HSBC Global Research

Energy Transition

26 January 2022

Energy & Climate Watch

The nuclear option

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- Push for 'net zero' has thrown nuclear a lifeline; we think renewed interest is warranted, but with important caveats
- Costs, safety and public perceptions are all key factors in its future; we see risk of phasing-out in DM as EM ramps up
- We look at Europe, Russia and Asia, to explore differing nuclear dynamics at play

Nuclear energy is divisive, and will remain so. For some politicians and societies nuclear energy is simply a non-starter because of concerns around waste, safety or costs. Others see it as a viable way to provide both energy security and decarbonise. These sharply opposing views often make nuclear deployment a binary choice.

Shelving it makes a challenging decarbonisation equation even harder. The push to reach global 'net zero' should include discussions about a proven low-carbon technology, in our view. The IEA sees the need for global nuclear capacity to double by 2050 to feed growing electricity demand whilst cutting emissions, requiring policy shifts and hundreds of billions of dollars in investment. It is an imperfect tool, but one that could do a useful job; it is not a silver bullet, but also neither an irrelevant relic.

In need of a re-invention of sorts. Unlike emerging technologies, nuclear has a long operating history, albeit a chequered one. Innovation (such as small modular reactors) and fresh capital raising are indicating a revival is taking hold. To capitalise on the opportunity posed by decarbonisation, nuclear needs to play to its strengths by showing it can be cost competitive and reliable, whilst addressing its unique drawbacks such as concerns around hazardous waste and safety.

Risks, unknowns and plenty of concerns. Despite renewed excitement about nuclear's future, cost overruns, recent performance issues in Europe and unrest in Kazakhstan (a major producer of uranium) are reminders of some of the hurdles it faces. Furthermore, concerns from mainstream and ESG investors and policy-makers around the handling (and cost) of waste disposal may never fully abate.

EM is pressing ahead as DM's nuclear future hangs in balance. The DM nuclear footprint is c75% of capacity today, but almost all forecast growth comes from EM. We look at Asia, Russia and Europe to explore differing nuclear dynamics at play; in some cases, meeting energy demand growth is more a factor than decarbonisation.

This is our latest report on the Energy Transition theme. If you want to subscribe to any of our nine big themes, *click here*.

This is an abridged version of a report by the same title published on 26-Jan-22. Please contact your HSBC representative or email AskResearch@hsbc.com for more information.

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The nuclear option

- Nuclear offers a unique role in decarbonising electricity, but its chequered history still looms large, and will not easily fade
- Defining its contribution, demonstrating cost competitiveness, and re-gaining confidence over safety and waste are crucial for its future
- Push for 'net zero' has thrown nuclear a lifeline, but its revival in some regions will be a hard-fought battle

We've been here before, haven't we?

Nuclear is the second-largest source of low-carbon electricity generation…

To say nuclear energy has had a chequered history is an understatement, but after a turbulent few decades, it is now re-emerging as a potential decarbonisation option. Nuclear energy is of meaningful size today and needs a resurgence in investment and policy attention, rather than being propelled from a standing start like some early-stage low-carbon technologies.

It also tends to be a sensitive topic, with investors, civil society and governments often having polarising views on its place in a national energy mix – evidenced by debate on its inclusion in the EU's sustainable investing guidelines (or Taxonomy). It also tends to carry high policy costs, the need for massive financing, a plan for hazardous waste and regulatory scrutiny - all of which are only warranted if nuclear is going to play a meaningful role, leaving choices on its use to be more binary in nature.

...but may need to 're-invent' itself to secure a long-term place in future energy systems

At the core of some discussions around nuclear energy is do we *need* more nuclear to meet global climate targets? The simple answer is that taking a proven and at-scale low-carbon technology out of the equation makes hitting 'net zero' even more challenging. However, that alone does not earn it a place in the decarbonisation technology portfolio; to secure a future role nuclear needs to play to its distinctive strengths – low-carbon, large scale, baseload electricity generation – and seek to address its unique weaknesses – costs, safety, reactor operating reliability, differences in country safety standards, long-life hazardous waste, issues around financing and concerns it risks 'crowding out' green investment.

EM nations are expanding capacity as the DM footprint stalls; we look at dynamics in Europe, Russia and Asia

Finally, there is a geographical angle at play. Most of today's (aging) nuclear footprint is in the developed world, but we expect emerging nations to account for a large majority of global capacity growth in coming years. Whilst it is seen as a tool to hit emissions targets in many OECD nations, for some developing countries, reasons to build reactors are not necessarily linked to tackling climate change, but to feed growing energy demand. We explore the differing dynamics in three key regions, including how large-scale nuclear power in Europe is at risk of suffering a similar fate to that of the now discontinued Airbus A380 jet – being simply too large, too expensive and not fit for purpose anymore.

Nuclear should, in our view, we actively considered, but with important caveats

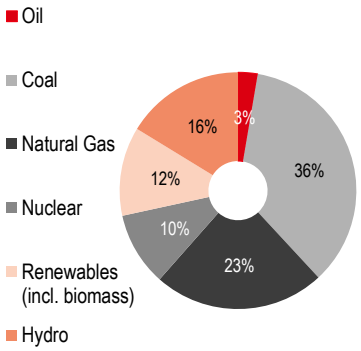
In our view, the urgency to cut global carbon emissions and drive electrification should mean that proven technologies that can play a meaningful role in decarbonisation, whilst maintaining stable energy supply, should be actively considered. However, there are important caveats, such as the need for nuclear safety standards and waste plans to regain wider confidence and for any build-out not to materially detract from 'green' capital allocation. However, we also note that some of nuclear's characteristics will label it as a non-starter for many.

Nuclear energy in charts

Nuclear accounts for around 10% of global electricity and a quarter of low-carbon power…

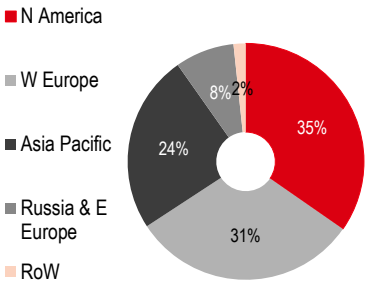
…generating more electricity than solar and wind combined in 2020

Global electricity generation by source (2020)



Source: IEA

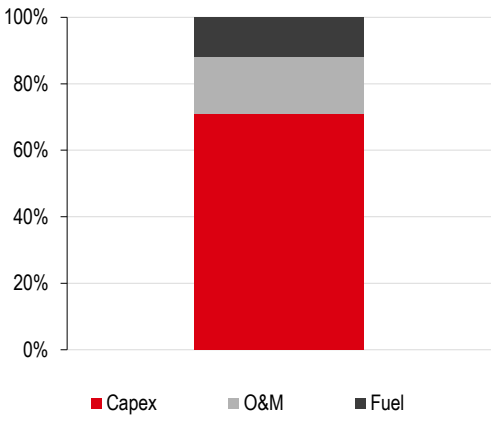
Global nuclear generation by region (2020)



Source: IEA

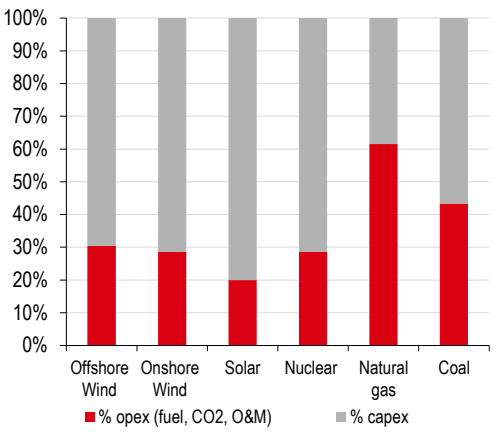
Its cost profile is more capex-orientated than conventional energy

Nuclear power levelised cost of electricity (LCOE) split



Source: IEA

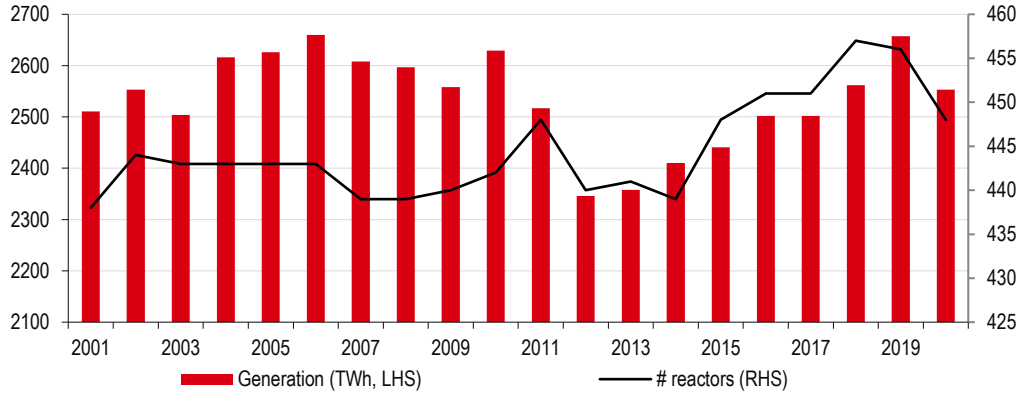
Capex/opex split by generation type



Source: IEA

Generation and reactor footprint have not materially grown in the last two decades

Global nuclear electricity generation and number of operating reactors since 2001



Source: International Atomic Energy Agency

Does nuclear fit with net zero?

- On paper, a scalable and proven low-carbon technology option should be part of the net zero technology mix discussion
- In practice, nuclear's potential role in decarbonisation is much more nuanced, with prominent concerns over cost, waste and safety
- The balance of pros vs cons, and a heavy dose of politics, will determine whether it is seen as a solution or a problem

Will pushing for 'net zero' lead to a nuclear re-birth?

To hit 'net zero' by 2050, electricity generation needs to double and emissions to fall over 90%; nuclear energy can play a role…

Reasons to think that a concerted push on climate needs to include more nuclear…
Simply put, a cornerstone of decarbonisation is the electrification of many energy-consuming activities such as transport, heating homes, and powering industry. A common thread in all future energy scenarios that tackle climate change is the need for much more low (or zero) carbon electricity – the IEA net zero scenario, for example, envisages global electricity use doubling by 2050 with associated sector emissions falling over 90% over the same period.

Nuclear is one way to provide zero-carbon electricity, at scale, in a manner that does not materially deviate from current grid structures and limits the introduction of potentially problematically high levels of intermittency to energy systems (e.g. from high wind / solar use).

…but it almost needs to re-invent itself to gain a place in the technology mix

Nuclear finds itself in an unusual position; rather than at a standing start – like other low-carbon technologies – it needs to turn around its fortunes and almost re-invent itself. Just by being a carbon-friendly generation method will not grant nuclear a 'free pass' to wider use going forward, evidenced by the fact that it has been overlooked in recent years as policy-makers around the world have favoured accelerating deployment of renewables and supported the emergence of the likes of green hydrogen and energy storage.

To carve out a role in decarbonisation, nuclear needs to show that it is safe, reliable and cost-effective and can offer something that other routes cannot: low-carbon, large-scale, baseload electricity generation via a proven technology.

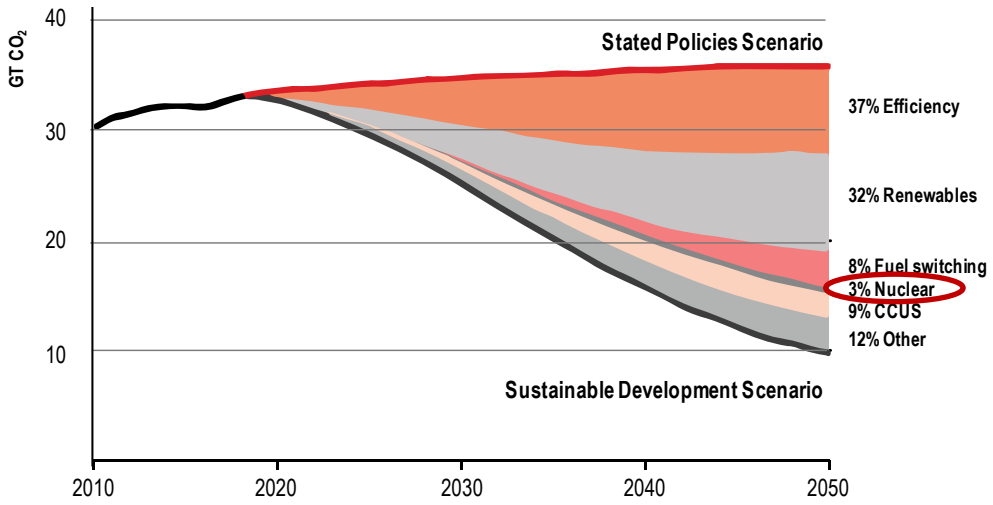
Nuclear's potential role in decarbonisation needs important context

… but like any individual technology, it is no silver bullet
Context is important; nuclear could play a bigger role in decarbonisation globally, but its likely contribution will be overshadowed by the likes of wind and solar, and energy efficiency (see chart on following page). It won't be a logical fix for all countries or regions, and will be more of an impactful lever for some, and less so for others. Advocating for a broader build-out of nuclear capacity also has a number of unique challenges: winning over public and political perceptions, granular policy requirements and questions on costs, safety and waste.

In our view, solving the broader energy-climate equation involves compromises; it will in most cases require a collection of imperfect technology options that provide a working collective solution. We think nuclear warrants consideration to play a meaningful role, partly because its exclusion makes reaching 'net zero' emissions all that more challenging. However, important caveats apply; its use should not actively impede climate action elsewhere, and it will also need to overcome the cost and safety hurdles that have plagued its deployment in recent years.

Despite generating more electricity than wind and solar in 2020, nuclear is seen to be a smaller lever for 2050 decarbonisation

Nuclear role in the IEA's Sustainable Development Scenario to 2050



Source: IEA

Nuclear could be an effective way to push baseload coal out of energy systems

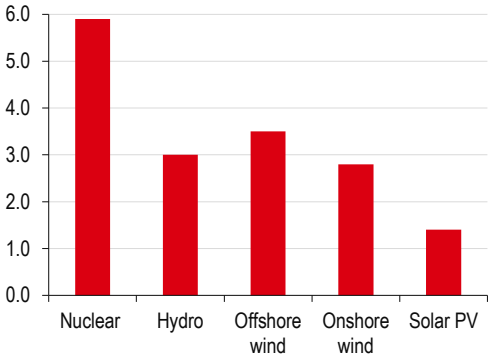
Could it play the role of the great coal displacer?

In theory, a larger build-out of nuclear energy globally could significantly cut carbon emissions; 1GW of nuclear-equivalent power running on coal would generate c6m tonnes CO_2 a year (compared to negligible amount from nuclear). If scaled, and deployed to displace such existing high CO_2 emitting sources (or in lieu of investment in new additional coal or gas generation capacity), then nuclear could put a meaningful dent in global emissions (the IEA estimates that nuclear has avoided 55bn tonnes CO_2 to date, roughly two years of global energy emissions).

In the below charts, nuclear (on paper) is more effective at displacing emissions from coal or natural gas than renewables on a per unit capacity basis, partly because of its ability to run at a high load factor (typically above 80% vs renewables 20-40%). This rationale does not always translate into decisions, and many countries see natural gas as a better way to curb emissions from coal-fired electricity generation, rather than nuclear (partly on cost grounds).

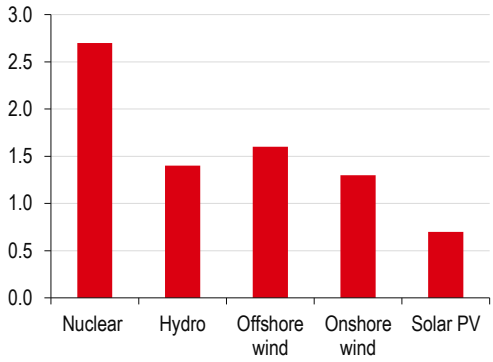
Carbon prices, if high enough, also can have a bearing on the relative economic merits of a fossil-fuel to nuclear switch where there is existing capacity. However, decisions around the phase-down, expansion or the introduction of nuclear energy tend not to be driven by market-led carbon pricing policies.

Annual emissions saving by displacing 1GW of coal with 1GW of other electricity technologies (m tonnes CO_2)



Source: IEA

Annual emissions saving by displacing 1GW of gas with 1GW of other electricity technologies (m tonnes CO_2)



Source: IEA

Climate goals aren't the primary driver in many cases

We explore the varying drivers of interest in nuclear energy

For the US and Europe, the equation around nuclear energy deployment could be reasonably be summarised by asking whether or not it makes reaching aggressive climate targets for grid decarbonisation (by 2035 in some cases) more feasible, quicker, cheaper and / or less disruptive. For example, small modular nuclear reactors feature in the UK's 10-point climate plan for net zero 2050. However, for many other countries exploring the merits of nuclear energy – typically in the EM world – there are often less immediate decarbonisation targets, and crucially, the need to satisfy rapidly growing energy demand (unlike in DM regions) with secure supply. This makes the dynamics around nuclear energy more nuanced and more of a question as to whether it is the right fix (economically and socially) for a given country's approach to energy, something we discuss later in this report.

Can shutting down nuclear in order to 'go green' introduce more energy volatility?

Some are phasing down nuclear quickly to double down on renewables

Some countries (eg Germany) are shunning nuclear as it doubles down on renewables. Other countries may take a slightly longer route to exiting nuclear as they bring replacement capacity online. Removing nuclear too quickly could risk introducing grid volatility, or force countries to ramp-up more emitting sources in the meantime. To some this represents a 'chicken and egg' situation; if the goal is for 100% renewable electricity in the future, is accelerating a nuclear exit to create some urgency for action a credible way to spur investment in green sources? The other side of the view, is whether by keeping nuclear running for longer delays the need for reform of an energy system to make it fit for an all-green future.

An often posed question is: Do we *need* more nuclear?

Reaching 'net zero' without more nuclear energy will be challenging

The answer, is not a yes or no. Rather, at a global level, achieving 'net zero' emissions without a proven, scalable, low-carbon electricity generation technology option like nuclear makes, on paper at least, a very challenging ambition all the more difficult to achieve. Parallels of a sort can be drawn with the perceived need (or not) for carbon capture - an imperfect solution that suffers from perception issues, cost questions and policy hesitancy, but nonetheless has scope to a role to play.

As stated above, the world will need significantly more electricity going forward, almost regardless of the outlook. Deployment of new power generation today is, more than ever, viewed through a lens of the asset's carbon emissions on an absolute and relative basis; on this basis nuclear performs well. Speed is also of the essence concerning the climate question, as massive emissions-cutting strides need to be made this decade to hit longer-term goals. Whilst deployment of renewable energy continues to reach new highs each year, it will likely need supporting low-carbon technologies that can add further tens (or hundreds) of GWs of low-carbon power to decarbonise the grid.

Not everyone is convinced. An academic study in Sweden (which currently relies on nuclear energy for about 40% of its electricity) found that "there are no, or only minor, cost benefits to reinvest in nuclear power plants in Sweden once the old ones are decommissioned" in the context of its push for 100% renewable electricity by 2040 (Kan, Hedenus, Reichenberg, 2020).

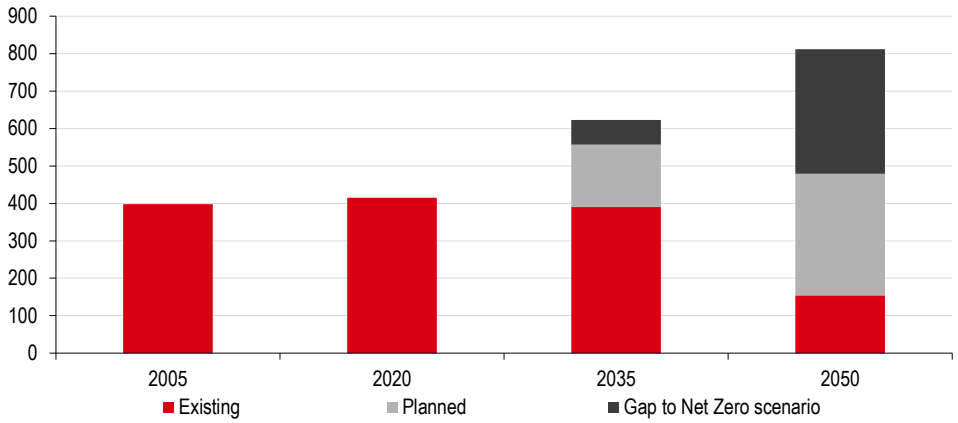
If not nuclear, then where do we get low-carbon baseload power generation from?

The question for some might be: if we don't choose nuclear then where do energy systems that are seeking to decarbonise get their baseload (non-intermittent) generation from? Alternative routes include the greater use of energy storage techniques to smooth out renewable energy generation patterns to match demand, such as batteries or hydrogen. Another is the use of natural gas or biomass, with carbon capture to reduce the associated emissions, avenues that the UK is actively considering or implementing. However, in more recent examples where nuclear energy has been phased out, it has been replaced with more emissions intensive options.

Net zero scenarios envisage a doubling of nuclear capacity by 2050…

The IEA's Net Zero scenario provided an indication of the of the speed, shape and nature of change needed in the energy system to reach global 'net zero' by mid-century. Within this, nuclear currently suffers from a similar dynamic to much of the rest of low-carbon energy – insufficient investment. The IEA sees a need for global nuclear capacity to roughly double from current levels of around 400GW by 2050, with currently planned new reactors only filling part of the gap, implying the requirement for a further cumulative investment of over USD1trn.

Global nuclear capacity: c500GW planned by 2050 but over 800GW needed for 'net zero'



Source: IEA

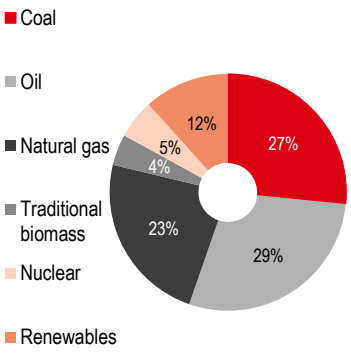
…with the growth largely coming from emerging market nations

The IEA Net Zero scenario envisages developed markets investing to effectively keep their current installed nuclear asset capacity base roughly flat in coming decades at just over 300GW, as older plants reach the end of their useful lives. The growth in overall global nuclear capacity is almost all driven by emerging and developing nations such as China, India, Russia, parts of the Middle East and Asia.

Within the wider context of the impact of nuclear on the global energy supply mix in a net zero emissions scenario, nuclear grows as a share of global energy (from 5% to 12%) by 2050. Whilst nuclear generated more electricity than wind and solar combined in 2020, in a net zero scenario is it set to be overshadowed by a huge rise in renewables that drives decarbonisation at the expense of incumbent fossil fuels (coal, oil and natural gas), as shown below.

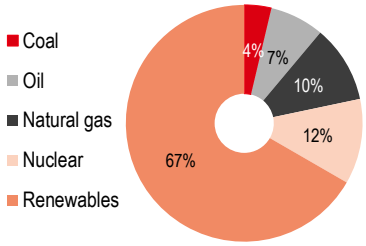
In a 2050 net zero scenario, nuclear's share of global energy would rise, but overshadowed by renewables

Global energy supply by source (2020)



Source: IEA

Global energy supply by source in net zero scenario (2050)



Source: IEA

Pros vs cons debate

Nuclear has some unique characteristics which make it relevant to the 'net zero' debate…

No energy source or technology is perfect. Addressing one of the so-called energy 'trilemma' issues (low-carbon, affordability and security of supply) can often open up a new problem on a different front. Nuclear is no different, as it has some characteristics that make it attractive for decarbonisation and meeting energy demand, but others that raise concerns or need remedies.

Nuclear has some unique features, both positive and negative, which make it a relevant technology option in the decarbonisation debate. There are typically many factors at play as to whether it is a good fit for including in a given country's energy choices, such as energy system characteristics, domestic natural resource endowments, as well as attitudes to nuclear power and decarbonisation conviction. Uncertainty around the right balance between its pros vs cons is evident in the wide range of approaches nuclear across different countries.

…below we briefly explore some of the pertinent dynamics at play

Pros

- *Baseload source of electricity generation*; nuclear provides a reliable and constant supply that can form the backbone of grid requirements, effectively running 24/7 at a high load factor which can help reduce emissions without introducing too much intermittency.
- *Low-carbon*; its core process does not generate meaningful CO_2 emissions per MWh.
- *Supply diversity*; nuclear has the potential to lower exposure to global commodity prices or supply concerns by diversifying supply and potentially enhancing energy security (although geopolitical risks related to uranium exporters would remain)
- *Proven technology*; nuclear has a long-standing operating history of several decades, and new innovation is set to deliver new modular reactors with the potential to lower costs and reduce delivery lead times.
- *Scale and energy density*; nuclear plants can provide gigawatts of capacity without taking up large amounts of land space per unit of capacity or generation (unlike solar).

Cons

- *Costs*; nuclear has not always been able to demonstrate cost-competitiveness on a per MWh basis (often needing high guaranteed offtake prices), especially when involving cost overruns at larger scale plants.
- *Rigidity;* nuclear is most commonly used as baseload, and whilst it isn't deployed as a 'peaking' technology, it does have a degree of flexibility to counter hydro/renewables intermittency (noting that constant ramping up and down of nuclear units can create strains for the plant system). Assets also have a very long life (40-60 years) which can mean they are sensitive to regulation changes and are 'locked in' for decades.
- *Decision risk*; nuclear projects are typically large and can take many years to plan, design, approve and build. This makes multi-billion dollar decisions prone to delays and at risk of a 'U-turn' during the process unless there is high investment decision clarity.
- *Political sensitivity*; public opinion at a national and local level is often not supportive of nuclear activity for a range of reasons, including safety and hazardous waste.
- *Safety*; the Fukushima disaster of 2011 remains a potent reminder of the risks of shoreline-based nuclear plants; as does the 1986 Chernobyl accident that dispersed radioactive air westwards over much of Europe. The issue of hazardous toxic waste is also a common concern as it is a long-life liability that needs to be safely managed.
- *Generation concentration*; large conventional nuclear plants (typically over 1GW) can mean that a material proportion of a given country's generation is from a relatively small number of physical sites (as is the case in France which usually gains up to three-quarters of demand from EDF nuclear generated at 56 reactors in 18 locations).

This is an abridged version of a report by the same title published on 18-Jan-22. The full note contains a look at the chequered history of nuclear energy, the waste conundrum, a review of costs, projects and performance as well a section on Small Modular Rectors and regional outlooks and a nuclear stock screen. Please contact your HSBC representative or email *AskResearch@hsbc.com* for more information.

Disclosure appendix

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The target price is based on the analyst's assessment of the stock's actual current value, although we expect it to take six to 12 months for the market price to reflect this. When the target price is more than 20% above the current share price, the stock will be classified as a Buy; when it is between 5% and 20% above the current share price, the stock may be classified as a Buy or a Hold; when it is between 5% below and 5% above the current share price, the stock will be classified as a Hold; when it is between 5% and 20% below the current share price, the stock may be classified as a Hold or a Reduce; and when it is more than 20% below the current share price, the stock will be classified as a Reduce.

Our ratings are re-calibrated against these bands at the time of any 'material change' (initiation or resumption of coverage, change in target price or estimates).

Upside/Downside is the percentage difference between the target price and the share price.

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*A stock was classified as volatile if its historical volatility had exceeded 40%, if the stock had been listed for less than 12 months (unless it was in an industry or sector where volatility is low) or if the analyst expected significant volatility. However, stocks which we did not consider volatile may in fact also have behaved in such a way. Historical volatility was defined as the past month's average of the daily 365-day moving average volatilities. In order to avoid misleadingly frequent changes in rating, however, volatility had to move 2.5 percentage points past the 40% benchmark in either direction for a stock's status to change.

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