tenaga, IHI, Petronas feasibility studies on AmmoniaCoal power plant	PTT's "Hydrogen Thailand Group" to advance Hydrogen as a new alternative energy MoU with ACWA Power, PTT and Electricity Generating Authority of Thailand (EGAT) to develop 225ktpa green hydrogen	ReNew signs MoU with Karnataka government to invest US$6.25Bn over seven years in renewables and green hydrogen projects		KOSPO Operates worlds Largest Fuel Cell Plant, 79MW H2 fuel cell power plant Korea aims for 15GW of fuel cells	First commercial power plant to be built in 2022 (360kW). JERA to use a 20% Ammonia mix in by 2035, aims for 100% ammonia by 2040 and use 30% Hydrogen in gas plants in 2025	EnergyAustralia's Tallawarra B project to use hybrid gas-hydrogen turbines for grid electricity, to be operational in 2023-24	Mitsubishi Power Americas signs purchase contract with HydrogenPro for delivery of 40 electrolysers	
Maritime	Keppel Sumitomo JV for Marine Ammonia Bunkering Sembcorp Marine & Shell trial H2 fuel cells in ships			Cochin Shipyard supply contracts with Norwegian clients to deliver container vessels powered by hydrogen	Launched "Three Gorges Hydrogen Boat" powered by 500 kw fuel cell for inland waterways, built by Jianglong Shipbuilding for Yangtze Power	Trial of a H2 tanker on the way, KSOE expects to hydrogen tankers by 2025	Kawasaki trials first liquid hydrogen shipment from Australia to Japan		Trials conducted by All American Marine (AAM) and SWITCH Maritime (SWITCH)	
Transport sector	Green Light powered with hydrogen and lithium-ion batteries in operation MoU signed for aviation hydrogen hub feasility study	H2X commenced hydrogen cell vehicle production after a MoU with SEDC Energy	National Oil and PTT open hydrogen fueling station in Pattaya	Reliance Industries and Olectra Greentech to commercially launch hydrogen buses by 2024	44 hydrogen-powered buses in operation in Zhangjiakou since Winter Olympics 2022	Hyundai will launch 700 hydrogen buses in Incheon by end of 2024	Commercial Japan Partnership Technologies Corporation (CJPT), Fukuoka Prefecture and Kyushu Railway (JR Kyushu) to collaborate on trials of a small hydrogen fuel cell electric bus in the Kyushu	Origin Energy and the Aluminium Revolutionary Chassis Company (ARCC) partnership unveiled hydrogen powered fuel-cell buses		Deutsche Bahn placed an order for 60 fuel city buses to CaetanoBus (Toyota)
Heavy duty Trucks			Toyota ties up with CP Group to develop Bio-hydrogen delivery trucks	Reliance unveiled H2 ICE trucks in partnership with Ashok Leyland	DHL Express runs pilot for hydrogen frieght trucks in Shanghai 1,000 hydrogen truck order signed with Sino-Synergy Hydrogen Energy Technology and a Construction company	Hyundai Motors launched world's first mass-produced large hydrogen powered fuel cell "Xcient" SK Energy operates hydrogen filling station for heavy duty hydrogen trucks	Toyoto to release hydrogen trucks in 2023	Hyzon conducts commercial trials of locally produced hydrogen fuel cell electric truck	Hyzon Motors delivered 29 FCEV trucks to HongYun, a steel major in China	H2Haul project deploys 16 heavy duty FCEV trucks in Belgium, France, Germany and Switzerland in collaboration with two major European truck manufacturers, IVECO and VDL.
City Gas Blending	Feasibility study by City Energy			NTPC and Gujarat Gas started pilot with 5% Hydrogen blending (targets to reach 20%) in Piped natural gas	Feasibility study	KOGAS and DNV to test viability in 5,000 kms transmission network		ATCO to pilot hydrogen blending (2-5%) in 4Q22	Multiple Pilots/Proposals ongoing with blending at 5-40% range in California, New York. New Jersey, Florida, North Carolina, Ohio, South Carolina, Southeast, Texas, Utah, Virgina	Germany tests 8-20% hydrogen blend - conducted by Netze BW in household pipeline. France, Spain, and Austria blending limit is 4-6%; Switzerland and Finland's is lower at 1-2%
Industries/ Other sectors	Keppel Data Centres to evaluate potential supply of liquid hydrogen from Woodside		Industrial Estate Authority of Thailand (IEAT) in talks with Japan, plans to invest in hydrogen energy in industrial estates/smart parks	Tata Steel initiated trial for hydrogen gas injection in blast furnace Airtel installed fuel cells in data centres (Bloom Energy)		POSCO to invest US$40bn in Australia by 2040; 70% of this will be invested in hydrogen manufacturing, rest in green steel	Panasonic conducts pilot test in Kusatsu plant with hydrogen fuel cells, liquid hydrogen towers, solar panels and Tesla megapack to run the entire plant on renewable/hydrogen sources	Covestro ties up 100ktpa of green hydrogen from Fortescue Future Industries - supply to start from 2024		
Trains				Indian Railways to launch hydrogen powered trains by 2023	Hydrogen train in operation, jointly developed by CRRC and Chengdu Railway group rolled out in Xinjin, China.	Ministry unveiled hydrogen powered electric train developed by Woojin Industrial Systems and Korea Railroad	East Japan Railway Co in partnership with Toyota Motor and Hitachi tested "Hybari" hydrogen fueled train in 2022, commercial services to begin in 2030	Feasibility study	Stadler Rail awarded Ballard Power systems contract to deliver six 100kW FCmove-HD+ fuel cell engines for the delivery of FLIRT H2 type trains to San Bernardino County Transportation Authority (SBCTA). Trains are expected to be operational in 2024	Hydrogen powered passenger trains operational in Germany in regional rail line (buildt by Alstom)

Source: Morgan Stanley Research, news articles

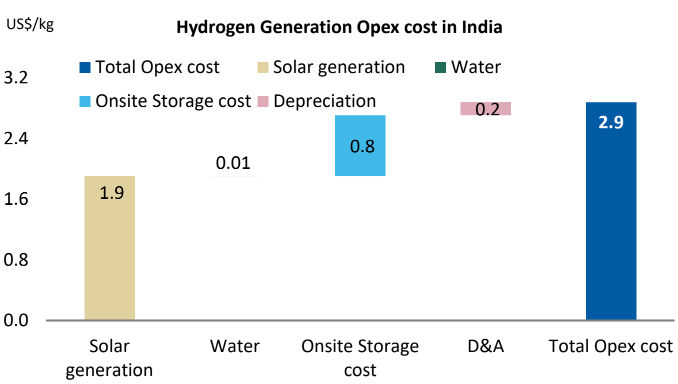
India: Case Study on Green H_2 Cost Reduction

India's grey hydrogen demand is 10% of global demand, and the country has been making quick strides in the adoption of green hydrogen. We have seen multiple companies and state governments make initial plans to use a cluster model to expand usage of green hydrogen. BPCL and the Kerala state government, along with Chart Industries, are looking to develop a hydrogen cluster near the port of Kochi with a US$0.6bn investment for 0.2 mntpa of hydrogen and 150MW of electrolysers (Exhibit 94). Similarly, the Gujarat state government is looking to use the Hydrogen Valley Innovation Cluster to enhance the readiness of technologies in the green hydrogen value chain for manufacturing and deployment as small-scale demonstration.

Comparing India's policy with the US: While India has one of the lowest renewable costs – a key component of hydrogen economics to achieve gas parity – countries like the US are providing US$3/kg in subsidies that could see consumers only pay largely for transportation, as MS estimates cost of green hydrogen in the US to be near the government incentive amount. While India's policy does talk about capex and production-related subsidies, we believe an amount that will put green hydrogen at gas parity implies US$0.5-1/kg of government incentives at the start. The US$2.4bn proposed government incentives could partly be used for this and partly for lower electrolyser costs, but the breakdown is yet not clear. If green H2 production costs fall below US$2/kg and closer to current grey hydrogen costs, government support may not be required. This could be achieved beyond 2025 with corporates like RIL targeting to lower costs to US$1/kg.

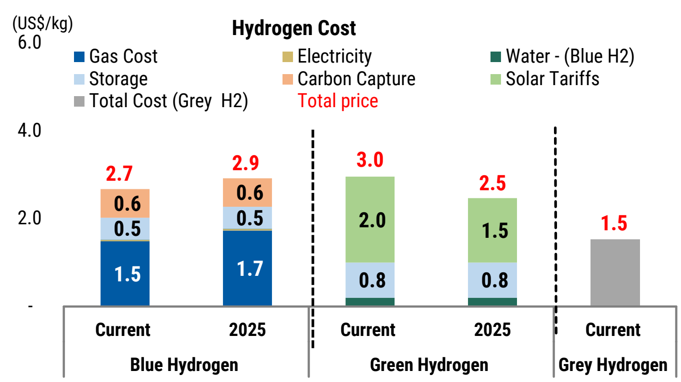
"[I] am sure that India can set an even more aggressive target of achieving under $1 per kg within a decade. This will make India the first country globally to achieve US$1 per 1 kilogram in a decade – the 1-1-1 target for Green Hydrogen" (RIL CEO)

Exhibit 92: India Green H2: Hydrogen production costs in India are still high compared to alternative fuels, but government support is increasing adoption



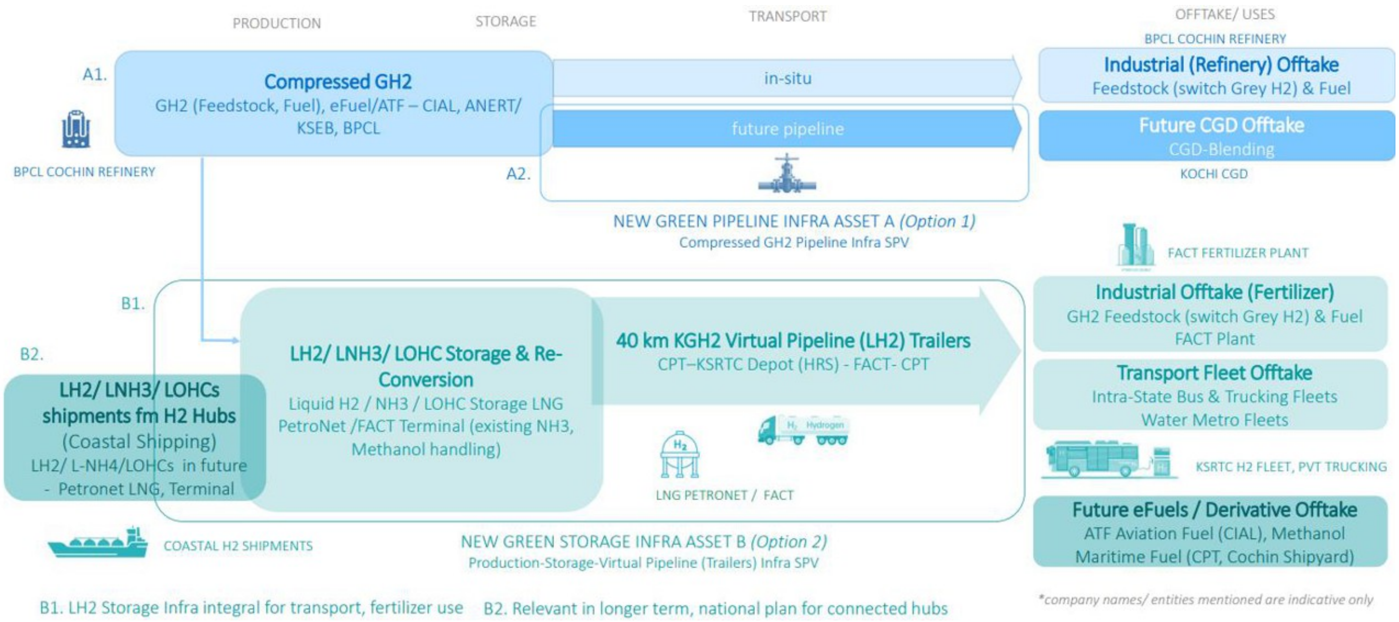
Source: Morgan Stanley Research. Note: Based on 20MW electrolyser economics

Exhibit 93: India: Green vs. blue vs. grey hydrogen economics



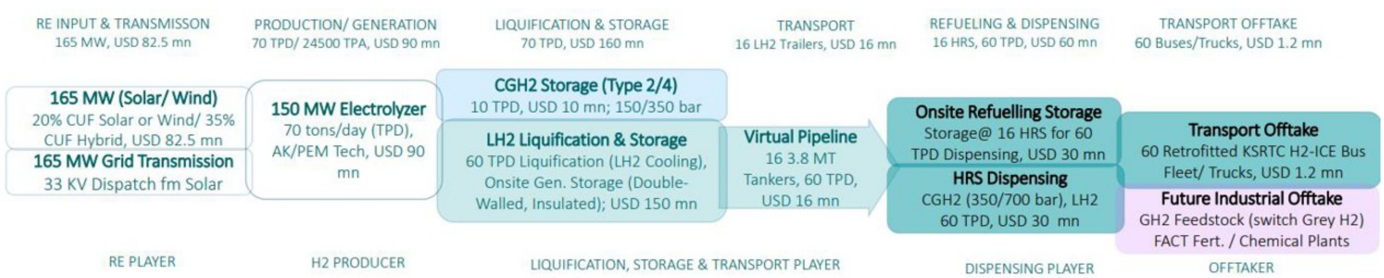
Source: Morgan Stanley Research estimates

Exhibit 94: India: A cluster model being proposed in the state of Kerala would lower costs for industrial users and, if successful, could be a model for raising green adoption locally and for export markets



Source: India Hydrogen Alliance

Exhibit 95: Green H_2 cluster hydrogen economics for Kochi



SN	ELEMENTS OF VALUE CHAIN	TECHNOLOGY	SIZE	UNIT COST	ELEMENT COST	REMARK
1	Renewable Electricity	Solar/ Wind	165 MW	INR 4 Cr/MW	82.5 M$	20% CUF of solar or Wind/ hybrid of 35% CUF
2	Transmission	Microgrid/ Grid	165 MW	-	0	Assuming 33 KV dispatch from Solar
3	Hydrogen generation	Electrolyzer (Alkaline/ PEM)	150 MW	0.6 M$/MW	90 M$	Alkaline/ PEM electrolyzer (Alkaline could be cheaper)
4	Hydrogen storage (CGH2)	Type-2/ 4 (150 / 350 bar)	10 MT	1 M$/MT	10 M$	Cascade based storage in Type-2 (150 bar) or Type-4 (350 bar)
5	Liquification & Storage (LH2)	LH2 Cooling & onsite storage	60 TPD	1 M$/2.5 MT (Storage)	150 M$	LH2 precooling, Double walled insulated tank for stationary storage
6	LH2 transportation	60 cubic mtrs (double walled)	3.8 MT	1 M$/ Truck	16 M$	16 tankers for 60 TPD evacuation daily
7*	LH2 storage (HRS)	Onsite refuelling station storage	60 MT	0.5 M$/MT	30 M$	16 HRS for 60 TPD dispensing
8*	Mobility dispensing	CGH2 (350/ 700 bar) and LH2	60 TPD	0.5 M$/TPD	30 M$	Dispensing into vehicles - CGH2 @ 350/ 700 bar, LH2 onboard storage
9*	H2 ICE mobility	Retrofitted truck and buses	60 Units	INR 0.15 Cr/Unit	1.2 M$	Retrofitted BS-4 (or BS-3) truck/ buses from Kerala state
					410 M$	

*7,8,9 assumes transport offtake only. Alternate industrial offtake can be added to aggregate demand across multiple use-cases.

NOTE: This includes design and EPC costs, but indicative and for preliminary discussions, to be finalized after techno-commercial study.

Source: India Hydrogen Alliance, Morgan Stanley Research

The Cost of Wind Power

Wind Power Deflation = Efficiency Factors – Turbine Cost

We see cost deflationary pressures from turbine efficiency gains offset by more expensive turbines as manufacturers seek to normalise margins in a potentially undersupplied market. We expect a 2.5% increase in capacity factor for every 50m increase in rotor diameter.

Limited scope for significant deflation: The equipment cost for wind power is unlikely to significant deflate. As machines and components become larger, we are seeing higher rates of component failures. This is translating into higher warranty provisions for incumbents like Vestas, GE, and Siemens, among others. The conclusion is that the recent shift to bigger, more cost-effective machines is essentially pushing their physical limits and causing performance issues.

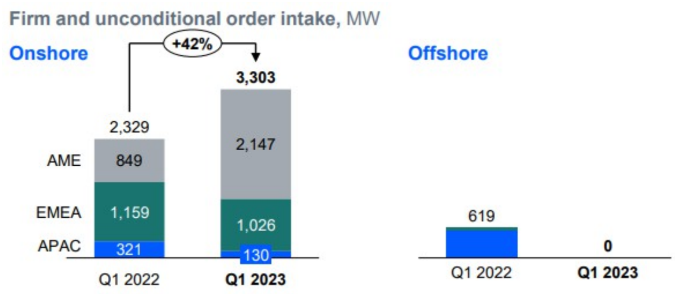
Manufacturing costs have substantially come off from the highs of 2022 (our MS Wind OEM Cost Index has reduced to 126 (i.e., 26% above pre-COVID levels), down from a reading of >200 in mid-2021. However, we believe the cyclical cost deflation story has played out, and we see limited scope for significant downside to costs from current levels, given that key costs such as wages and components, which are sticky, are steadily inching up.

Asia: Manufacturing margin normalisation: We estimate the levelised cost of electricity from onshore wind will decline from ~US$50/MWh in 2023 to ~US$42/MWh by 2030, while LCOE from offshore wind will decline from ~US$98/MWh to US~$72/MWh. We see margin compression in the onshore wind turbine market normalising through 2030 as Chinese developers marginally slow installations of wind projects. We see larger cost deflation from the offshore wind market as manufacturers introduce larger offshore turbines with 15% lower unitary capex.

US: IRA drives cost reductions: We estimate the levelised cost of electricity (including a US$26/MWh production tax credit) for onshore wind to decline from ~US$41/MWh in 2023 to ~US$33/MWh by 2030, while LCOE from offshore wind declines from ~US$114/MWh to ~US$66/MWh. We expect LCOE improvements to come from a combination of manufacturing scale/opex leverage and higher capacity factors, driven by larger blade diameters.

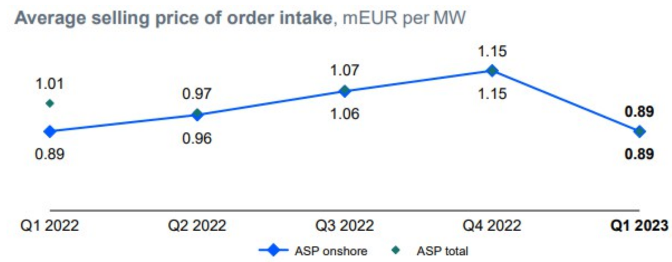
Europe: We estimate the levelised cost of electricity from onshore wind will decline from ~US$71/MWh in 2023 to ~US$52/MWh by 2030, while LCOE from offshore wind declines from ~US$78/MWh to ~US$56/MWh. We see Europe's pioneering role in the offshore wind industry driving its cost advantage vs. other regions. We think technological evolution and higher scale have the potential to bring costs down and efficiency up in both offshore and onshore wind, but they also need to be balanced by the need of OEMs to rebuild their margins.

Exhibit 96: Vestas 1Q23 onshore orderbook intake has risen sharply YoY...



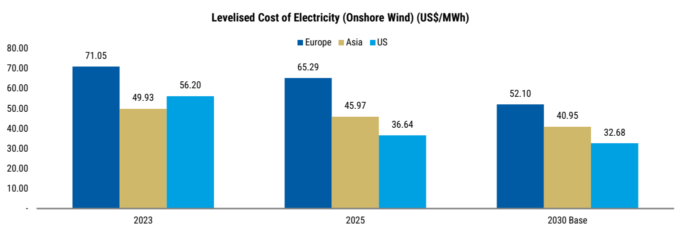
Source: Company data

Exhibit 97: ...however, average selling price has seen a significant correction after a very strong 2022



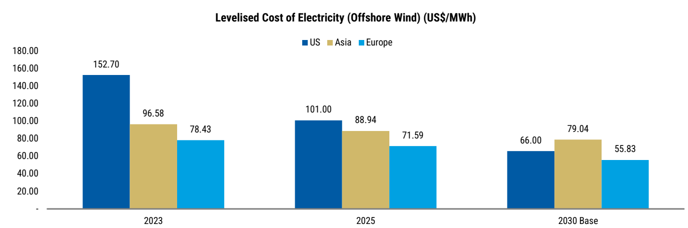
Source: Company data

Exhibit 98: Globally we see the cost of onshore wind electricity declines being led by the US



Source: Morgan Stanley Research estimates

Exhibit 99: Globally we see the cost of offshore wind electricity declines being led by Europe



Source: Morgan Stanley Research estimates

Wind Turbines: Less Scope for Cost Deflation

We think larger capacity wind turbines will be the key driver of cost deflation, however this will be tempered by the push for margin normalisation as manufacturers adjust their ASPs for higher material and transport costs in a multipolar world. In addition, we do not see a paradigm shift in turbine technology compared to the likes of solar and batteries.

We see more scope for cost deflation in offshore wind vs. onshore wind given the different stages in maturity of technology. One lever of upside potential could come from increasing Chinese exports of wind turbines, which are significantly cheaper; however, the push for energy security and supply localisation presents the biggest hurdle.

Increasing power rating: Larger capacity turbines often use smaller blades per MW and lighter nacelle weight per MW (Exhibit 101), which helps to drive cost efficiencies. National Renewable Energy Laboratory estimates that the nacelle is the largest cost component for the wind turbine, accounting for 35% of total capex.

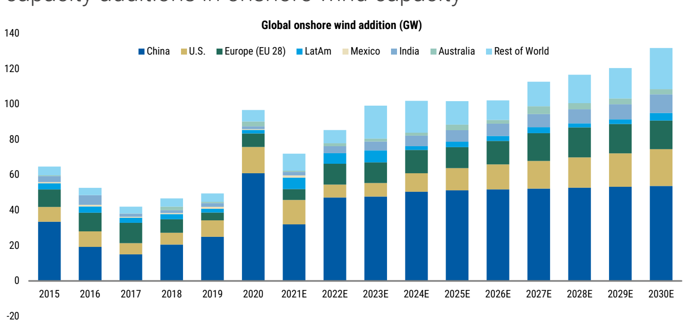
Balance of system costs and O&M costs per MW are also expected to decline with larger capacity turbines given the decline in the number of turbines required for an equivalent wind farm size.

Capacity factors are also expected to increase with the increase in rotor diameters. We estimate a 2.5% improvement in capacity factor for every 50m increase in rotor diameter.

Onshore wind: Larger nacelles, rotors and blades (which increase capacity and have positive scale effects due to decreasing blade length/MW (Exhibit 102) and decreasing weight/MW) and taller towers (which increase capacity factors due to the wind speed increase with higher elevation) will be the key for onshore wind costs reductions. We estimate that blade length/MW decreases by 40% from 3MW to 5.5MW capacity. Global new additions for onshore turbine capacity are mostly 2-3MW.

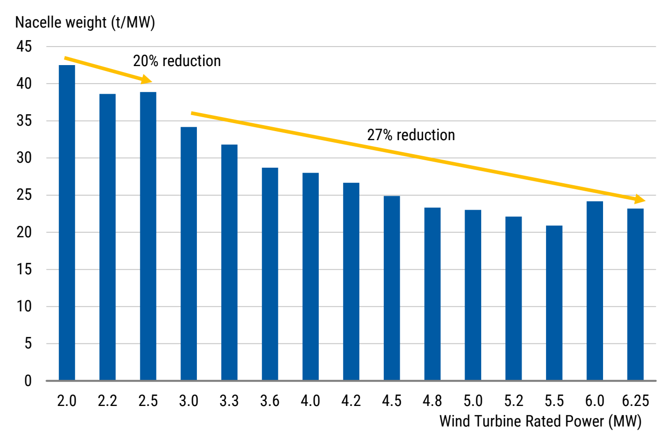
Modular manufacturing is currently being explored to overcome logistical and transportation-related issues for larger blades and could provide further installed cost reduction.

Exhibit 100: We expect China and the US to drive incremental capacity additions in onshore wind capacity



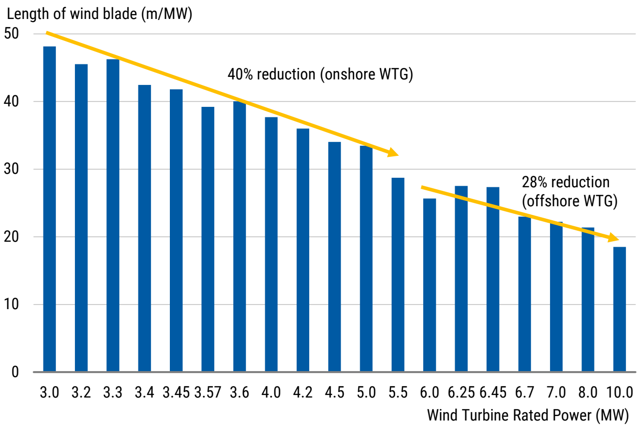
Source: BP, IEA, e = Morgan Stanley Research (E) estimates

Exhibit 101: Average nacelle weight (t/MW) reduction for increase in power capacity



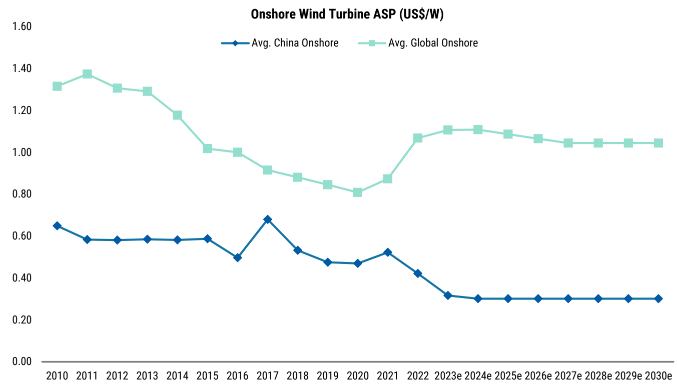
Source: Windey, Morgan Stanley Research

Exhibit 102: Average wind blade length (m/MW) reduction for increase in power capacity



Source: CWEA, Morgan Stanley Research

Exhibit 103: Onshore wind turbine ASPs (US$/W): Less scope for cost reduction given maturity of technology

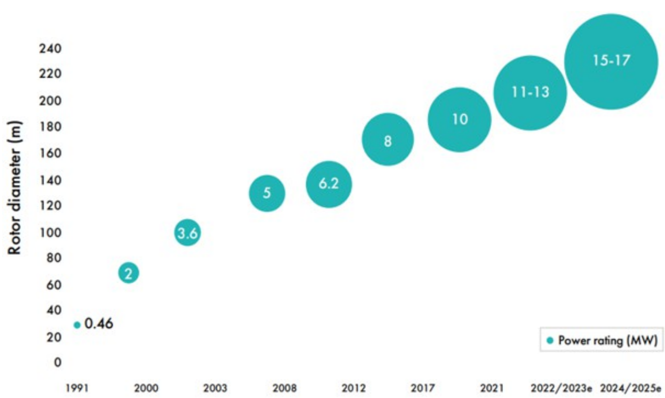


China ASPs reference Goldwind and Ming Yang, Global ASPs reference Siemens Gamesa and Vestas
Source: Company data, Morgan Stanley Research estimates

Offshore wind: Similar to onshore wind, larger nacelles, rotors and blades are expected to drive cost reductions given the aforementioned efficiencies. While scaling up power capacity has been the clear trend for offshore wind (Exhibit 104), the current debate is where capacity caps out given installation and vessel size constraints along with the need for OEMs to balance capital costs with financial returns for the expensive manufacturing moulds. For instance, National Renewable Energy Laboratory currently uses 18MW as its advanced technology innovation scenario for 2030, with next-generation materials and installation/operation regimes required, while Vestas' offshore pipeline will focus on 15MW turbines as their largest capacity turbine in the coming years.

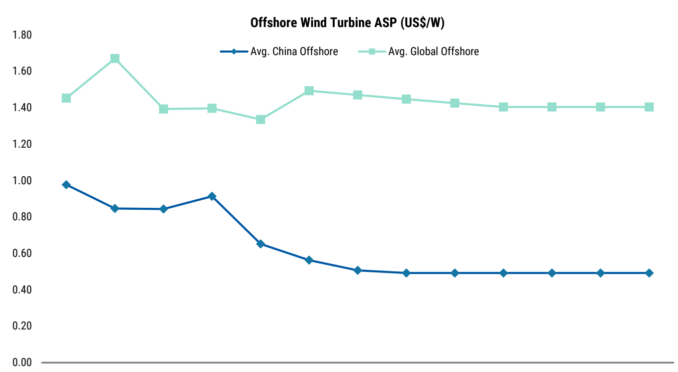
Additional cost reduction drivers include design improvements that reduce the size and weight of the offshore platform, as well as the usage of high voltage direct current (HVDC) transmission technology that has lower energy losses.

Exhibit 104: Offshore wind has seen substantial increases in power ratings in recent years



Source: Global Wind Energy Council

Exhibit 105: Offshore wind turbine ASPs (US$/W) show a significant disconnect in China's offshore turbine prices



China ASPs reference Goldwind and Ming Yang, Global ASPs reference Siemens Gamesa and Vestas
Source: Company data, Morgan Stanley Research estimates

Wind: The Supply Situation

Two wind markets: The global wind turbine market is broadly bifurcated between China and the rest of the world (Exhibit 108). Chinese-made turbines are predominantly used in the domestic market, accounting for 97% of installations, while the global market is supplied by the likes of Vestas, General Electric and Siemens Gamesa.

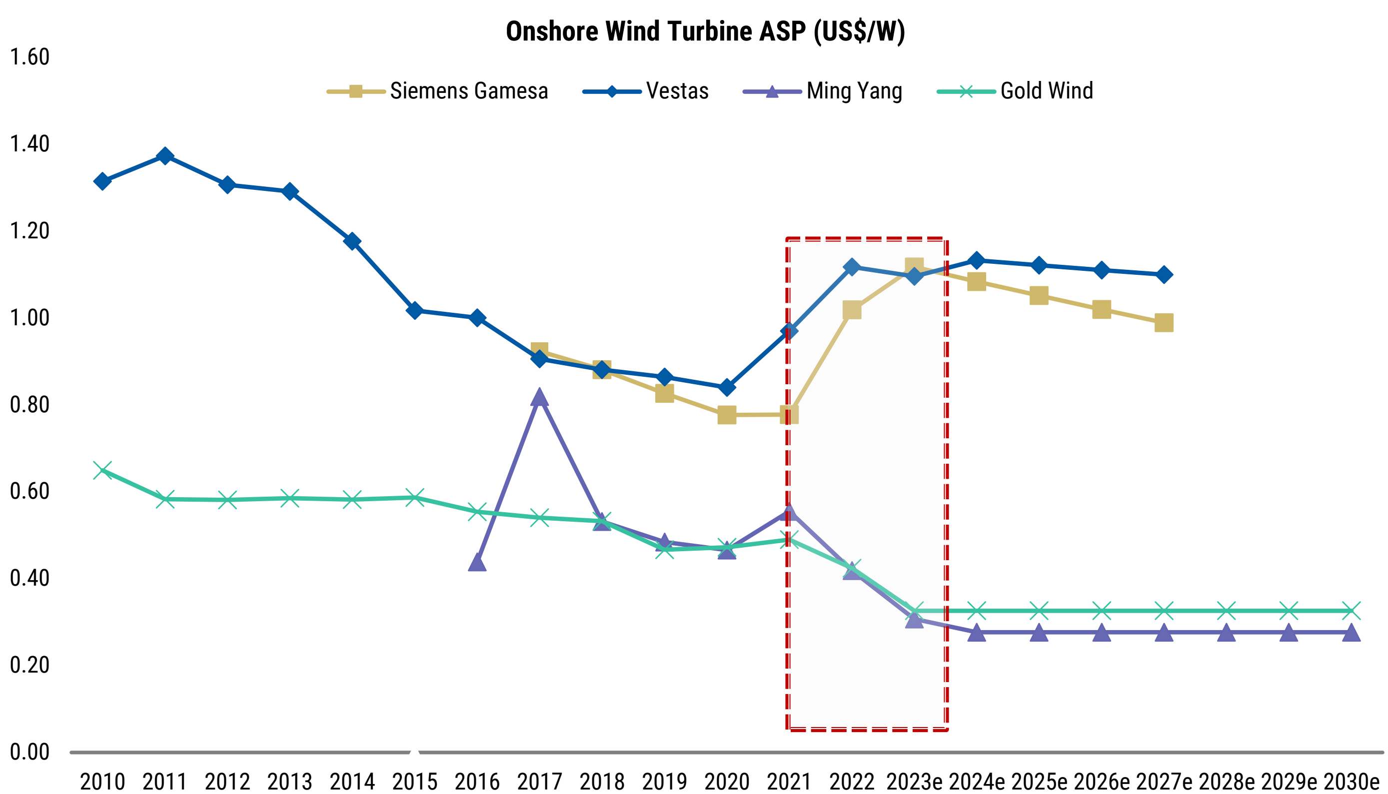
Given the size of its domestic market, the Global Wind Energy Council (GWEC) estimates that China accounts for 60% of the world's 163GW wind manufacturing capacity, with Europe making up 19% and the US accounting for 9% (Exhibit 110). Based on current capacity, GWEC estimates that there is sufficient capacity both onshore and offshore in the immediate term, but potential shortages start to kick in from 2025-26 onwards, particularly in Europe and North America (Exhibit 112).

Pre-Covid, ASPs for both Chinese and global manufacturers were trending lower, but this changed in 2022 as Chinese ASPs continued their downward trend while global players raised prices to reflect higher raw material and transport costs (Exhibit 106). Chinese ASPs trended lower given intense competition for domestic market share following the end of government subsidies for onshore wind, with players willing to accept gross margin compression down to 5%.

Potential upside from Chinese exports: Given the significant cost differential in Chinese turbines versus the likes of Vestas and Siemens, we think there is scope for potential upside should Chinese manufacturers make inroads into overseas markets. Chinese manufacturers have stated that they would like to expand overseas market share, with Goldwind targeting 5% by 2025.

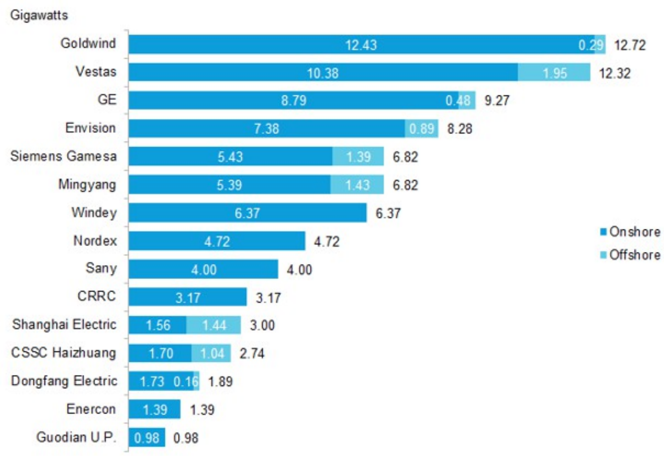
However, the broader geopolitical focus on energy security, supply chain security and friend-shoring of renewable supply chains are obstacles to global expansion, as are differences in certification standards, limited service offerings, and the short overseas track record of Chinese manufacturers.

Exhibit 106: Onshore wind turbine ASPs (US$/W): Chinese ASPs declined in 2022 given intense competition for market share



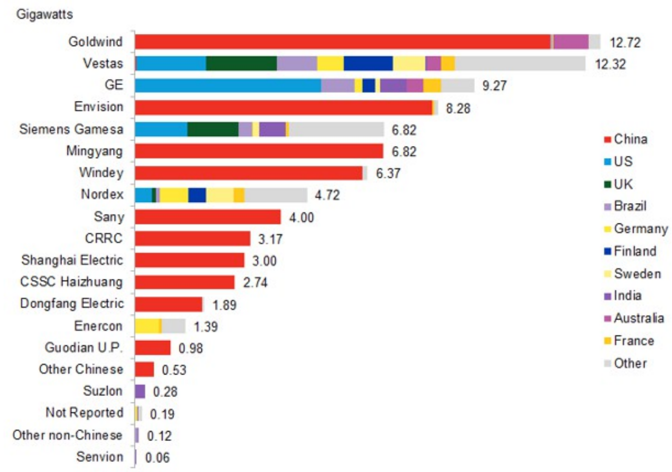
Source: Company data, Morgan Stanley Research estimates

Exhibit 107: 2022 global wind market share: Chinese manufacturers such as Goldwind, Envision and Mingyang feature prominently



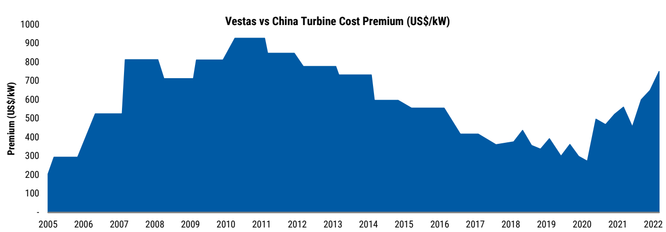
Source: BNEF, company data

Exhibit 108: 2022 global wind market breakdown by region: Chinese manufacturers have limited overseas installations



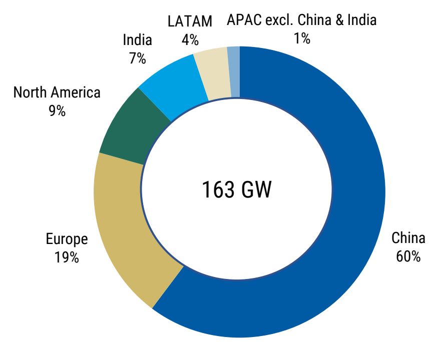
Source: BNEF, company data

Exhibit 109: Vestas vs. Chinese wind turbine cost premium has increased after several years of compression, as steel prices in China remain significantly lower than in the rest of the world



Source: Vestas, IRENA, Morgan Stanley Research

Exhibit 110: 2023 global wind manufacturing capacity: China has 2/3rds of global capacity



Note: Manufacturing capacity based on wind turbine nacelle assembly capacity
Source: GWEC, Morgan Stanley Research

Exhibit 111: Global Wind Energy Council: Potential onshore wind undersupply in Europe and the US from 2026

Onshore Wind Demand vs Supply Analysis (GW)	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	15	18	19	21	23	24	24	25
US	8	9	10	13	15	17	18	20
LATAM	6	5	5	5	5	5	5	5
China	60	60	60	60	60	65	65	65
India	3	4	5	5	5	5	5	5
RoW	6	10	10	14	14	14	14	15
Global	97	106	109	117	122	129	131	135

Note: Green indicates sufficient capacity and red indicates potential undersupply, based on current and announced capacity
Source: GWEC, Morgan Stanley Research

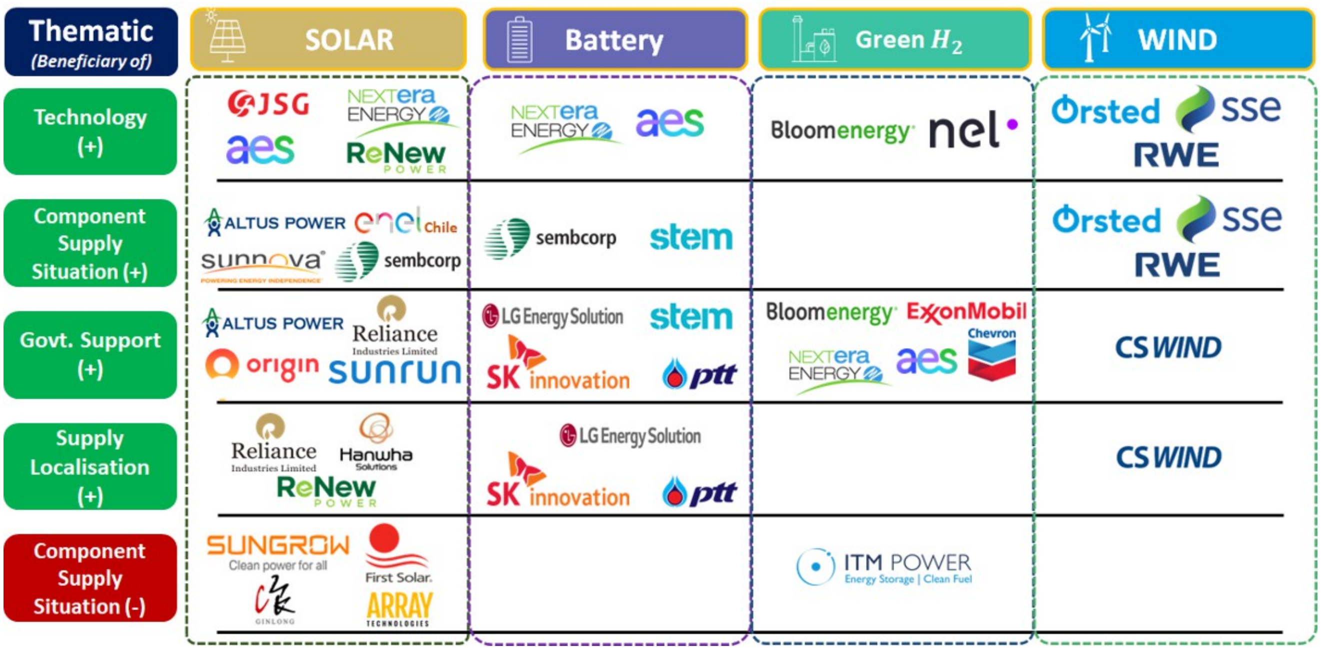
Exhibit 112: Global Wind Energy Council: Potential offshore wind undersupply from 2025 in the US and 2026 in Europe

Offshore Wind Demand vs Supply Analysis (GW)	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Europe	6	3	7	10	12	15	21	26
North America	1	2	4	5	4	5	5	5
LATAM	-	-	-	-	-	-	1	1
China	10	12	12	15	15	15	15	15
APAC ex. China	2	2	3	3	4	5	7	8
Global	18	18	26	32	35	40	48	55

Note: Green indicates sufficient capacity and red indicates potential undersupply, based on current and announced capacity
Source: GWEC, Morgan Stanley Research

Ways to Play the Energy Transition: Global Investment Implications

Exhibit 113: How are we positioned across the various technologies



Source: Morgan Stanley Research

We think there are three overarching themes to play the energy transition: (1) existing integrated energy and utility companies benefiting from lower investment costs; (2) green solution equipment manufacturers gaining market share as supply chains shift and they benefit from government support. Companies that see pressure due to this shift in market share would be key UWs; (3) Clean power developers/producers within the US/Europe with planned growth pipelines to expand capacity. In the next section of the report, we provide a list of the key stock beneficiaries and their competitive advantages.

#1 Existing Integrated Energy and Utility Companies Investing in the Energy Transition: Strong cashflows to aid capital deployment could drive a valuation re-rating as they increase the mix of renewables in their portfolios.

- We think component oversupply as a result of increasing manufacturing capacity may also be beneficial due to lower capex spend and consequently higher returns
- We highlight *NextEra, AES, RWE, Origin Energy, PTT and Reliance Industries* as our key picks.

#2 Green Solution Equipment Manufacturers: Structural growth opportunities, improvements in technology, and government commitment to localising capacity are key drivers.

- We see government support most prominently in the push for supply localisation in the US, where strong IRA incentives have attracted significant capital investments.
- We highlight *NEL, SK Innovation and Hanwha Solutions* as key beneficiaries of the IRA in addition to multiple US names while *JA Solar* and *Jingsheng Medical* are expected to see strong structural growth.
- We see the need to be selective on equipment manufacturers as increased manufacturing capacity, excess competition and execution issues may drive down margins. We highlight *Ginlong Technologies, Sungrow, ITM Power, First Solar and Array Technologies* as most challenged.

#3 Clean Power Developers/Producers: Cheaper capital costs, structural growth opportunities, various areas of oversupply, and declines in production costs could boost margins.

- We highlight multiple developers across geographies that are best positioned, including *Altus Power, Sembcorp Industries, Sunnova, Sunrun, Orsted, SSE.*

Energy Transition Comps

Exhibit 114: Energy transition – Most and least preferred names

Company Name	Ticker	MS Rating	Energy Transition Theme	Mkt Cap	12M Return	Last Price (Local CCY)	Upside / (Downside)			Price Target (Local CCY)			CCY	P/E		EV/EBITDA		ROE		MS Analyst
				(US$MM)	%		Bull	Base	Bear	Bull	Base	Bear		2023E	2024E	2023E	2024E	2023E	2024E	
US Key Picks																				
NextEra	NEE.N	OW	Renewables, Hydrogen	147,373	-6.3%	72.66	39%	28%	(19%)	101.0	93.0	59.0	USD	23.3x	21.3x	13.9x	13.2x	12.8%	12.4%	David Arcaro
AES	AES.N	OW	Renewables, Hydrogen	15,218	5.4%	21.38	87%	36%	(11%)	40.0	29.0	19.0	USD	12.5x	11.5x	11.8x	13.0x	76.3%	58.2%	David Arcaro
Altus Power	AMPS.N	OW	Solar	1,049	-4.7%	6.50	177%	54%	(26%)	18.0	10.0	4.8	USD	12.9x	20.6x	17.9x	16.6x	19.2%	10.0%	Andrew Percoco
Bloom Energy	BE.N	OW	Fuel Cells/Hydrogen	3,859	9.6%	18.42	237%	63%	(73%)	62.0	30.0	5.0	USD	NM	NM	NM	12.2x	-43.3%	-4.5%	Andrew Percoco
Stem, Inc.	STEM.N	OW	Energy Storage	1,204	-12.7%	7.00	271%	71%	(57%)	26.0	12.0	3.0	USD	NM	NM	NM	NM	-23.5%	-17.1%	Andrew Percoco
Sunnova	NOVA.N	OW	Solar	2,648	16.1%	22.91	258%	83%	(56%)	82.0	42.0	10.0	USD	NM	390.0x	64.1x	66.3x	-1.6%	0.6%	Andrew Percoco
Sunrun	RUN.O	OW	Solar	4,697	-10.3%	21.83	262%	79%	(59%)	79.0	39.0	9.0	USD	22.7x	75.8x	NM	NM	3.1%	0.9%	Andrew Percoco
ExxonMobil	XOM.N	OW	Fuel Cells/Hydrogen	409,878	234.8%	101.38	57%	19%	(27%)	159.0	121.0	74.0	USD	12.0x	12.3x	5.3x	5.1x	17.6%	16.1%	Devin McDermott
Chevron	CVX.N	EW	Energy Storage	292,045	8.3%	153.44	71%	28%	(21%)	262.0	197.0	121.0	USD	11.2x	8.9x	4.8x	3.8x	16.1%	19.4%	Devin McDermott
New Fortress Energy	NFE.O	OW	Solar	5,689	-16.8%	27.18	216%	84%	(37%)	86.0	50.0	17.0	USD	5.4x	4.4x	6.6x	5.0x	81.3%	66.2%	Devin McDermott
Latin America Key Picks																				
Enel Chile	ENELCHILE.SN	OW	Renewables	4,930	234.8%	58.00	36%	0%	(31%)	79.0	58.0	40.0	CLP	8.4x	8.3x	5.0x	4.7x	11.7%	11.4%	Miguel Rodrigues
Europe Key Picks																				
SSE	SSE.L	OW	Integrated Energy	24,984	8.3%	1,779	69%	41%	(16%)	3,000	2,500	1,500	GBp	11.1x	9.2x	8.4x	7.0x	20.5%	21.3%	Robert Pulleyn
Orsted	ORSTED.CO	OW	Renewables	39,758	-16.8%	625	92%	36%	(4%)	1,200	850	600	DKK	39.7x	29.0x	16.3x	11.9x	9.3%	11.3%	Robert Pulleyn
RWE	RWEG.DE	OW	Utilities	33,286	17.1%	39	104%	33%	(13%)	80.0	52.0	34.0	EUR	9.5x	14.6x	4.8x	6.0x	11.3%	6.3%	Robert Pulleyn
NEL	NEL.OL	OW	Hydrogen	2,029	-11.1%	13	171%	75%	(36%)	34.0	22.0	8.0	NOK	NM	NM	NM	NM	-11.5%	-8.8%	Arthur Sitbon
Asia Pacific Key Picks																				
Sembcorp Industries	SCIL.SI	OW	Renewables	7,599	101.3%	5.39	51%	24%	(25%)	8.0	6.6	4.0	SGD	13.1x	14.4x	9.6x	10.2x	19.3%	15.3%	Mayank Maheshwari
PTT	PTT.BK	OW	Integrated Energy	28,695	6.7%	34.50	22%	7%	(22%)	42.0	37.0	27.0	THB	9.9x	7.9x	6.0x	5.5x	9.5%	11.7%	Mayank Maheshwari
Reliance Industries	RELI.NS	OW	Integrated Energy	232,583	13.5%	2,797	40%	15%	(31%)	3,918	3,210	1,916	INR	23.2x	21.0x	10.7x	9.6x	10.0%	10.1%	Mayank Maheshwari
SK Innovation	096770.KS	OW	Integrated Energy	11,691	2.9%	164,000	65%	28%	(39%)	270,000	210,000	100,000	KRW	22.0x	8.4x	7.2x	5.3x	4.0%	10.0%	Young Suk Shin
Hanwha Solutions	009830.KS	OW	Renewables	5,963	27.8%	42,950	56%	35%	(32%)	67,000	58,000	29,000	KRW	13.2x	9.0x	5.5x	5.0x	6.4%	8.8%	Michael Koh
Origin Energy	ORG.AX	OW	Battery	10,150	52.5%	8.58	56%	3%	(25%)	13.4	8.9	6.5	AUD	20.1x	16.2x	5.6x	5.1x	7.2%	10.2%	Rob Koh
Jingsheng Mechanical	300316.SZ	OW	Solar	11,969	-9.4%	66.41	126%	43%	(32%)	150.0	95.0	45.0	CNY	17.9x	15.8x	13.6x	11.1x	44.2%	35.4%	Sheng Zhong
LG Energy Solutions	373220.KS	EW	Battery	101,289	45.8%	538,000	54%	17%	(20%)	830,000	630,000	430,000	KRW	58.2x	33.3x	25.3x	16.5x	11.8%	18.4%	Young Suk Shin
CS Wind	112610.KS	OW	Wind	2,760	21.9%	82,900.00	40%	23%	(22%)	116,000	102,000	65,000	KRW	30.7x	16.5x	13.7x	9.2x	12.8%	21.6%	Michael Koh
ReNew Energy	112610.KS	OW	Wind	2,324	-5.2%	5.64	43%	15%	(34%)	8.06	6.48	3.75	USD	58.2x	34.4x	10.0x	9.9x	3.0%	4.9%	Girish Achhipalia
Most Challenged																				
Array Technologies	ARRY.O	UW	Solar	3,037	79.8%	19.98	60%	(20%)	(75%)	32.0	16.0	5.0	USD	31.8x	23.3x	14.1x	12.0x	75.7%	55.7%	Andrew Percoco
First Solar	FSLR.O	UW	Solar	22,181	208.5%	206.71	3%	(13%)	(57%)	212.0	180.0	89.0	USD	29.0x	16.3x	18.8x	10.5x	13.1%	20.5%	Andrew Percoco
ITM Power	ITM.L	UW	Hydrogen	674	-58.7%	76.00	163%	18%	(34%)	200.0	90.0	50.0	GBp	NM	NM	NM	NM	-15.3%	-16.7%	Arthur Sitbon
Ginlong Technologies	300763.SZ	UW	Solar	5,796	-60.4%	107	69%	22%	(44%)	180.0	130.0	60.0	CNY	29.0x	22.5x	22.7x	17.5x	20.9%	23.4%	Simon Lee
Sungrow	300274.SZ	UW	Solar	23,515	-16.0%	114	26%	(21%)	(53%)	144.0	90.0	54.0	CNY	40.3x	30.8x	29.9x	23.3x	22.7%	24.6%	Simon Lee
AES Brasil	AESB3.SA	UW	Renewables	1,467	29.3%	12	29%	3%	(31%)	15.0	12.0	8.0	BRL	46.0x	30.5x	9.8x	7.9x	3.5%	5.2%	Miguel Rodrigues

Source: Morgan Stanley Research estimates, Refinitiv

China: Pockets of Opportunity

Solar Modules

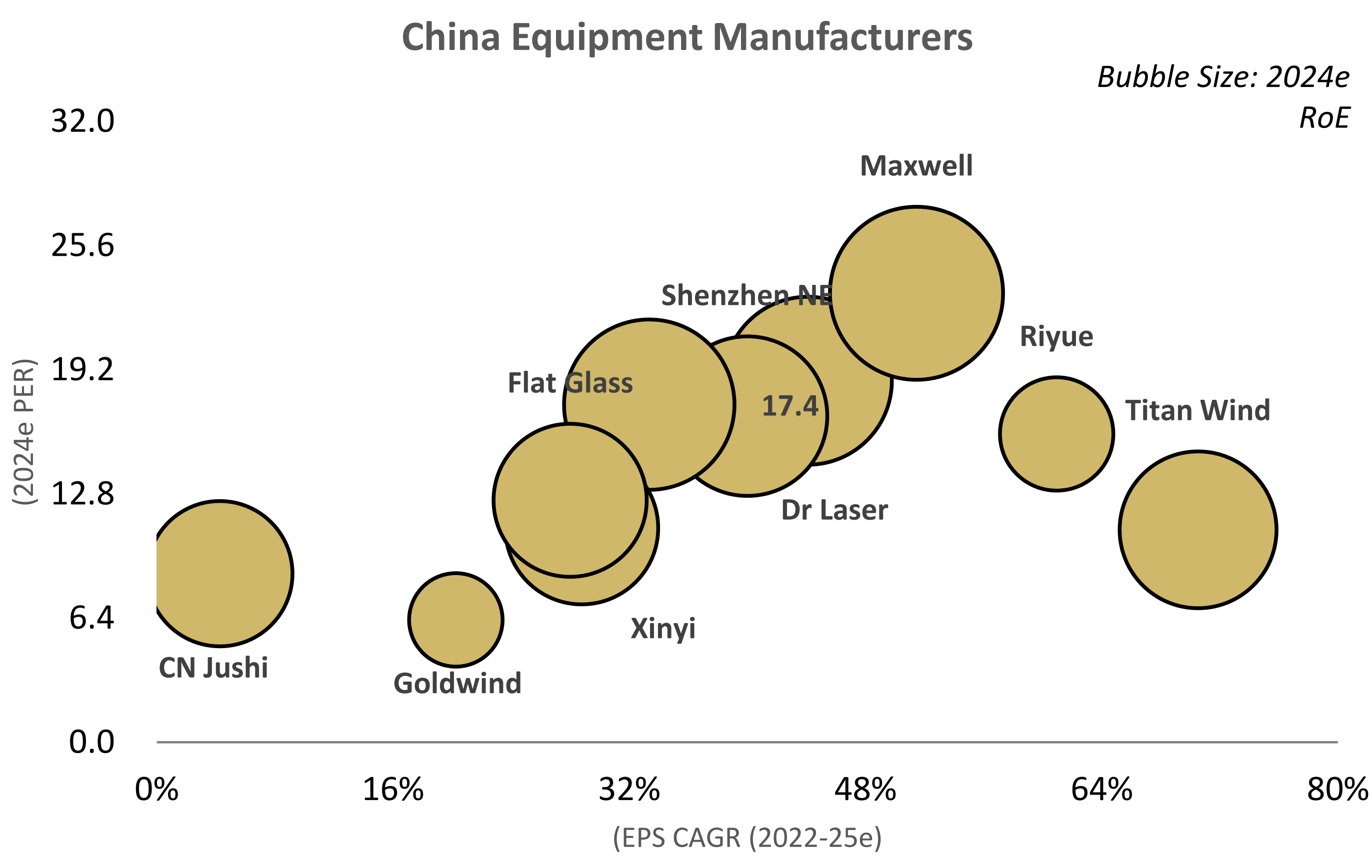
Key Stock Picks – Most and Least Preferred: We like **JA Solar, Jingsheng Mechanical and Longi** but least prefer Ginlong and Sungrow.

Key Competitive Advantages: JA Solar has the greatest exposure to high value export markets and the highest profit margin among all module makers. JA Solar also has one of the largest exposures to Topcon cell/modules in 2023/24. Jingsheng Mechanical is a leading solar equipment provider of crystal growing furnaces with revenue forecasts driven by a strong equipment order backlog, capacity expansion and growth in the materials segment. For Longi, we see 20% volume growth in 2024 with margins largely stable.

Long-Term Drivers & What Investors Might Be Missing: We estimate global solar module shipments will grow from 300GW in 2022 to 400-430GW in 2023 and 480-520GW in 2024. With solar stocks trading at low-teens P/Es on 2023 earnings, we believe the market is pricing in very low earnings growth for the industry, compared with our expected 20%. Strong solar demand means concerns over module margins are overdone, in our view.

Risks to Competitive Advantages: There are new entrants in the solar module segment, but the top 5 solar module companies continue to gain global share. Their R&D expenses far exceed global peers, and thus we believe they will further consolidate their leading position.

Exhibit 115: China renewable equipment manufacturers: PEG vs. RoE profile



Source: Eikon, Morgan Stanley Research estimates

US: Who Wins in the Clean Power Landscape?

Key Stock Picks – Most and Least Preferred: In our view, each of the companies within our US clean tech coverage will benefit from the more generous provisions for clean energy support in the Inflation Reduction Act, whether in the form of increased demand for their products and services or in the form of tax credits. That being said, we believe that companies with the capability to navigate through near term headwinds to renewables growth while also establishing a wide competitive moat with long-term barriers to entry will outperform. We highlight our most and least preferred stocks based on this view.

Most Preferred:

- **AES (AES; OW):** Major US renewables developer, exiting coal and accelerating growth post 2025. i) highly resilient earnings supported by long-term contracts with creditworthy customers (mostly USD-denominated) and solid frameworks for the utility operations; ii) enhanced visibility on financial outlook and growth potential; and iii) attractive ESG rate of change, with robust renewables growth and ongoing portfolio decarbonisation.
- **Altus Power (AMPS; OW):** We believe AMPS will continue to serve as a market leader in commercial and industrial (C&I) distributed solar development, which is poised to grow significantly, supported by i) rising utility bills, ii) rising grid instability, iii) customer demands for price certainty (i.e., not exposed to fluctuating power prices), and iv) corporate decarbonisation goals.
- **Bloom Energy (BE; OW):** We view BE as a big beneficiary of several key trends including: (i) advantage in its time-to-power C&I corporate customers using its fuel cell baseload power, (ii) the growing "economic wedge" or value proposition of distributed energy, (iii) rising grid instability, (iv) grid capacity limitations, (v) the $3/kg hydrogen tax credit included in the IRA.
- **NextEra Energy (NEE; OW):** We expect NEE to be one of the biggest beneficiaries of the Inflation Reduction Act. NEE is also likely to be a major player in the nascent green hydrogen market, which is poised to rapidly accelerate given lucrative new incentives. Strong competitive differentiation gives NEE a strong line of sight to maintain share in a fast-growing US renewables market.
- **ExxonMobil (XOM; OW):** We expect XOM to continue to be a leader in carbon capture and clean hydrogen/ammonia, as it plans to invest US$17bn into lower emissions initiatives through 2027. XOM has a strong and growing presence in carbon capture, with 4.2 million metric tons of new CO2 capture agreements contracted this year, equity interest in about one-fifth of the world's carbon capture capacity, and the Denbury acquisition giving valuable Gulf Coast CO2 pipelines for outsized carbon capture potential.
- **Chevron (CVX; OW):** We see CVX improving its lower carbon position with a focus on renewable energies expansion. With the acquisition of the largest biodiesel operator in the US in 2022 (Renewable Energy Group), it plans to increase renewables fuel production capacity by 50 Mboe/d by 2030. It also has active development of CCUS on the Gulf Coast (>1bn tons of CO2 storage in the region), and hydrogen in the US and Asia Pacific.
- **New Fortress Energy (NFE; OW):** We believe NFE offers a differentiated energy transition plan with terminal operations focused in developing nations, and flexible supply via fast LNG. Current operations are mainly in Central America, Brazil, Jamaica, and Puerto Rico (with further expansion opportunity) to transition power generation from carbon-intensive fuel oil and coal to natural gas. The IRA should also spur growth through the development of 2 hydrogen hubs.
- **Stem, Inc. (STEM; OW):** In our view, the improvement in global battery supply, IRA support through a standalone storage ITC, and STEM's focus on driving higher margin software sales positions STEM as an attractive way to play the US energy storage market. We favor STEM's approach to profitability with its focus on recurring software revenue rather than on storage hardware, which we believe is becoming increasingly commoditised.
- **Sunnova (NOVA; OW):** As the third-largest US rooftop solar developer, we see long-term interest in distributed generation driving upside for Sunnova: utility bill inflation and rising grid instability supporting demand for rooftop solar, falling clean energy costs, and NOVA's extensive suite of product offerings positioning the company well for the next-generation home energy system setup. On our math, NOVA's stock is trading at the value of its existing assets and pricing in little-to-no growth, which we see as unlikely as rooftop solar penetration grows.
- **Sunrun (RUN; OW):** Sunrun is the largest US rooftop solar developer, with several trends benefitting growth and per-customer value: rising utility costs, worsening grid reliability, falling clean energy costs, and its EV partnership with Ford for the F-150 Lightning. We calculate that the stock is pricing in just three years of growth followed by no customer additions, which is unlikely in our view due to robust demand for rooftop solar long-term.

Least Preferred:

- **Array Technologies (ARRY; UW):** In our view, ARRY's competitive moat could be competed away as we see trackers becoming an increasingly commodity-like product. While the IRA will provide a meaningful benefit to the utility-scale solar market over the next several years, we believe that policy benefits in the long term will diminish as competition drives down margins.
- **First Solar (FSLR; UW):** We expect FSLR to benefit significantly from the manufacturing tax credits under the IRA as a fully-integrated domestic solar panel manufacturer. However, we see a risk of increased competition as companies both domestically and internationally expand their manufacturing footprint in the US, which will likely drive down the long-term earnings profile of the company.

Key Competitive Advantages: In the **solar** market, we see competitive advantages for the large rooftop solar developers, given their ability to install and finance solar systems with a 25-year agreement offered to consumers at a discounted cost to the incumbent utility provider. The distributed solar installers have ample headroom to raise pricing given high and rising utility bills, which we believe will continue providing an "easy sale" for customers to turn to distributed energy or even "cut the utility cord" in the future. Within the **energy storage** market, we see battery hardware becoming more of a commodity-like product as the supply chain improves, but we believe system integrators who can focus on software and services will remain differentiated longer-term. Storage system integrators that can provide software and services to monitor and optimise storage assets can maintain more asset-light business models while remaining technology-agnostic to different battery chemistries.

Finally with **green hydrogen**, while this decarbonisation technology is more nascent compared to wind and solar, we believe that continued capital cost declines for electrolysers, deflationary costs of solar and wind renewable generation, and potential for green hydrogen to decarbonise hard-to-abate sectors will drive meaningful expansion within this market. We are currently seeing a few companies aiming to be the first-movers in the green hydrogen ecosystem by building out manufacturing capacity and scale to eventually produce green hydrogen at a cost that is comparable to grey, and we believe these players are likely to maintain a vital role in this market long-term.

Long-Term Drivers & What Might Investors Be Missing: We believe investors underappreciate the long-term dynamics that utility bills will continue to rise while clean energy costs will continue to fall. Utilities are facing pressures on cost due to spending needs for hardening the grid, transmission and distribution, commodity price inflation, and repairs for climate change-driven weather damages. Regions like the West Coast and Northeastern US face some of the highest utility rates, making these regions a comparatively "easy sale" for residential rooftop solar that can be priced at a discount to the utility – while utility bills have risen 2-10% each year, the costs for solar have been falling >10% per year.

The value proposition for distributed energy generation across corporate customers, in our view, has also not been fully appreciated by the market. Providers like Bloom Energy can offer on-site baseload distributed generation at a discount to the utility to customers who need stable power – this is a particularly attractive offer for corporations like datacenter customers or healthcare centers who are looking for a fast time-to-power and for reliable access to electricity 24/7. Additionally, decarbonisation is a growing theme for many corporates as companies are setting emissions reduction targets on scope 1, 2, and 3 emissions and focusing on a path to net-zero goals. Both utilities and corporates who are looking to decarbonise can benefit from the cheap, and deflationary, costs for renewable energy as large-scale solar and wind are more economic compared to new natural gas plant builds today in various regions of the country.

Risks to Competitive Advantages: We see a few near-term headwinds as the biggest risks to renewables growth and deployment in the US. First, renewables projects must receive the necessary approvals from the long queues in the interconnection and permitting process, which has led to widespread delays for projects reaching their commercial operation dates. Without potential legislative reforms to improve the speed at which projects can exit the queue and start commercial operations, we expect near-term project timelines to continue facing the risk of delays. Developers have also commented on observed shortages in labor availability, impacting installations on the field. Resiliency in the supply chain is another issue for the clean energy industry due to the heavy reliance on imported equipment and critical components, which is at risk to trade and import-related policy headwinds such as UFLPA and AD/CVD. Since the IRA's passing, we have seen a large volume of clean energy manufacturing announcements in the US and increased focus among companies to nearshore their operations. However, we expect that it could take a few additional years for companies to re-route the supply chain to fully de-risk from policy-related headwinds.

Europe: Who Wins in the Solar, Wind, Storage, and Hydrogen Landscape?

Key Stock Picks – Most and Least Preferred: In European utilities, our key preferred names are **SSE** (Top Pick), **RWE** and **Orsted**. While ambitious net zero government targets should support long-term growth in renewables generation and transmission, we see an attractive entry point to these names, as current market prices discount low or no value to growth pipelines and already price in challenging economics in some of the existing portfolio. In the hydrogen space, we like electrolyser manufacturer **NEL** (Overweight, covered by Arthur Sitbon), which we believe is well positioned to capture electrolyser demand growth in Europe and in the US. However, ITM Power (Underweight, covered by Arthur Sitbon), which faces some operational issues that could take time to be resolved, is least preferred.

Most Preferred:

- **SSE (SSE; OW).** SSE is our preferred integrated utility and top sector pick, given the combination of positive attributes from its position as a 'double play' on UK net zero ambitions. Best in class network growth with electricity transmission (ET) to grow >14% over the coming decade is the core driver of the equity story. The attractive UK regulatory system, with policy support for net zero, ET, and the inflation linkage makes for a compelling anchor to the investment case. In addition, the largest growth optionality from unused seabed acreage in UK & Ireland renewables (which are also largely inflation linked) should deliver best in class renewables EBITDA even versus RES pure plays.

- **RWE (RWE; OW).** We see a three-pronged investment case. First, in the near term, we see continued enhanced earnings and cash flow from elevated commodity prices and tight supply/demand in power markets to provide material cash for reinvestment. Second, we see RWE as an 'Energy Security Champion' and likely beneficiary of Germany's energy policy for diversification away from Russia and wider decarbonisation. We expect significant investment opportunities and see upside to strategic growth targets. Third, we expect RWE to transition to a mostly green-powered business through the disposal of lignite assets in the coming years.
- **Orsted (ORSTED; OW)**. We see an attractive entry point for an industry-leading best in class operator amid a long-term growth story. We see Orsted as oversold on a perfect storm of rising yields, funding concerns, value creation and execution ability. We believe the recent CMD reconnected management with investors with reassuring messages around value creation, ability to deliver and organic funding for the current 2030 plan. With 15% underlying EPS CAGR to 2030 and the stock valuing no future growth and existing challenged projects at a discount, we see an attractive buying opportunity. Furthermore, catalysts in 2H23, including datapoints from offshore auctions, should sustain the re-rating.

- **NEL (NEL.OL; OW)**. While we think European wind & solar developers will also ultimately be able to benefit from the hydrogen opportunity (via the needs for additional wind & solar projects as well as their growing direct involvement in hydrogen production), we think this is a more long-dated optionality and that for now, the market will mainly focus on hydrogen pure-plays. In this context, electrolyser manufacturer NEL is our preferred way to play the hydrogen theme in Europe, despite the demanding valuation. With our expectation that the group reaches 4 GW of annual electrolyser manufacturing capacity in 2025, we think it will be ideally positioned to capture part of the growth in future electrolyser demand. In the short-term, we think we may have come to the end of a prolonged wave of earnings downgrades for the name and the recent improvement in order intake is encouraging.

Least Preferred:

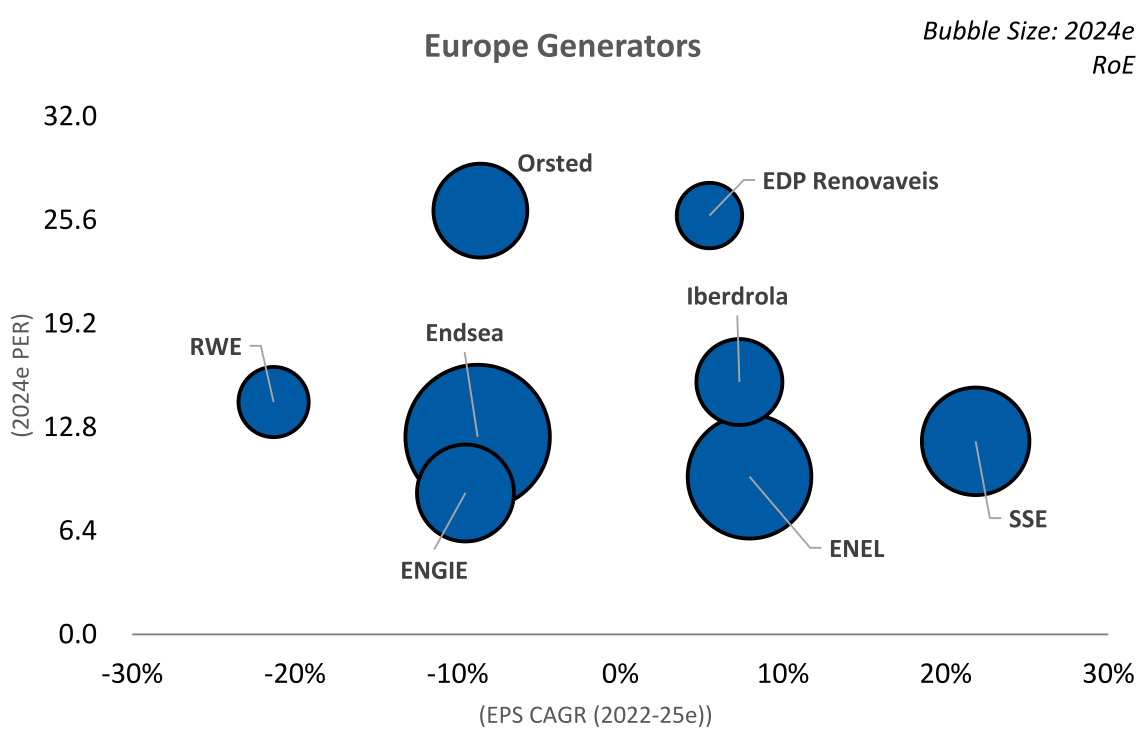
- **ITM Power (ITM.L; UW).** ITM Power is one of NEL's key competitors and has also been growing its electrolyser manufacturing capacity. But with recent weak order intake, delayed deliveries on flagship projects and an ongoing management transition, we think it will take time for the group to address its main operational issues. In the meantime, we see a risk that ITM could lose ground vs. peers in a market that will gradually become more competitive. And while the group's turnaround may prove successful, we expect the market to give limited credit to a potential turnaround for now.

Key Competitive Advantages: RWE, Orsted and most European integrated utilities with significant renewables exposure (Iberdrola, Enel, and Engie, for instance) have built extensive and diversified pipelines of renewable projects over the past few years. Scale (and a cheap cost of capital, especially for integrated names with high regulated EBITDA exposure) allows these groups to be cost competitive, while diversification allows them to be very selective, hence driving significant value creation from their new projects. As the biggest developers of renewables in core markets, we see these stocks having a scale cost advantage that is difficult to match by new entrants. Further competitive advantages include relationships within the supply chain and existing positions in land access (via acreage and/or JVs). In the electrolyser manufacturing space, we see NEL's key competitive advantage as being that it is one of the first movers in the space.

Long-Term Drivers & What Might Investors Be Missing: The key investor concern regards a contraction in renewable projects' IRR-WACC spreads due to capex inflation and higher yields. However, we believe that challenged economics are limited to a few projects where offtake power prices have already been locked in but financing and procurement haven't been secured. We already see an uptrend in prices in government capacity auctions and corporate PPAs (see Episode 5 – Supportive Offshore Wind Datapoint from our Renewables Value Creation series), which shows developers' ability to pass through upward cost pressures (see Renewables: Value Creation Prospects Unappreciated). Thus, we believe that projects' value creation levels should be (at least) preserved at similar IRR> WACC spreads, and in Europe potentially widen for new projects. In this context, we see our preferred stocks as particularly cheap, as they discount no or almost no value for their unsecured future renewables growth.

Risks to Competitive Advantages: Key concerns for renewables-exposed stocks are the lack of visibility on regulation, in particular government intervention in the context of the recent energy crisis, and the erosion of value creation from persistent inflation or further rises in yields. both could trigger further de-rating for terminal value long-duration utility stocks. Furthermore, lack of policy maker action to accelerate permitting times and provide visibility for the industry is working against establishing the supply chain required for the growth ambitions by host countries. In the electrolyser manufacturing space, we think new entrants (typically large industrials with more firepower) or overseas competition (where manufacturing costs are lower) could put European independent electrolyser manufacturers' ramp-up and profitability improvement trajectory under pressure, ultimately creating risks to their long-term market share. While we acknowledge these are real risks for the players, we also believe the strong drive towards local content in Europe and the US will help these groups' prospects.

Exhibit 116: Europe renewable generators: PEG vs RoE profile



Source: Eikon, Morgan Stanley research estimates

Korea: Charging Up for the World

Batteries

Key Stock Picks – Most and Least Preferred: Within Korea's EV battery supply chain, we see **SK Innovation's risk/reward profile as most attractive and LG Energy Solution as a key beneficiary of ESS demand.** While the company's operating efficiency and profitability are still below its domestic peers largely due to relatively shorter manufacturing expertise, its aggressive expansion in the US positions it as one of the biggest beneficiaries of the IRA, and this ramp-up, coupled with improvements in production yields, is leading to sequential margin expansion. Although we are constructive on the long-term secular growth potential of the overall battery supply chain, we see extreme levels of valuation for certain stocks, and currently have UW ratings on battery material suppliers such as Ecopro BM and Solus Advanced Materials.

Key Competitive Advantages: Korean battery makers are leaders in NCM battery technology, which is known to have higher energy density vs. LFP and therefore is used in higher-end EV models. Through 20+ years of R&D and 10+ years of supply, Korean cell companies have established a strong track record of product quality and manufacturing stability and are supplying numerous global OEMs worldwide. Given the industry's high barriers to entry (technology, capital intensity, labor specialty, etc.) we think leading Korean battery makers' positioning will likely linger as they further expand capacity to maintain market share. The breadth of the ecosystem is getting deeper as both major conglomerates (Lotte, POSCO, etc.) and start-ups are diving into the value chain to enjoy the TAM growth.

Long-Term Drivers & What Might Investors Be Missing: Leading the hegemony for next generation battery technology is a key long-term driver for Korean battery companies, in our view. Korean battery companies have been successful in taking NCM/NCA market share but clearly underestimated the growth of the LFP market, and their late start puts them years behind Chinese LFP suppliers. There is room for battery technology to further improve, and the race to capture that market is still fierce. Toyota has recently announced targets to commercialise solid state batteries by 2027, and Chinese cell makers are continuously announcing new form factors (CTP, CTC, etc.) or chemistries (M3P, sodium-ion, etc.). While there are execution risks to these new developments, investors should not overlook breakthroughs in new battery/energy technologies that may cause changes to competitive dynamics.

Risks to Competitive Advantages: We see policy as the biggest risk. While policies like the IRA and the EU's CO2 emission regulations have been working in favor of the Korean battery value chain's growth, including upstream materials, any reversal in policy direction that eases entry for Chinese batteries into Western markets would lower Korean battery players' competitive advantage. As long as governments focus on increasing EV penetration, which requires lower-cost EVs, we see a high likelihood of a continued rise in Chinese EV exports to Western markets, and LFP's market share expansion in US (despite not being eligible for IRA benefits).

Renewables

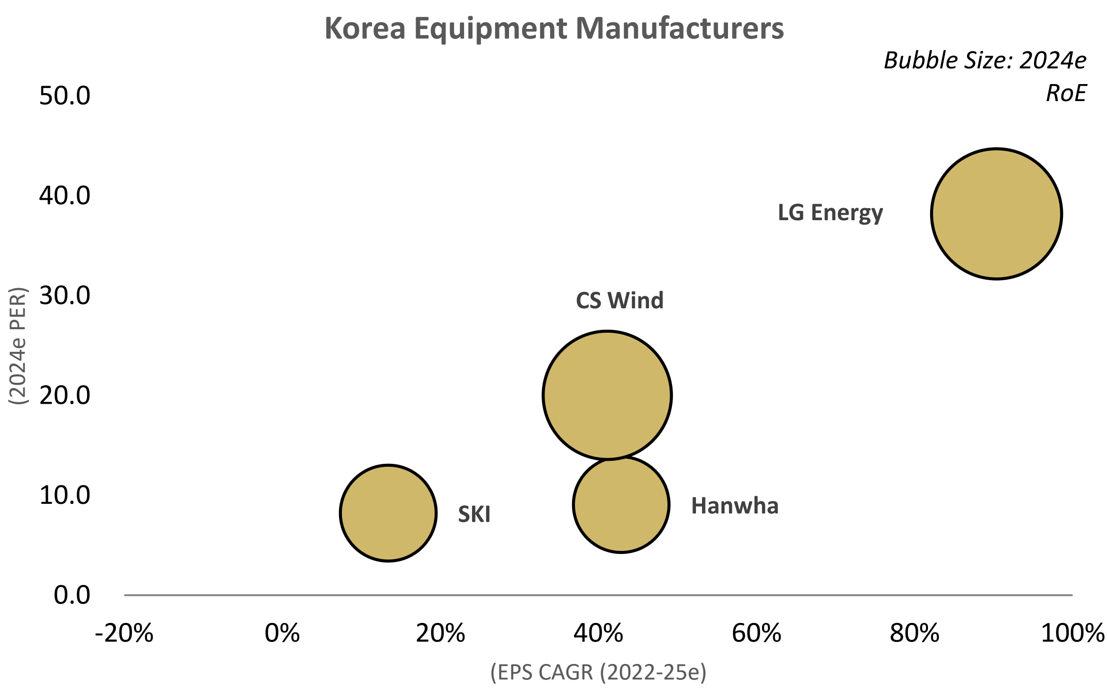
Key Stock Picks – Most and Least Preferred: Among Korean renewable energy names, we prefer Hanwha Solutions and CS Wind, who are both key beneficiaries of the IRA and have a global presence. We have a relative UW on Doosan Fuel Cell, as we believe it needs more time for the fuel cell market to bloom. Hanwha Solutions is a solar cell/module manufacturer with the leading US market share in residential and commercial solar power generation. CS Wind is a wind tower manufacturer with the leading global market share, ex China. For more details on the companies, refer to: S. Korea Renewable Energy: Powering the Generation Shift (7 Jun 2022).

Key Competitive Advantages: Hanwha's key advantage is its positioning as one of the few non-China suppliers and the US market's heightened barriers to entry for Chinese solar makers, particularly with the legislation of UFLPA. The IRA has given Hanwha an additional moat, and Hanwha responded with additional capacity expansion on US soil. CS Wind's key advantage is its strong product quality and strong selling power to all leading wind turbine OEMs. The company's recent acquisition of Bladt (link) will lead to expansion into offshore foundations, which we believe could create synergies with its existing tower business.

Long-Term Drivers & What Might Investors Be Missing: Renewable energy's secular growth will be accelerated by a deflating LCOE, made possible by developments in next-generation technology as noted in this report. The commercialisation of perovskite will be the next breakthrough for Hanwha Solutions, which the company targets for 2025/26. For wind, expanding turbine sizes is an ongoing challenge, but as highlighted by recent quality issues reported by Siemens (link), technological hurdles may emerge, which could work as potential headwinds that investors may have to watch out for.

Risks to Competitive Advantages: Similar to all other secular growth sectors, we see policy as the biggest risk. Like batteries, while key policies like the IRA have been working in favor of HSC and CSW, policies that ease Chinese solar/wind products' entry into the US market would eat into their leading position.

Exhibit 117: Korea renewable equipment manufacturers: PEG vs. RoE profile



Source: Eikon, Morgan Stanley Research (e) estimates

India – Energy Transition with Growth

India's consumption and sources of energy are changing in a disruptive fashion. As compared to rest of the world, India's energy needs are still growing, and therefore legacy capacity using fossil fuels will not be destroyed as it transitions to a higher share of renewables. India's per-capita energy consumption is likely to rise 60%, on our estimates, to about 1450 Watts per day in the coming decade, with two-thirds of the incremental supply coming from renewable sources. We believe the energy transition is a significant theme for the upcoming decade with multiple opportunities emerging across the value chain for investors and corporates alike. We estimate total investments of US$726bn over the next decade as India accelerates its energy transition.

The energy transition will 1) positively impact India's terms of trade, 2) entail about three-quarters of a trillion dollars in energy capex, 3) eventually reduce headline inflation volatility as the imported energy share of GDP declines, 4) lower fertiliser subsidies, 5) improve living conditions, and 6) create new demand for solutions such as electric vehicles, cold-storage chains, and green hydrogen-powered refineries and fertiliser plants.

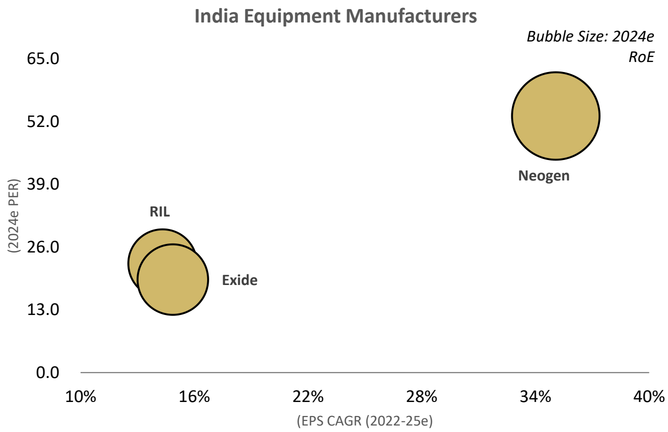
India is building its own renewable infrastructure supply chain in solar, batteries, and green hydrogen, and government incentives are supporting the growth, and unlike in the past is no longer a follower, but moving in step with rest of the world to grow its low carbon fuel value chain. While the scale is currently small and there are questions on how quickly and competitively India can scale up its supply chains, we believe local market demand and duties on imports from Chinese equipment like modules will incentivise supply chain localisation. However, the risks are there if these incentives were to be removed.

Reliance Industries (RELI; OW): Reliance is a classic example of a company transitioning its brown portfolio into investing in green electrons and infrastructure. Reliance is aiming to provide the nuts and bolts behind the evolution of India's energy transition and the world's hydrogen ecosystems. RIL plans to transform its energy business with an over-arching strategy to offer decarbonisation solutions globally at a competitive price (similar to its existing energy portfolio) in a market potentially worth US$5trn by 2030. The strategy is to provide supporting infrastructure in areas of hydrogen, integrated solar PV and grid batteries – all areas with high entry barriers, technological advances and good returns. It plans to create five giga-factories (a combined US$15bn investment, we estimate) offering the entire spectrum of renewable/distributed energy solutions as it capitalises on India's quartz and silicon resources. The focus on the hydrogen value chain offers significant opportunities to decarbonise energy operations, complement energy storage with batteries, and potentially export green ammonia. See Exhibit 120

As the world retools the way it produces and uses energy, and as energy security takes center-stage, green hydrogen is gaining attention with India's policymakers. Hydrogen adoption plans are quickly progressing, with RIL best positioned to capitalise. By the end of this decade, we anticipate RIL will see about US$10bn of NAV creation from hydrogen and related ecosystems in our base case. We also expect hydrogen to account for nearly 10% of RIL's earnings by then as it invests nearly US$4-5bn in getting fully integrated from panels for solar electricity to produce green hydrogen and convert it into fertilisers that use green ammonia as an input.

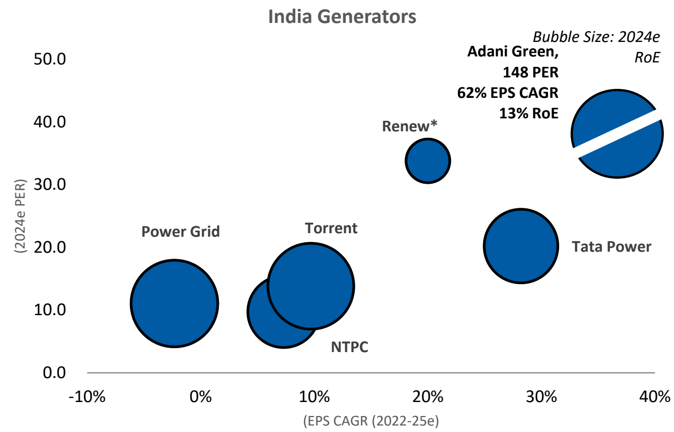
ReNew Energy (RNW; OW): Renew is strongly positioned to play India's energy transition, driven by its core renewable energy business, and forays into module manufacturing and green hydrogen. RNW is fully funded to fulfill its growth aspirations. Receivables issues are diminishing. F23-26e EBITDA CAGR of 18% is one of the highest among global peers.

Exhibit 118: India renewable equipment manufacturers: PEG vs. RoE profile



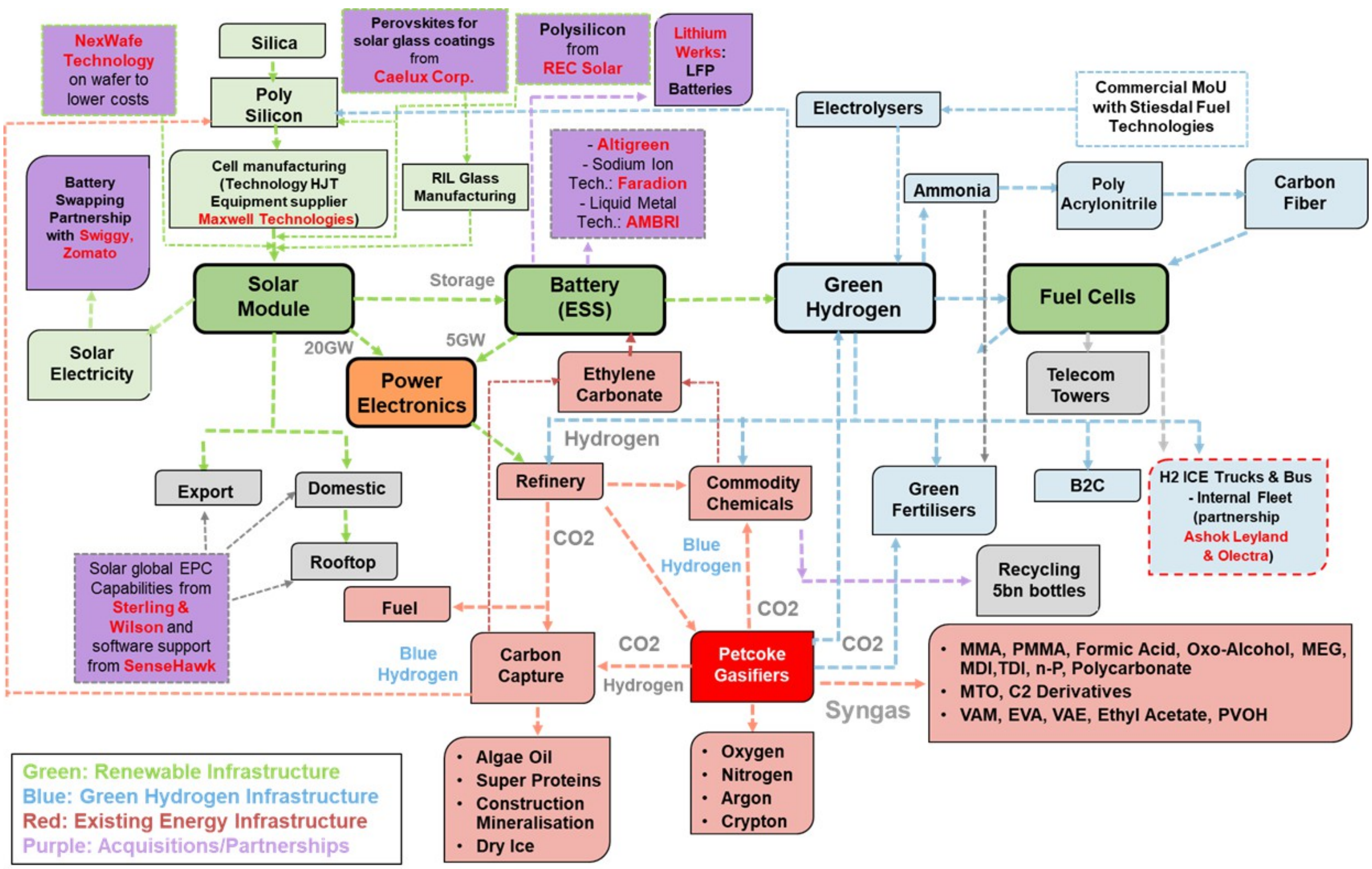
Source: Eikon, Morgan Stanley Research

Exhibit 119: India renewable generators: PEG vs. RoE profile



*Renew based on 2025 estimates
Source: Eikon, Morgan Stanley Research

Exhibit 120: Green energy ecosystem in the making



Source: Company data, Morgan Stanley Research

Southeast Asia: Underappreciated Upside

Conventional energy players are taking a bigger share in energy transition investments in India and Southeast Asia. We expect multiples to re-rate as these companies grow their new energy portfolios. We highlight Sembcorp Industries and PTT as the key beneficiaries of this trend.

Key Stock Picks – Most Preferred:

- **Sembcorp Industries (SCIL; OW)**: Sembcorp Industries (SCI) is taking advantage of tight electricity markets to grow shareholder value and grow its renewable energy arm, see note here. Singapore expects hydrogen to meet half of its power needs by 2050 and Sembcorp Industries is one of the most active companies in pursuing hydrogen adoption – it has committed to a hydrogen-ready gas-fired power plant by 2026 in Singapore, and is working with Mitsubishi and Chiyoda for the transportation of hydrogen via methylcyclohexane.

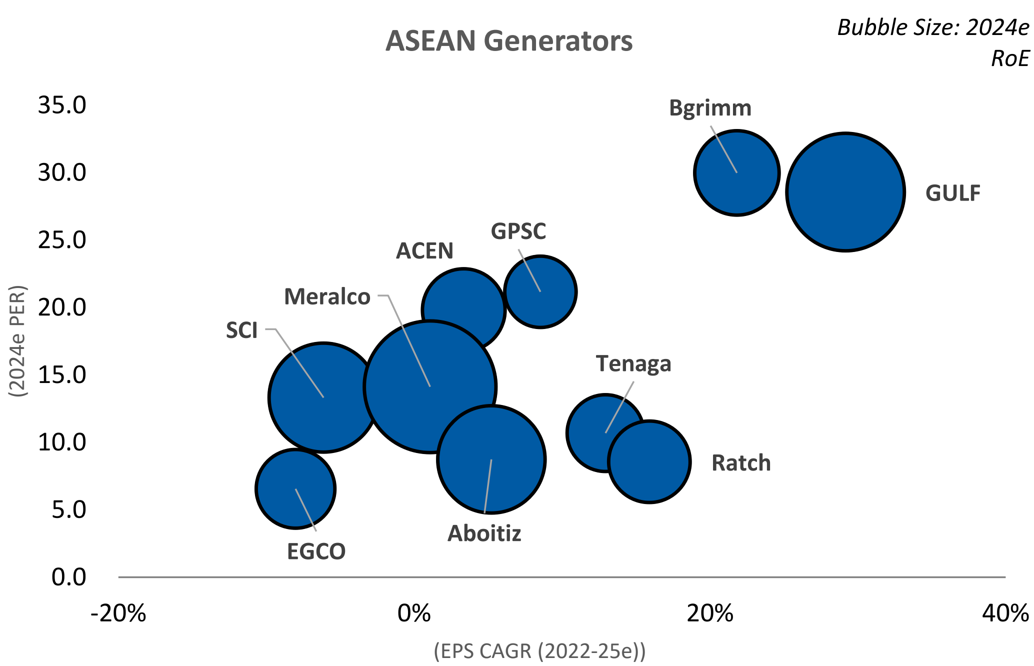
- **PTT (PTT; OW):** PTT is in the process of transforming itself into Asean's energy transition juggernaut as it commissions >US$10bn investments by 2030 across the energy landscape. Unlike global peers, PTT is executing its vision using an asset-light model, signing up with technology leaders as it drives Thailand's energy transition. We believe this approach diversifies regulatory uncertainty among a larger group of investors and potentially accelerates the pace of monetisation and payback.

Key Competitive Advantages: Balance sheet strength is a common denominator among these names, providing them with the capital resources to pursue these investments which, in some cases, require high upfront capex. PTT also benefits from strong manufacturing capabilities and low labour costs in India and Thailand.

Long-Term Drivers & What Might Investors Be Missing: We think investors are underappreciating the re-rating potential as clarity on capital allocation improves, even as the pace of monetisation surprises positively. The partnership approach with industry leaders (CATL, Mitsubishi, Nexwafe, etc.) should also help mitigate execution risks.

Risks to Competitive Advantages: Execution risks and dilutive returns from these investments will be key headwinds to track and will likely weigh on medium-term multiples. Regulatory uncertainty, excess competition, customer penetration, and unattractive tariffs in Asia are other key risks.

Exhibit 121: Asean renewable producers: PEG vs. RoE profile



Source: Eikon, Morgan Stanley Research (e) estimates

Australia: Decarbonisation & Renewables

The ASX has few pure-play renewable stocks or second derivative plays after a decade of policy uncertainty, and, more recently, several years of corporate activity.

Key Stock Picks – Most and Least Preferred:

- Between our integrated utilities, we **prefer ORG (OW) over AGL (EW)**, which has a preferable electricity market positioning, in our view (net short energy, with an uncomplicated renewable power purchase agreement strategy). Having said that, AGL owns a 20% interest in Tilt Renewables, an independent power producer with nearly 2GW of operating assets and a 4GW development pipeline, and we think the value of the Tilt platform is underappreciated by investors (9% of our target equity value).

- Between our regulated and contracted utilities, we are less constructive on **APA (EW)**. APA remains Australia's largest gas pipeline owner and operator, but its future growth plans skew to electricity transmission and lower emissions generation, which we think underpins APA's longer-term prospects on this theme.

Key Competitive Advantages

Australia's key competitive advantages globally include its renewable resources, investor-friendly capital markets, and a range of policy support measures. Policy-makers have developed an integrated system plan for the build-out of renewables and the required transmission, and we think the market underestimates the policy mechanisms to support renewables targets (Exhibit 122).

Having said that, supply chain constraints, including permitting and labour availability, are material, and are acting as a near-term inflationary driver for Australia's power prices.

Long-Term Drivers & What Might Investors Be Missing

In May, the Australian government announced the A$2bn Hydrogen Headstart initiative to help scale up green hydrogen projects, e.g., 2-3 flagship projects with up to 1GW of electrolyser capacity. The domestic hydrogen market is small and uneconomic without subsidies (we estimate a green hydrogen production cost of A$9/kg at current levelised renewables costs), and most large project announcements are aimed at Asian export markets, e.g., ammonia.

We are tracking 20GW of electrolyser projects in Australia within our proprietary plant database.

Risks to Competitive Advantages

Supply chain constraints, including permitting and labour availability, are material, and are acting as a near-term inflationary driver for Australia's power prices.

Australia's policy complexity remains high in view of the mix of state and federal targets.

Exhibit 122: Australia's renewable energy targets

State/Territory	2005a	2020a	2020e	2025e	2030e	2035e	2050e	Mechanism
Queensland	190.6	-19.0%			-30%		-100%	Queensland Climate Action Plan
New South Wales	160.7	-17.6%			-50%		-100%	Net Zero Plan Stage 1: 2005-2030
Australian Capital Territory	1.4	-20.9%		-61%	-74%		-100%	ACT Climate Change Strategy (vs. 1990)
Victoria	121.4	-29.8%	-30%	-31%	-48%	-78%	-100%	Victorian Climate Change Act 2017. Net zero by 2045
South Australia	35.6	-31.1%			-50%		-100%	Climate Change Action Plan 2021-2025 - Currently reviewing the Climate Change Act 2007
Tasmania	19.3	-127.8%					-100%	Draft Climate Change Action Plan 2023-25
Northern Territory	14.1	36.2%			-50%		-100%	Climate Change Response
Western Australia	76.0	4.5%			-14%		-100%	Western Australian Climate Policy (-80% below 2020 levels)
Total/Average	**619.1**	**-20.7%**			**-37%**		**-100%**	
Australia's COP27 NDC	624.2				-43%		-100%	Climate Change Act 2022

Sources: Government websites, National Greenhouse Gas Inventory, Department of Industry, Science, Energy and Resources, Morgan Stanley Research estimates.

LatAm Power Generation: Prefer Chile over Brazil

Global power equipment deflation is reducing the cost of developing new capacity (LCOE), and thus should have a negative impact on long-term energy prices in LatAm. However, we believe momentum differs significantly between Chile and Brazil. **In Brazil, a potential deflationary trend could further delay the recovery of energy prices**, which have already been negatively affected by current high water reservoir levels (due to good hydrology) and electricity oversupply. **In Chile, where long-term power prices have spiked, we don't believe the deflation trend will be strong enough in the near term to make energy prices unattractive.** We believe the high marginal cost of operations (spot prices) should remain high, due to relatively tighter energy supply-demand balance (e.g., also driven by coal-fired plants decommissioning), transmission bottlenecks, and reservoir levels. This should support long-term prices at higher levels for longer, enabling the development of greenfield projects at attractive returns, especially in lower capex scenarios.

LatAm power price drivers for different time horizons: This discussion can be largely divided into three time horizons:

1) Short term (up to 18 months): Power prices are, in practice, represented by the marginal cost of operation (i.e., cost to produce the next MWh), which ultimately depends on hydrology conditions, fuel costs, and other factors. Such variables make short-term prices highly volatile and cannot be controlled.

2) Medium term (1-4 years): Between these periods, power prices can be influenced by the supply-demand balance, combined with some influence from the short-term and long-term drivers. For example, a tight supply-demand balance in a period of already high marginal cost of operation (e.g. due to bad hydrology) can help to keep power prices above normalised levels for a few years, similar to the Chile case currently. On the other hand, if the power system has an oversupply, combined with low marginal cost of operations (e.g. due to good hydrology), this could help to maintain power prices lower for longer, which is the case of Brazil currently.

3) Long term (beyond 4 years): Power prices should gradually converge to the marginal cost of expansion (CME) of the most efficient source that, in Brazil and Chile, currently is the development cost of wind and solar projects. In the horizon beyond four years, the players would have incentives to expand capacity (if the power prices are above the LCOE). The opposite is true if prices are low – players won't build incremental capacity, and demand growth would shave off excess capacity until prices converge on the marginal cost again.

Key Stock Picks – Most and Least Preferred: We favor Chile's ENELCHILE.SN (OW) over Brazil's AESB3.SA (UW).

• **Enel Chile (ENELCHILE; OW) is our preferred way to play LatAm power generation**. Our constructive view is mostly supported by the combination of: 1) renewables' growth potential, with a 30GW pipeline, and 2) the upward trend in power prices in Chile, as the August 2022 auction cap prices of US$41/MWh were 71% above 2021's levels and still not enough to attract the gencos' interest (the auction ended up contracting only 15% of the total demanded volume). In addition, management believes current average long-term power price references should surpass US$50/MWh, representing meaningful upside to the price cap reference from the last auction. We see 30% upside to our bull case valuation, which assumes, among other optimistic projections, energy prices at US$45/MWh. Every US$5/MWh change in our energy price base case assumption of US$35/MWh (from 2025 onwards) positively affects our valuation by 10%, all else equal.

• **We would avoid exposure to AES Brasil (AESB3; UW)**, as, although we welcome renewable growth initiatives, we remain relatively concerned with specific risks, such as AESB's exposure to the persistent hydro-deficit and energy repricing (mainly after 2026), for which we see potential downside risk due to electricity oversupply and the current relatively comfortable hydrology situation.

***Key Competitive Advantages*:** Chile and Brazil offer among the most favorable conditions for renewable generation development globally, especially for wind and solar.

• **Chile** is moving rapidly towards a cleaner matrix with a high penetration of unconventional renewables, as solar and wind assets currently represent 35% of its installed capacity, and the percentage is expected to keep growing over the coming years, reaching 60% by 2030 and 75% by 2050. This growth would be possible as Chile ranks #2 in energy transition attractiveness among 107 emerging markets (according to Bloomberg's 2021 Climate Scope), and #1 in the Americas. The country's southern region has strong wind generation potential, while the northern region (the Atacama Desert), according to Solargis, is the most favorable environment in the world for solar generation, benefiting from 4,000 hours of sunlight annually. Finally, in addition to incremental renewable capacity, the government decided in 2019 to phase out all of the country's 5.5GW coal-fired capacity by 2040. Some companies have already reached that objective, such as Enel Chile, which just closed its last coal-fired thermal plant.

• **Brazil** already has a relatively clean power matrix, with hydro and renewables representing almost 80% of total installed capacity. Wind and solar centralised sources have increased share from 2% and 0% in 2012, respectively, to 13% and 4% in 2022; going forward, we expect renewables' outsized growth to continue, mostly supported by a combination of technology improvements, scale, decarbonisation concerns worldwide, and a highly competitive LCOE versus other sources, as we show below.

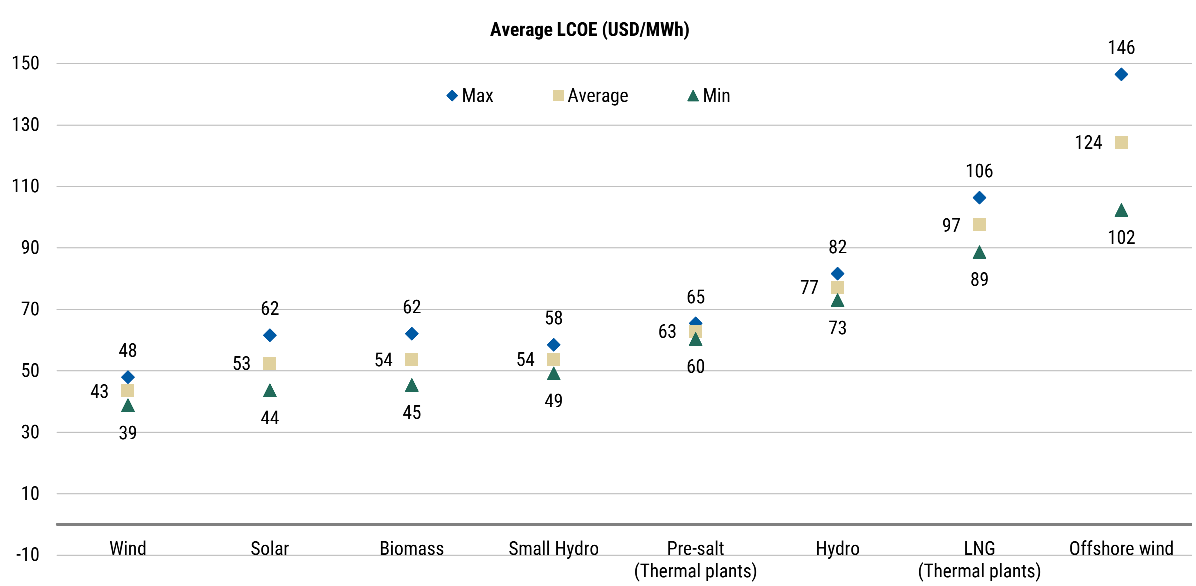
Long-Term Drivers & What Might Investors Be Missing: Energy prices remain one of the most important value drivers for LatAm generation stocks. We believe most investors share similar concerns on Brazil power prices' bearish outlook and generally agree with our relatively guarded view on power generation. In Chile, however, we see upside risks to our and consensus estimates.

• **In Chile**, we believe renewable projects are accretive, and we see upside risk to our Enel Chile estimates. In our view, the following factors support the company's positive growth momentum: i) Chile's current energy supply-demand is relatively balanced, which supports the necessity to develop new generation projects to meet growing demand; ii) a recovery in long-term power prices is suggested by the last energy auction held in August 2022, which had average prices of US$37/MWh (above the previous auction at US$25/MWh) to be delivered after 2027; iii) Enel Chile's projects are in different stages of development, already allowing earnings contribution in 2023/24; and iv) upside risk to our medium- and long-term estimates (supported by its 11GW mature pipeline). While in our base case we assume only the projects under construction (the standard assumption across our coverage universe), we incorporate 3.2GW of new projects in our bull case (from Enel Chile's 11GW mature pipeline), corresponding to Ch$5.6 per share (11% of the current market price, or 13% of our base case).

• **In Brazil**, we continue to prefer power distribution over generation, of which our guarded view is mainly supported by the persistence of low energy prices for longer (mostly driven by good hydrology, coupled with oversupply). Although we don't believe current low prices are sustainable in the long term due to significant differences in development costs (LCOE), we lack visibility on when long-term power prices could recover.

Risks to Competitive Advantages: Besides limited visibility on power price evolution, which is among the most important value drivers for LatAm power generation stocks, other risks include: i) execution and financing risks; ii) supply chain constraints; iii) regulatory and fiscal uncertainties, mostly regarding visibility on subsidies and market opening conditions; iv) dilutive returns for new investments; and v) grid connection constraints, mostly related to necessary approvals (e.g., regulatory, environmental) and transmission connectivity, dependent on transmission expansion.

Exhibit 123: Brazil average LCOE (USD/MWh, as of 2022)



Source: PSR, Morgan Stanley Research. Notes: 1) The sensitivity analysis assume equity real IRRs at 9-11%, and include average capex assumptions for the following sources: Onshore wind (R$5-6.5k/MW), Solar (R$3.5-5.5k/MWac), Biomass (R$5-7.2k/MW), Small hydro (R$7-8.5k/MW), Pre-salt & LNG thermal (US$0.6-0.8k/MW), Hydro (R$7.5-8.5k/MW), Offshore wind (US$2.3-3.5k/MW). Also, renewable assumptions do not include incentivised energy spread conditions, given no 50% discount on distribution/transmission fees. 2) LCOEs translated at BRL/USD 4.74.

LCOE Calculation Methodology & Assumptions

Levelised cost of electricity (LCOE) is a measurement of the present value of the lifetime cost of a power generation/storage project divided by present value of the volume of electricity it produces/stores. LCOE is a widely used measurement of the cost of producing/storing electricity by a certain technology. Below we highlight our estimates and key assumptions used in our calculations.

Core advantages of LCOE

- Simple and widely used
- Measures value across the projected life-cycle
- Ability to compare costs of generation across technologies

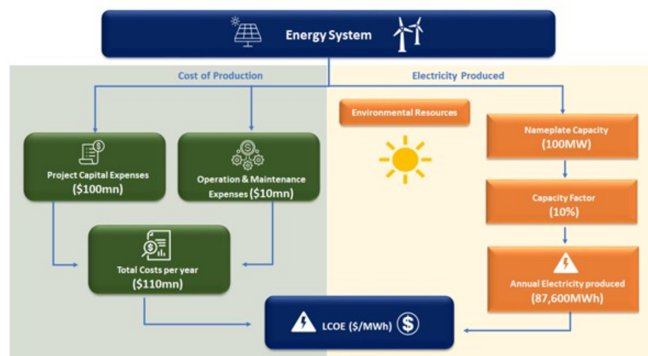
Limitations to calculations

- Oversimplified financing assumptions
- Ignores project specific costs

Simplified LCOE calculation

$$\frac{\sum_{t=1}^{n} \frac{CAPEX_t + O\&M_t + Fuel_t}{(1+WACC)^t}}{\sum_{t=1}^{n} \frac{Electricity\ Generated_t}{(1+WACC)^t}}$$

Exhibit 124: A visual guide to LCOE calculation



Source: Morgan Stanley Research

Exhibit 125: Key installed capital cost assumptions

Key Capital Cost Assumptions	2021	2023	2025	2030
US				
Solar installed cost (US$ mn/MWdc)	0.85	1.00	0.89	0.66
Onshore wind installed cost (US$ mn/MW)	1.72	1.85	1.76	1.63
Offshore wind installed cost (US$mn /MW)	4.83	4.00	3.70	2.54
ESS System (US$/kWh)	327	348	269	242
Electrolyser installed (Alkaline) (USmn/MW)	NA	1.90	1.63	1.12
Electrolyser installed (PEM) (USmn/MW)	NA	2.20	1.81	1.12
Europe				
Solar installed cost (US$ mn/MWdc)	0.62	0.63	0.61	0.61
Onshore wind installed cost (US$ mn/MW)	1.11	1.38	1.30	1.11
Offshore wind installed cost (US$mn /MW)	2.27	2.51	2.36	2.01
ESS System (US$/kWh)	327	348	269	242
Electrolyser installed (Alkaline) (USmn/MW)	NA	1.90	1.90	1.12
Electrolyser installed (PEM) (USmn/MW)	NA	2.20	2.20	1.12
Asia				
Solar installed cost (US$ mn/MWdc)	0.65	0.60	0.54	0.50
Onshore wind installed cost (US$ mn/MW)	1.02	0.97	0.94	0.89
Offshore wind installed cost (US$mn /MW)	2.30	2.19	2.08	2.01
ESS System (US$/kWh)	242	255	230	201
Electrolyser installed (Alkaline) (USmn/MW)	1.09	1.28	0.89	0.87
Electrolyser installed (PEM) (USmn/MW)	NA	2.20	1.81	1.12

Source: Morgan Stanley Research estimates

Exhibit 126: Asia solar key LCOE assumptions

Technological curve	2021	2023	2025	2030
Utilisation rate	18%	19%	22%	26%
O&M costs (US$/Mwh)	5.0	5.0	4.0	3.0
Degradation rate (year)	0.50%	0.50%	0.40%	0.25%
WACC	7.1%	7.3%	7.1%	7.1%
EPC Cost Inflation	-5.0%		2.0%	7.2%
Solar Module (US$/w)	0.25	0.20	0.17	0.16
Non-module Cost Deflation			-13.5%	-24.9%
DC to AC Conversion	1.33	1.33	1.33	1.33

Source: Morgan Stanley Research estimates

Exhibit 127: Asia onshore wind – key LCOE assumptions

Technological curve		2021	2023	2025	2030
Utilisation rate		27%	27%	33%	35%
O&M costs (US$/Mwh)		11.0	11.6	12.1	13.4
WACC		8.1%	8.4%	8.1%	8.1%
Build Cost		1,020.00	969.00	939.93	892.93
Subsidies	No				

Source: Morgan Stanley Research estimates

Exhibit 128: Asia offshore wind – key LCOE assumptions

Technological curve		2021	2023	2025	2030
Utilisation rate		32%	35%	37%	45%
O&M costs (US$/Mwh)		24.0	25.2	26.5	29.2
WACC		8.1%	8.4%	8.1%	8.1%
Build Cost ex. transmission (US$/kW)		2,371.31	2,252.74	2,140.11	2,075.90
Subsidies	No				

Source: Morgan Stanley Research estimates

Exhibit 129: Asia battery energy storage – key LCOE assumptions

LFP Technological curve	2021	2023E	2025E	2030E
Cycle Life	4,500	4,500	4,500	4,500
Degradation per 1000 cycles	2%	2%	2%	2%
Cells (US$/kwh)	83.0	93.0	87.0	80.2
Racks (US$/kwh)	108.0	116.0	102.0	85.0
Energy Management System (US$/kwh)	14.0	10.0	8.0	7.2
Power Conversion System (US$/kwh)	13.0	13.0	12.0	10.0
EPC Margins	24.0	23.2	20.9	18.2
Round Trip Efficiency	95%	95%	95%	95%

Source: Morgan Stanley Research estimates

Exhibit 130: Asia hydrogen (alkaline) – key LCOE assumptions

Technological curve	2021	2023	2025	2030
Electrical Efficiency (LHV)	60%	62%	70%	75%
Stack Lifetime	50,000	30,000	40,000	50,000
Capex	0.50	0.51	0.39	0.31
HHV	0.06	0.05	0.04	0.04

Source: Morgan Stanley Research estimates

Exhibit 131: US solar – key LCOE assumptions

Technological curve		2021	2023	2025	2030
Utilisation rate		22.6%	23.3%	24.1%	26.0%
Operating costs (US$/Mwh)		5.4	5.7	5.4	4.7
Degradation rate (year)		0.50%	0.50%	0.50%	0.50%
WACC		6.6%	6.9%	6.6%	6.6%
Solar Module (US$/w)		0.33	0.45	0.40	0.30
Non-Module Cost		0.52	0.55	0.49	0.36
ITC?	Yes	26.0%	30.0%	30.0%	30.0%
DC to AC factor		1.3	1.3	1.3	1.3

Source: Morgan Stanley Research estimates

Exhibit 132: US onshore wind – key LCOE assumptions

Technological curve		2021	2023	2025	2030
Utilisation rate		39%	40%	41%	42%
O&M costs (US$/Mwh)		10.9	11.1	10.9	10.6
WACC		7.2%	7.5%	7.2%	7.2%
Build Cost		1,718	1,854	1,762	1,634
PTC?	Yes	15.00	26.00	26.00	26.00

Source: Morgan Stanley Research estimates

Exhibit 133: US offshore wind – key LCOE assumptions

Technological curve		2021	2023	2025	2030
Utilisation rate		43%	44%	45%	47%
O&M costs (US$/Mwh)		30	28	26	23
WACC		8.8%	9.1%	8.8%	8.8%
Build Cost ex. transmission (US$/kW)		4,833	4,000	3,700	2,538
Subsidies	Yes	15.00	26.00	26.00	26.00

Source: Morgan Stanley Research estimates

Exhibit 134: US battery energy storage – key LCOE assumptions

Li-ion Technological curve	2021	2023	2025	2030
Cycle Life	4,500	4,500	4,500	4,500
Degradation per 1000 cycles	2%	2%	2%	2%
Cells (US$/kwh)	104.5	93.5	87.9	83.4
Racks (US$/kwh)	120.6	157.4	101.1	95.3
BoS (US$/kwh)	40.0	34.9	30.4	21.6
Power Conversion System (US$/kwh)	19.0	16.6	14.5	10.3
EPC and System Integrator Margins	42.6	45.4	35.1	31.6
Round Trip Efficiency	95%	95%	95%	95%

Source: Morgan Stanley Research estimates

Exhibit 135: US hydrogen (alkaline) – key LCOH assumptions

Technological curve	2023	2025	2030
Electrical efficiency (%, LHV)	68%	68%	69%
Stack lifetime (operating hours)	75,000	79,010	90,000
Capex - electrolyser system (USDmn/MW)	0.87	0.70	0.40
Capex - other (USDmn/MW)	1.03	0.93	0.72
Total capex (USDmn/MW)	1.90	1.63	1.12
Other capex/system	118%	133%	180%
Electricity Price	39	34	27

Source: Morgan Stanley Research estimates

Exhibit 136: EU solar – key LCOE assumptions

Technological curve	2021	2023	2025	2030
Utilisation rate	14.7%	15.0%	15.3%	16.0%
Opex ($mn/MW) - Europe	0.021	0.019	0.018	0.015
WACC	3.1%	5.2%	5.2%	5.2%
Installed Cost (US$/MW)	0.62	0.63	0.61	0.61

Source: Morgan Stanley Research estimates

Exhibit 137: EU onshore wind – key LCOE assumptions

Technological curve	2021	2023	2025	2030
Utilisation rate	27%	28%	28%	30%
Opex ($mn/MW) - Europe	0.027	0.025	0.023	0.020
WACC	3.1%	5.2%	5.2%	5.2%
Installed Cost (US$/MW)	1.11	1.38	1.30	1.11

Source: Morgan Stanley Research estimates

Exhibit 138: EU offshore wind – key LCOE assumptions

Technological curve	2021	2023	2025	2030
Utilisation rate	46%	48%	49%	52%
Opex ($mn/MW) - Europe	0.059	0.051	0.046	0.033
WACC	3.1%	5.2%	5.2%	5.2%
Installed Cost ex transmission (US$/MW)	2.27	2.51	2.36	2.01

Source: Morgan Stanley Research estimates

Exhibit 139: EU battery energy storage – key LCOE assumptions

Li-ion Technological curve	2021	2023	2025	2030
Cycle Life	4,500	4,500	4,500	4,500
Degradation per 1000 cycles	2%	2%	2%	2%
Cells (US$/kwh)	104.5	93.5	87.9	83.4
Racks (US$/kwh)	120.6	157.4	101.1	95.3
BoS (US$/kwh)	40.0	34.9	30.4	21.6
Power Conversion System (US$/kwh)	19.0	16.6	14.5	10.3
EPC and System Integrator Margins	42.6	45.4	35.1	31.6
Round Trip Efficiency	95%	95%	95%	95%

Source: Morgan Stanley Research estimates

Exhibit 140: EU hydrogen (PEM) – key LCOH assumptions

Technological curve	2023	2025	2030
Electrical efficiency (%, LHV)	68%	68%	69%
Stack lifetime (operating hours)	75,000	79,010	90,000
Capex - electrolyser system (USDmn/MW)	0.87	0.70	0.40
Capex - other (USDmn/MW)	1.03	0.93	0.72
Total capex (USDmn/MW)	1.90	1.63	1.12
Other capex/system	118%	133%	180%
Electricity Price	39	34	27

Source: Morgan Stanley Research estimates

Comparable Companies

Exhibit 141: Renewable utility developers

Company Name	Market Cap (USD mn)	P/E			EV/Sales			EV/EBITDA			ROE		
		2023FY	2024FY	2025FY	2023FY	2024FY	2025FY	2023FY	2024FY	2025FY	2023FY	2024FY	2025FY
UTILITY DEVELOPERS													
AES Corp.	15,481	12.7	11.7	10.2	3.6	4.1	4.3	11.9	13.1	13.4	76%	58%	45%
Ameren Corp	22,183	19.4	18.1	17.0	4.9	5.0	4.9	12.7	12.1	11.5	11%	11%	11%
Atlantica Sustainable Infrastructure	2,813	20.7	12.8	9.8	6.0	5.3	4.7	8.7	7.5	6.7	8%	13%	15%
Avangrid Inc	14,408	17.1	16.1	15.0	3.3	3.5	3.7	11.7	12.1	12.2	4%	5%	5%
American Electric Power Co	43,649	16.1	15.2	14.1	4.5	4.6	4.8	11.1	11.2	10.9	11%	11%	12%
CGN New Energy Holdings	1,219	5.2	5.0	4.6	3.2	3.1	2.9	7.3	6.9	6.4	16%	14%	14%
China Longyuan Power Group	32,329	8.4	7.7	NA	9.2	9.1	NA	14.7	14.0	NA	11%	12%	NA
China Resources Power	10,983	7.6	6.0	NA	2.3	2.1	NA	6.1	5.3	NA	11%	14%	NA
China Suntien Green Energy Co., Ltd.	6,666	4.8	4.3	3.8	4.6	4.7	4.7	12.9	11.5	10.1	11%	11%	12%
Clearway Energy Inc	5,482	25.4	21.5	21.2	11.6	10.9	10.5	13.4	11.5	11.2	10%	12%	13%
CMS Energy Corp	17,319	19.1	17.8	16.5	3.8	3.8	3.9	12.8	12.0	11.7	13%	13%	13%
Consolidated Edison Inc	32,838	19.0	17.7	16.8	4.0	4.0	4.0	11.3	11.0	10.8	8%	9%	9%
CPFL ENERGIA	8,505	8.8	8.2	8.0	1.6	1.6	1.5	6.0	6.0	6.0	29%	29%	27%
Dominion Energy Inc	42,106	13.1	13.2	13.3	5.3	5.3	5.4	10.4	10.2	10.1	13%	12%	10%
Duke Energy Corp	70,001	16.1	15.2	14.3	5.2	5.1	5.1	11.3	10.9	10.6	9%	10%	10%
Edison International	26,653	14.7	13.7	12.5	3.5	3.5	3.5	9.6	9.1	8.7	13%	14%	14%
EDP Renovaveis	18,969	27.2	24.7	21.4	10.3	9.4	8.8	13.1	12.5	11.6	7%	7%	7%
Endesa SA	22,995	13.7	11.6	9.0	1.3	1.4	1.3	7.5	6.6	5.8	27%	33%	37%
ENEL	71,647	10.5	9.3	8.4	1.2	1.3	1.3	7.2	6.7	6.4	19%	20%	20%
Enel Chile	4,963	8.4	8.3	10.8	1.5	1.5	1.5	5.1	4.7	5.1	12%	11%	8%
ENGIE	40,958	7.3	8.1	9.1	1.2	1.8	1.9	4.7	5.0	5.0	15%	14%	12%
Engie Brasil	7,608	11.2	10.6	9.2	4.6	4.8	4.9	6.7	6.6	6.1	38%	40%	45%
Entergy Corp	21,019	12.7	11.8	11.2	3.6	3.7	3.8	9.3	9.2	9.2	13%	13%	13%
Eversource Energy	24,916	16.4	15.3	14.1	3.9	3.9	3.9	10.9	10.6	10.1	10%	10%	10%
Exelon Corp	41,074	17.5	16.1	14.9	4.2	4.2	4.2	10.5	10.2	9.8	10%	10%	10%
Huaneng Power	17,248	25.9	19.5	NA	2.2	2.2	NA	9.6	9.0	NA	8%	10%	NA
Iberdrola SA	79,705	15.2	15.0	14.3	2.2	2.2	2.1	9.2	9.5	9.2	12%	11%	12%
NextEra Energy Inc	146,136	23.1	21.2	19.5	7.8	7.7	7.6	13.8	13.1	12.8	13%	12%	13%
NextEra Energy Partners LP	11,284	28.7	13.3	12.2	12.3	9.7	9.1	18.0	13.4	12.4	12%	25%	27%
Oersted A/S	39,758	39.7	29.0	34.1	4.0	3.9	4.0	17.5	11.0	12.9	9%	11%	8%
Public Service Enterprise Group Inc	31,766	18.3	17.1	15.5	6.9	6.8	6.6	12.6	12.2	11.7	12%	13%	13%
RWE AG	33,286	9.5	14.6	17.0	0.7	0.9	1.1	5.6	6.9	7.7	11%	6%	5%
Sempra Energy	46,162	15.9	15.1	13.9	5.2	5.1	4.9	12.9	12.7	12.3	11%	11%	12%
Southern Company	75,819	19.1	17.1	16.0	5.0	4.9	4.8	12.2	11.5	11.1	13%	14%	14%
SSE	24,984	11.1	9.2	10.6	1.2	1.2	1.2	8.4	7.0	7.2	20%	21%	16%
Xcel Energy Inc	34,623	18.7	17.5	16.7	3.9	3.9	3.9	11.3	11.1	10.8	11%	11%	11%
Longi Green Energy Technology	31,381	14.2	12.2	10.8	1.5	1.3	1.1	9.6	7.2	6.0	25%	25%	24%
Tongwei Co Limited	22,338	8.5	10.4	8.2	1.0	0.9	0.8	4.9	5.8	5.0	31%	23%	27%
China Yangtze Power	71,376	17.3	16.0	NA	9.4	8.7	NA	12.6	11.6	NA	16%	16%	NA
HuanengLancang River Hydropower	17,722	16.2	14.2	NA	9.2	8.5	NA	11.7	10.7	NA	12%	12%	NA
Titan Wind Energy Suzhou Co	3,560	13.2	10.6	9.7	2.1	1.6	1.3	11.6	9.5	7.5	23%	24%	22%
China Everbright Environment	2,359	3.5	3.4	3.4	3.2	3.1	3.0	10.0	9.9	10.0	11%	11%	10%
China Suntien Green Energy	6,666	4.8	4.3	3.8	4.6	4.7	4.7	12.9	11.5	10.1	11%	11%	12%
Jiangsu Zhongtian Technology	7,514	13.2	10.6	8.8	0.9	0.7	0.5	6.2	4.9	3.9	14%	15%	16%
Average	**29,783**	**15.2**	**13.4**	**12.8**	**4.4**	**4.2**	**3.9**	**10.4**	**9.7**	**9.2**	**15%**	**16%**	**16%**
Median	**22,666**	**14.9**	**13.5**	**12.5**	**3.9**	**3.9**	**3.9**	**11.0**	**10.4**	**10.1**	**12%**	**12%**	**13%**

Source: Refinitiv, company data, Morgan Stanley Research estimates. Price data as of July 18, 2023

Exhibit 142: Renewable equipment manufacturers

Company Name	Market Cap (USD mn)	P/E			EV/Sales			EV/EBITDA			ROE		
		2023FY	2024FY	2025FY	2023FY	2024FY	2025FY	2023FY	2024FY	2025FY	2023FY	2024FY	2025FY
EQUIPMENT MANUFACTURERS													
Dr Laser	2,390	33.0	23.7	18.7	9.5	6.4	5.0	28.0	19.5	16.2	*19%*	*25%*	*25%*
First Solar Inc	21,629	28.3	15.9	10.0	4.9	3.4	2.4	18.3	10.2	6.0	*13%*	*21%*	*27%*
General Electric Co.	121,833	71.0	28.2	20.9	1.9	1.7	1.5	11.6	7.6	5.9	*5%*	*13%*	*16%*
Goldwind	5,805	6.3	6.1	5.1	1.6	1.6	1.5	7.3	7.1	6.4	*9%*	*8%*	*9%*
Prysmian S.p.A.	10,868	14.2	14.5	12.9	0.7	0.7	0.6	7.1	7.1	6.3	*19%*	*17%*	*17%*
Riyue Heavy Industry Co Ltd	2,640	22.6	16.8	13.0	2.6	2.1	1.7	13.6	9.8	7.4	*9%*	*11%*	*13%*
Titan Wind Energy Suzhou Co Ltd	3,560	13.2	10.6	9.7	2.1	1.6	1.3	11.6	9.5	7.5	*23%*	*24%*	*22%*
TPI Composites Inc.	438	NM	NM	12.4	0.5	0.4	0.3	133.2	12.6	4.5	*-161%*	*NM*	*294%*
Shenzhen SC New Energy Technology Corp	5,038	23.9	17.5	27.8	3.6	2.3	3.1	21.0	15.4	27.1	*21%*	*24%*	*12%*
Suzhou Maxwell Technologies Co Ltd	7,875	38.9	25.1	20.5	7.5	4.0	3.3	44.8	20.5	15.0	*18%*	*30%*	*31%*
Vestas Wind Systems A/S	28,284	NM	54.1	36.9	2.6	2.4	2.1	54.1	24.7	19.4	*-4%*	*16%*	*20%*
Xinyi Solar	9,625	15.8	10.8	9.2	3.4	2.4	2.1	11.3	8.3	7.2	*16%*	*22%*	*23%*
Flat Glass Group Co. Ltd	9,623	16.9	11.3	8.6	3.5	2.7	2.1	15.3	10.6	7.8	*19%*	*24%*	*25%*
Flat Glass Group Co. Ltd	9,623	28.0	18.7	14.2	3.5	2.7	2.1	15.3	10.6	7.8	*19%*	*24%*	*25%*
China Jushi	7,692	10.6	9.7	8.8	3.4	2.8	2.5	9.6	7.5	6.6	*19%*	*18%*	*18%*
Average	**16,461**	**24.8**	**18.8**	**15.2**	**3.4**	**2.5**	**2.1**	**26.8**	**12.1**	**10.1**	***3%***	***20%***	***39%***
Median	**7,875**	**22.6**	**16.4**	**12.9**	**3.4**	**2.4**	**2.1**	**15.3**	**10.2**	**7.4**	***18%***	***21%***	***22%***

Source: Refinitiv, Company data, Morgan Stanley Research estimates. Price data as of July 18, 2023

Exhibit143: Utility company comparables

Company Name	Market cap, current, USD (MM)	P/E			EV/EBITDA			P/BV			ROE			Dividend yield		
		2023e	2024e	2025e	2023e	2024e	2025e	2023e	2024e	2025e	2023e	2024e	2025e	2023e	2024e	2025e
Australia companies																
AGL Energy	5,410	26.3 e	10.0 e	9.7 e	10.5 e	7.0 e	6.9 e	1.3 e	1.3 e	1.2 e	4.2% e	13.4% e	12.9% e	2.9% e	6.8% e	6.9% e
APA Group	7,888	35.4 e	30.7 e	28.1 e	12.7 e	11.5 e	11.1 e	4.9 e	5.8 e	6.8 e	12.3% e	16.3% e	20.5% e	5.7% e	6.0% e	6.6% e
Origin Energy	10,073	20.1 e	16.2 e	12.5 e	5.6 e	5.1 e	4.5 e	1.6 e	1.6 e	1.4 e	7.2% e	10.2% e	12.4% e	5.1% e	4.0% e	3.7% e
Australia Average		**27.3**	**18.9**	**16.8**	**9.6**	**7.9**	**7.5**	**2.6**	**2.9**	**3.1**	**7.9%**	**13.3%**	**15.3%**	**4.5%**	**5.6%**	**5.7%**
China Companies																
Huaneng Power International Inc.	2,924	12.5 e	9.4 e	NA	9.6 e	9.0 e	NA	1.0 e	0.9 e	NA	8.1% e	10.3% e	NA	4.0% e	5.3% e	NA
China Suntien Green Energy Co., Ltd.	661	4.9 e	4.4 e	3.9 e	13.0 e	11.5 e	10.2 e	0.5 e	0.5 e	0.4 e	11.0% e	11.4% e	12.0% e	7.4% e	8.2% e	9.3% e
China Longyuan Power Group	3,373	8.7 e	7.9 e	NA	14.9 e	14.3 e	NA	0.9 e	0.8 e	NA	11.5% e	11.5% e	NA	2.3% e	2.5% e	NA
China Resources Power	10,983	7.8 e	6.1 e	NA	6.1 e	5.4 e	NA	0.8 e	0.8 e	NA	11.5% e	13.6% e	NA	5.1% e	6.5% e	NA
China Power International Development*	4,923	10.6	7.7 e	6.0 e	9.1	7.3 e	5.9 e	0.8	0.7 e	0.7 e	7.8%	10.1% e	11.9% e	4.2%	5.6% e	7.4% e
China Average		**8.9**	**7.1**	**5.0**	**10.5**	**9.5**	**8.0**	**0.8**	**0.7**	**0.6**	**10.0%**	**11.4%**	**12.0%**	**4.6%**	**5.6%**	**8.3%**
Hong Kong Companies																
CLP Holdings	19,691	12.5 e	11.3 e	11.2 e	6.3 e	6.8 e	7.5 e	1.4 e	1.3 e	1.3 e	11.7% e	12.4% e	12.0% e	5.6% e	5.7% e	5.8% e
HK Electric Investments	5,405	13.3 e	13.1 e	13.0 e	11.0 e	10.6 e	10.3 e	0.9 e	0.9 e	0.9 e	6.6% e	6.6% e	6.6% e	6.7% e	7.2% e	7.2% e
Power Assets Holdings*	11,087	13.6 e	13.1 e	13.2 e	39.5 e	37.9 e	31.0 e	1.0 e	1.0 e	1.0 e	7.2% e	7.4% e	7.5% e	7.0% e	7.0% e	7.0% e
CK Infrastructure Holdings	13,011	12.0 e	11.3 e	11.3 e	32.9 e	31.8 e	23.0 e	0.8 e	0.8 e	0.8 e	7.0% e	7.2% e	7.1% e	6.5% e	6.6% e	6.5% e
Hong Kong Average		**12.8**	**12.2**	**12.2**	**22.5**	**21.8**	**18.0**	**1.0**	**1.0**	**1.0**	**8.1%**	**8.4%**	**8.3%**	**6.4%**	**6.6%**	**6.6%**
India Companies																
NTPC	22,144	10.2 e	9.6 e	8.7 e	7.9 e	7.4 e	6.8 e	1.2 e	1.2 e	1.1 e	12.3% e	13.0% e	13.5% e	4.2% e	4.6% e	5.3% e
Power Grid Corporation of India	20,504	11.3 e	11.8 e	11.7 e	7.1 e	6.6 e	6.4 e	1.9 e	1.9 e	1.8 e	18.3% e	17.2% e	16.2% e	5.1% e	5.1% e	5.1% e
ReNew Energy Global PLC	1,565	NM	NM	NM	8.9	10.1 e	9.9 e	1.8	1.7 e	1.6 e	(3.3%)	3.0% e	4.9% e	0.0%	0.0% e	0.0% e
Tata Power Co	8,627	18.8 e	17.6 e	18.7 e	11.3 e	10.4 e	9.6 e	2.4 e	2.5 e	2.2 e	14.5% e	15.9% e	13.2% e	0.9% e	0.8% e	0.8% e
Petronet LNG	4,099	10.7	10.7 e	10.0 e	5.7	5.6 e	5.1 e	2.3	2.1 e	1.9 e	23.9%	21.6% e	20.8% e	4.4%	4.7% e	5.0% e
GAIL	8,728	12.4	7.3 e	6.8 e	8.1	5.2 e	4.9 e	1.1	1.0 e	0.9 e	8.7%	15.4% e	14.9% e	4.7%	5.2% e	5.5% e
India Average		**12.7**	**11.4**	**11.2**	**8.2**	**7.5**	**7.1**	**1.8**	**1.7**	**1.6**	**12.4%**	**14.4%**	**13.9%**	**3.2%**	**3.4%**	**3.6%**
Malaysia Companies																
Tenaga Nasional	11,608	14.7 e	13.9 e	15.4 e	3.4 e	3.2 e	3.0 e	0.9 e	0.8 e	0.8 e	6.0% e	6.3% e	5.5% e	4.3% e	3.6% e	3.2% e
Petronas Gas*	7,388	17.8 e	17.4 e	16.5 e	9.6 e	9.4 e	9.1 e	2.5 e	2.4 e	2.4 e	13.9% e	13.8% e	13.8% e	4.8% e	4.8% e	4.9% e
Gas Malaysia*	849	10.9 e	11.7 e	11.3 e	6.5 e	6.8 e	6.1 e	2.9 e	2.7 e	2.9 e	25.0% e	21.6% e	20.2% e	7.4% e	6.7% e	7.1% e
Malaysia Average		**14.4**	**14.3**	**14.4**	**6.5**	**6.5**	**6.1**	**2.1**	**2.0**	**2.0**	**15.0%**	**13.9%**	**13.2%**	**5.5%**	**5.0%**	**5.1%**
Indonesia Companies																
Perusahaan Gas Negara	2,206	10.6 e	8.5 e	8.7 e	4.3 e	3.7 e	3.5 e	0.8 e	0.8 e	0.8 e	7.9% e	9.9% e	9.3% e	6.6% e	8.3% e	8.0% e
Indonesia Average		**10.6**	**8.5**	**8.7**	**4.3**	**3.7**	**3.5**	**0.8**	**0.8**	**0.8**	**7.9%**	**9.9%**	**9.3%**	**6.6%**	**8.3%**	**8.0%**
Philippines Companies																
Manila Electric Company	7,275	13.5 e	12.9 e	12.2 e	9.6 e	8.7 e	8.1 e	3.2 e	2.9 e	2.7 e	25.9% e	25.0% e	24.1% e	5.0% e	5.2% e	5.5% e
Aboitiz Power Corporation	4,601	14.0 e	11.8 e	11.3 e	10.4 e	9.1 e	8.6 e	1.5 e	1.4 e	1.3 e	11.3% e	12.7% e	12.5% e	3.6% e	4.2% e	4.4% e
Philippines Average		**13.8**	**12.3**	**11.8**	**10.0**	**8.9**	**8.4**	**2.4**	**2.2**	**2.0**	**18.6%**	**18.8%**	**18.3%**	**4.3%**	**4.7%**	**4.9%**
Thailand Companies																
Ratchaburi Electricity*	2,279	9.7 e	8.6 e	7.4 e	13.4 e	13.3 e	9.5 e	0.8 e	0.7 e	0.6 e	8.1% e	8.7% e	9.0% e	6.1% e	6.0% e	8.6% e
Electricity Generating Public Company	2,077	6.1 e	6.1 e	6.8 e	4.0 e	3.9 e	4.4 e	0.5 e	0.5 e	0.5 e	9.5% e	9.0% e	7.6% e	5.2% e	5.2% e	5.2% e
Bgrimm Power*	2,712	NM	30.0 e	25.9 e	12.5 e	11.3 e	9.6 e	2.5 e	2.4 e	2.7 e	7.5% e	9.3% e	11.7% e	1.3% e	1.7% e	1.7% e
Gulf Energy*	16,616	35.5 e	28.6 e	23.4 e	30.4 e	25.3 e	21.9 e	5.2 e	4.7 e	4.5 e	15.6% e	17.6% e	310.6% e	1.4% e	1.7% e	2.6% e
GPSC*	4,503	24.4 e	21.2 e	20.7 e	14.5 e	14.1 e	15.7 e	1.4 e	1.4 e	1.4 e	5.8% e	6.7% e	6.9% e	2.4% e	2.7% e	2.8% e
Thailand Average		**18.9**	**18.9**	**16.8**	**14.9**	**13.6**	**12.2**	**2.1**	**1.9**	**1.9**	**9.3%**	**10.3%**	**69.2%**	**3.3%**	**3.5%**	**4.2%**
Singapore Companies																
SembCorp Industries	7,479	12.3 e	13.6 e	14.7 e	9.3 e	9.9 e	9.9 e	2.1 e	1.9 e	1.7 e	19.3% e	15.3% e	12.7% e	2.2% e	2.0% e	1.9% e
Keppel Corporation	9,430	12.6 e	12.0 e	12.1 e	19.6 e	18.4 e	19.8 e	1.1 e	1.0 e	1.0 e	8.5% e	8.6% e	8.2% e	4.4% e	4.7% e	4.7% e
Singapore Average		**12.5**	**12.8**	**13.4**	**14.4**	**14.2**	**14.8**	**1.6**	**1.5**	**1.4**	**13.9%**	**12.0%**	**10.4%**	**3.3%**	**3.3%**	**3.3%**
ASEAN Average		**15.2**	**15.1**	**14.3**	**11.3**	**10.6**	**9.9**	**1.9**	**1.8**	**1.8**	**12.6%**	**12.7%**	**34.8%**	**4.2%**	**4.4%**	**4.7%**
Asia Average		**14.6**	**13.1**	**13.0**	**11.9**	**11.0**	**10.1**	**1.7**	**1.6**	**1.7**	**11.1%**	**12.3%**	**22.8%**	**4.4%**	**4.8%**	**5.1%**

Source: Company data, Refinitiv, Morgan Stanley Research. e = Morgan Stanley Research estimates except for *non-covered companies, which are Refinitiv consensus estimates. as of July 18, 2023

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Stock Rating Category	Count	% of Total	Count	% of Total IBC	% of Rating Category	Count	% of Total Other MISC
Overweight/Buy	1353	37%	280	44%	21%	607	39%
Equal-weight/Hold	1658	46%	293	46%	18%	716	46%
Not-Rated/Hold	2	0%	0	0%	0%	0	0%
Underweight/Sell	610	17%	68	11%	11%	224	14%
Total	3,623		641			1547	

Data include common stock and ADRs currently assigned ratings. Investment Banking Clients are companies from whom Morgan Stanley received investment banking compensation in the last 12 months. Due to rounding off of decimals, the percentages provided in the "% of total" column may not add up to exactly 100 percent.

Analyst Stock Ratings

Overweight (O). The stock's total return is expected to exceed the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Equal-weight (E). The stock's total return is expected to be in line with the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Not-Rated (NR). Currently the analyst does not have adequate conviction about the stock's total return relative to the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Underweight (U). The stock's total return is expected to be below the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

Unless otherwise specified, the time frame for price targets included in Morgan Stanley Research is 12 to 18 months.

Analyst Industry Views

Attractive (A): The analyst expects the performance of his or her industry coverage universe over the next 12-18 months to be attractive vs. the relevant broad market benchmark, as indicated below.

In-Line (I): The analyst expects the performance of his or her industry coverage universe over the next 12-18 months to be in line with the relevant broad market benchmark, as indicated below.

Cautious (C): The analyst views the performance of his or her industry coverage universe over the next 12-18 months with caution vs. the relevant broad market benchmark, as indicated below.

Benchmarks for each region are as follows: North America - S&P 500; Latin America - relevant MSCI country index or MSCI Latin America Index; Europe - MSCI Europe; Japan - TOPIX; Asia - relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.

Stock Price, Price Target and Rating History (See Rating Definitions)

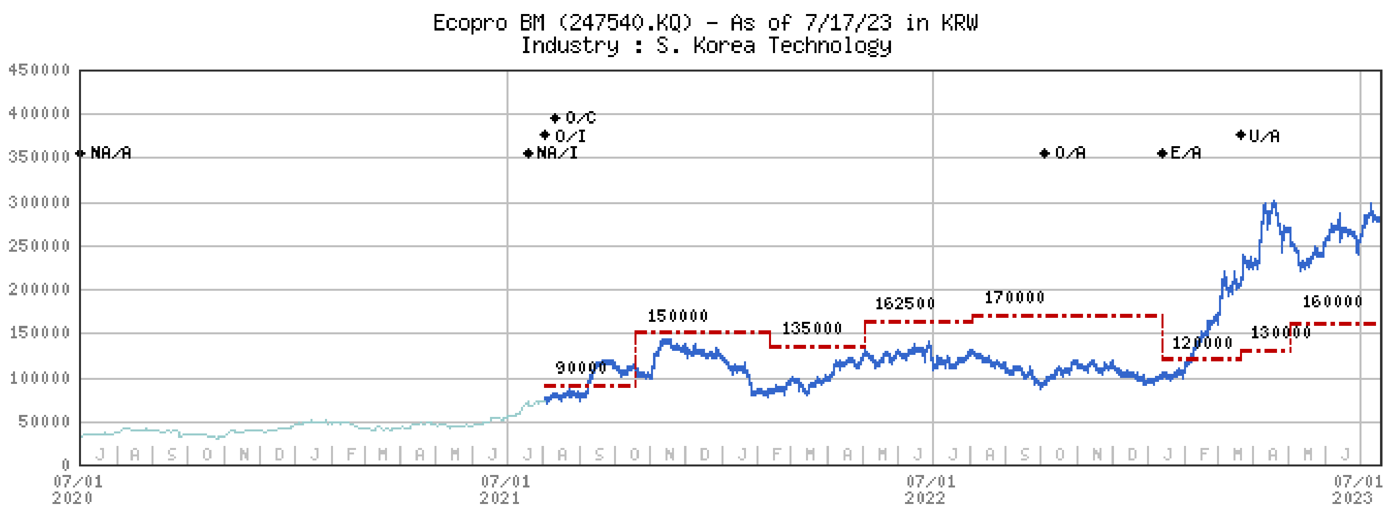
Stock Rating History: 7/1/18 : NA/A; 6/8/22 : U/A; 9/5/22 : E/A; 5/15/23 : O/A

Price Target History: 6/8/22 : 40000; 9/5/22 : 60000; 1/3/23 : 72000; 4/6/23 : 76000; 5/15/23 : 93000; 7/6/23 : 102000

Source: Morgan Stanley Research   Date Format : MM/DD/YY   Price Target -- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) — Stock Price (Covered by Current Analyst) ▬
Stock and Industry Ratings (abbreviations below) appear as ◆ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.



Stock Rating History: 7/1/18 : NA/C; 7/30/19 : NA/I; 11/18/19 : NA/A; 7/19/21 : NA/I; 8/3/21 : O/I; 8/12/21 : O/C; 10/4/22 : O/A; 1/12/23 : E/A; 3/20/23 : U/A

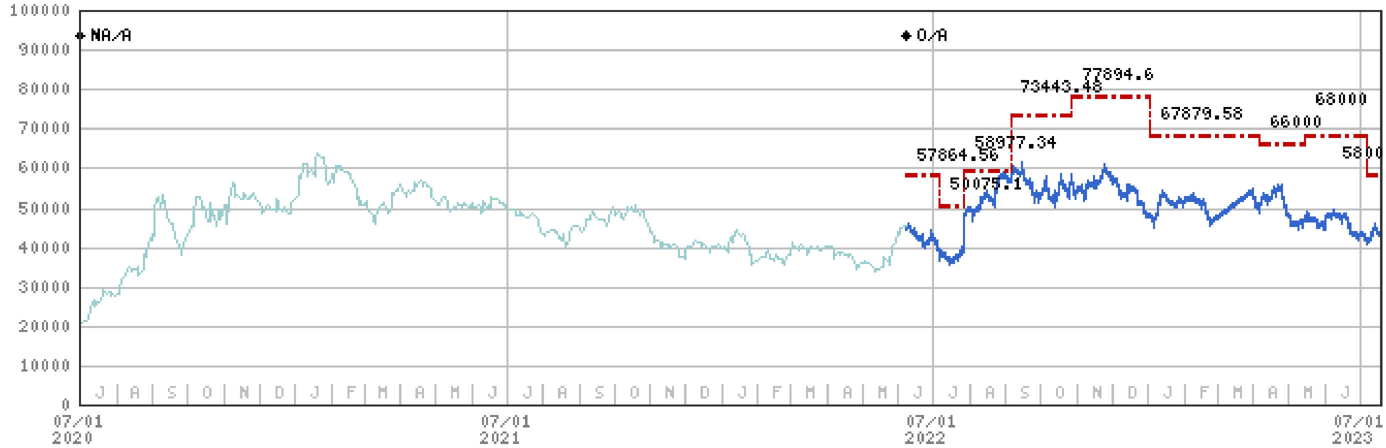
Price Target History: 8/3/21 : 90000; 10/20/21 : 150000; 2/11/22 : 135000; 5/3/22 : 162500; 8/3/22 : 170000; 1/12/23 : 120000; 3/20/23 : 130000; 5/2/23 : 160000

Source: Morgan Stanley Research   Date Format : MM/DD/YY   Price Target -- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) — Stock Price (Covered by Current Analyst) ▬
Stock and Industry Ratings (abbreviations below) appear as ◆ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.

Hanwha Solutions Corp (009830.KS) - As of 7/17/23 in KRW
Industry : S. Korea Energy & Materials



Stock Rating History: 7/1/18 : NA/A; 6/8/22 : O/A

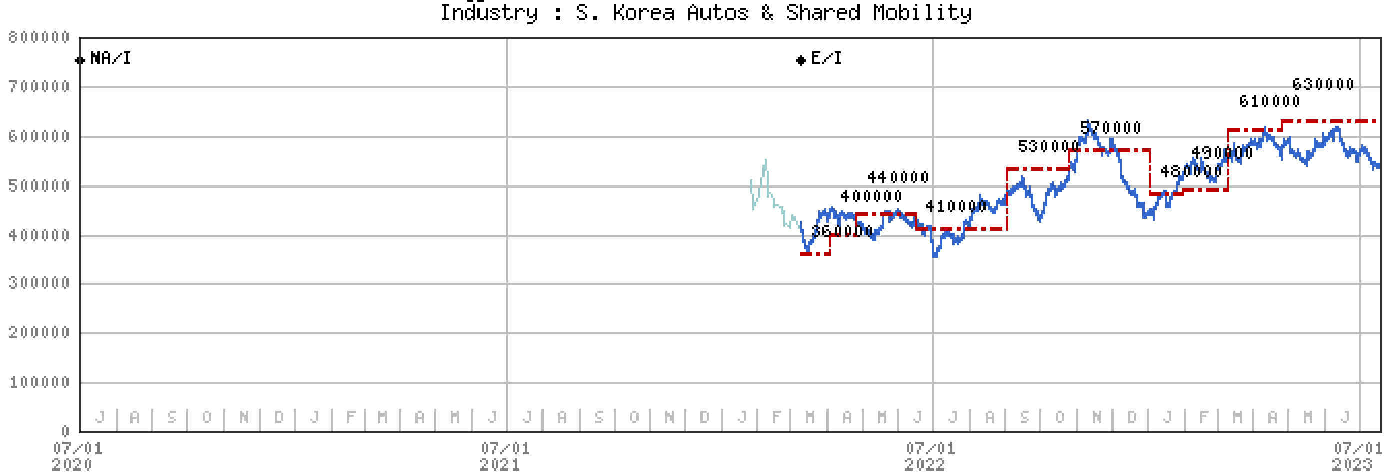
Price Target History: 4/14/16 : NA; 6/8/22 : 57864.56; 7/6/22 : 50075.1; 7/28/22 : 58977.34; 9/5/22 : 73443.48; 10/27/22 : 77894.6; 1/3/23 : 67879.58; 4/6/23 : 66000; 5/15/23 : 68000; 7/6/23 : 58000

Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target -- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) Stock Price (Covered by Current Analyst)
Stock and Industry Ratings (abbreviations below) appear as ◆ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.

LG Energy Solution (373220.KS) - As of 7/17/23 in KRW
Industry : S. Korea Autos & Shared Mobility



Stock Rating History: 7/1/18 : NA/I; 3/10/22 : E/I

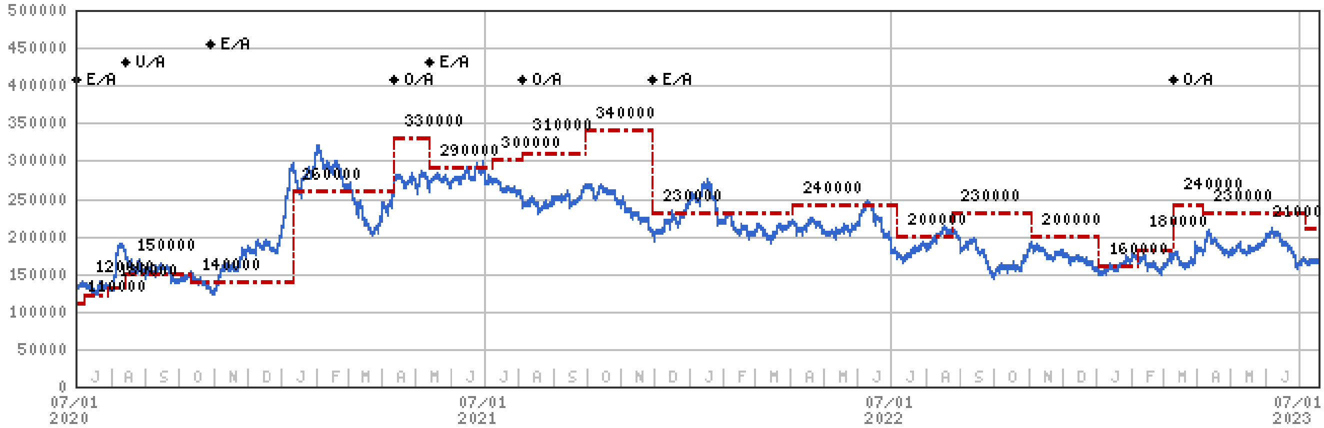
Price Target History: 3/10/22 : 360000; 4/4/22 : 400000; 4/27/22 : 440000; 6/16/22 : 410000; 9/2/22 : 530000; 10/26/22 : 570000; 1/3/23 : 480000; 1/30/23 : 490000; 3/10/23 : 610000; 4/26/23 : 630000

Source: Morgan Stanley Research Date Format : MM/DD/YY Price Target -- No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) Stock Price (Covered by Current Analyst)
Stock and Industry Ratings (abbreviations below) appear as ◆ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.

SK Innovation Co Ltd (096770.KS) - As of 7/17/23 in KRW
Industry : S. Korea Energy & Materials



Stock Rating History: 7/1/18 : O/A; 9/13/18 : NA/A; 8/20/19 : E/A; 8/14/20 : U/A; 10/30/20 : E/A; 4/12/21 : O/A; 5/13/21 : E/A; 8/5/21 : O/A; 11/29/21 : E/A; 3/10/23 : O/A

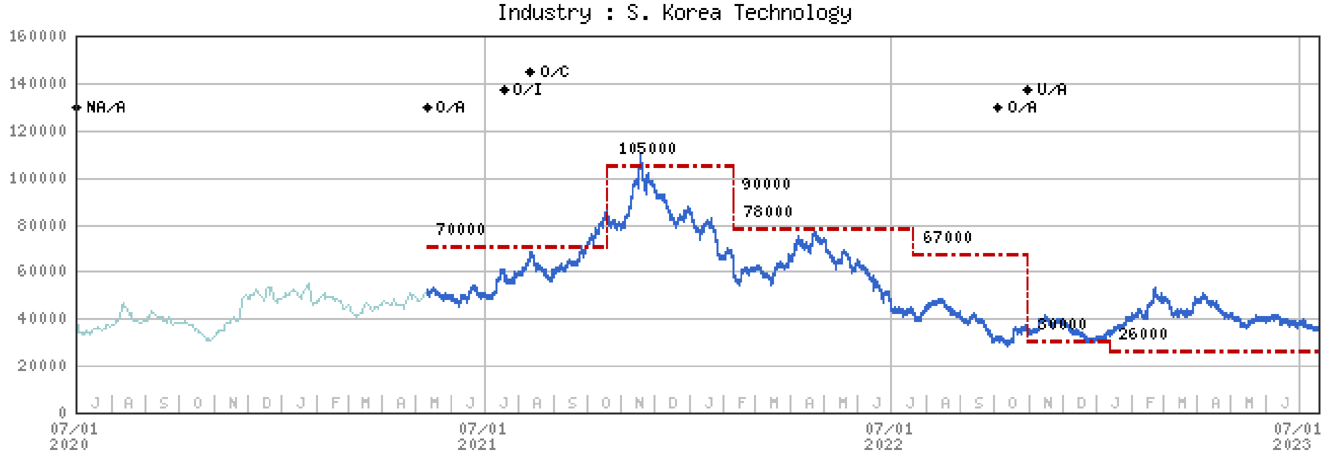
Price Target History: 5/17/18 : 270000; 9/13/18 : NA; 8/20/19 : 170000; 10/3/19 : 180000; 1/7/20 : 160000; 2/3/20 : 140000; 3/18/20 : 90000; 5/6/20 : 110000; 7/8/20 : 120000; 7/29/20 : 130000; 8/14/20 : 150000; 10/12/20 : 140000; 1/11/21 : 260000; 4/12/21 : 330000; 5/13/21 : 290000; 7/8/21 : 300000; 8/5/21 : 310000; 9/30/21 : 340000; 11/29/21 : 230000; 4/4/22 : 240000; 7/6/22 : 200000; 8/24/22 : 230000; 11/3/22 : 200000; 1/3/23 : 160000; 2/7/23 : 180000; 3/10/23 : 240000; 4/6/23 : 230000; 7/6/23 : 210000

Source: Morgan Stanley Research   Date Format : MM/DD/YY   Price Target --   No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) —   Stock Price (Covered by Current Analyst) —
Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

Effective January 13, 2014, the stocks covered by Morgan Stanley Asia Pacific will be rated relative to the analyst's industry (or industry team's) coverage.

Effective January 13, 2014, the industry view benchmarks for Morgan Stanley Asia Pacific are as follows: relevant MSCI country index or MSCI sub-regional index or MSCI AC Asia Pacific ex Japan Index.

Solus Advanced Materials Co Ltd (336370.KS) - As of 7/17/23 in KRW
Industry : S. Korea Technology



Stock Rating History: 7/1/18 : NA/C; 7/30/19 : NA/I; 11/18/19 : NA/A; 5/11/21 : O/A; 7/19/21 : O/I; 8/12/21 : O/C; 10/4/22 : O/A; 10/31/22 : U/A

Price Target History: 5/11/21 : 70000; 10/20/21 : 105000; 2/9/22 : 90000; 2/10/22 : 78000; 7/20/22 : 67000; 10/31/22 : 30000; 1/12/23 : 26000

Source: Morgan Stanley Research   Date Format : MM/DD/YY   Price Target --   No Price Target Assigned (NA)
Stock Price (Not Covered by Current Analyst) —   Stock Price (Covered by Current Analyst) —
Stock and Industry Ratings (abbreviations below) appear as ♦ Stock Rating/Industry View
Stock Ratings: Overweight (O) Equal-weight (E) Underweight (U) Not-Rated (NR) No Rating Available (NA)
Industry View: Attractive (A) In-line (I) Cautious (C) No Rating (NR)

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Morgan Stanley

The Americas
1585 Broadway
New York, NY 10036-8293
United States
Tel: +1 (1) 212 761 4000

Europe
20 Bank Street, Canary Wharf
London E14 4AD
United Kingdom
Tel: +44 (0) 20 7 425 8000

Japan
1-9-7 Otemachi, Chiyoda-ku
Tokyo 100-8104
Japan
Tel: +81 (0) 3 6836 5000

Asia/Pacific
1 Austin Road West
Kowloon
Hong Kong
Tel: +852 2848 5200