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The Energy Transition: Nuclear Dead And Alive

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Key Takeaways

- The global nuclear industry is facing challenges to do with safety concerns, tightening regulations post-Fukushima, phase-out policies in several countries, aging asset bases, increasingly volatile energy markets, and competition with renewables.
- We see little economic rationale for new nuclear builds in the U.S. or Western Europe, owing to massive cost escalations and renewables cost-competitiveness, which should lead to a material decline in nuclear generation by 2040. China and Russia by contrast, continue to build new nuclear capacities, supported by energy policies and significantly lower construction costs.
- We believe that carbon-free generation that existing nuclear assets provide, combined with steady growth in renewables, will be important at least over the next few decades to meet climate goals and to support stable electricity supply given intermittent nature of renewables.
- The post-2040 outlook for the nuclear industry will depend on development of broad-scale energy storage solutions (for example, through batteries or hydrogen) and smart grids, as well as on government support.
- We expect the credit trajectories of nuclear companies worldwide to differ depending on national energy policies and the degree of state support for nuclear.

The global nuclear industry, accounting for 10% of global power generation, faces many challenges as governmental and regulatory policies have shifted toward renewables, especially after the 2011 Fukushima nuclear accident. Concerns about the safety of nuclear plants and nuclear waste storage solutions, an aging global nuclear fleet, and massively escalating costs for many new projects have added to the industry's woes. Several developed countries, including Germany, Belgium, Switzerland, and Spain, are planning to phase out nuclear. Others, such as South Korea, Sweden, and even France aim to reduce it. In the U.S., the continuity of nuclear plants and future life extensions are under threat from prevailing low power prices.

Yet, nuclear's continued growth in some developing markets means global nuclear output is set to increase marginally over the next two decades. For example, Russia and China have established nuclear expertise, a largely state-owned vertically integrated nuclear chain, and funding from the government or from state-related banks.

In developed markets, we see little economic rationale for new nuclear build. Renewables are

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significantly cheaper and offer quicker payback on scalable investments at a time when power demand is stagnating. New nuclear construction requires massive upfront investments in complex projects with long lead times and risk of major cost overruns. Returns over nuclear assets' long useful life are exposed to fundamental uncertainties about the global energy transition, technology development, regulatory shifts, and increasingly volatile electricity markets. Still, we believe that a combination of steady growth in renewables and maintenance of a material share of nuclear baseload over the next decades will help to achieve huge CO_2 savings and smooth the energy transition, as it will remove the need for new gas units and give time for renewables to fill the void. Life extension costs could still be cost-competitive, in our view, notably when considering additional grid costs for renewables). This is particularly true for Japan or eastern Europe where renewables are still more expensive than nuclear.

The long-term outlook for nuclear post 2040 will in our view depend on the progress in mitigating the intermittency of renewables through smart grids and storage (such as wider deployment of batteries or hydrogen), while carbon capture solutions could help extend the life of fossil fuel. Small modular reactors require lower upfront investments than traditional large nuclear blocks and could be manufactured serially. However, they are still far too expensive and less scalable than renewables, and do not address fundamental nuclear safety and nuclear waste issues.

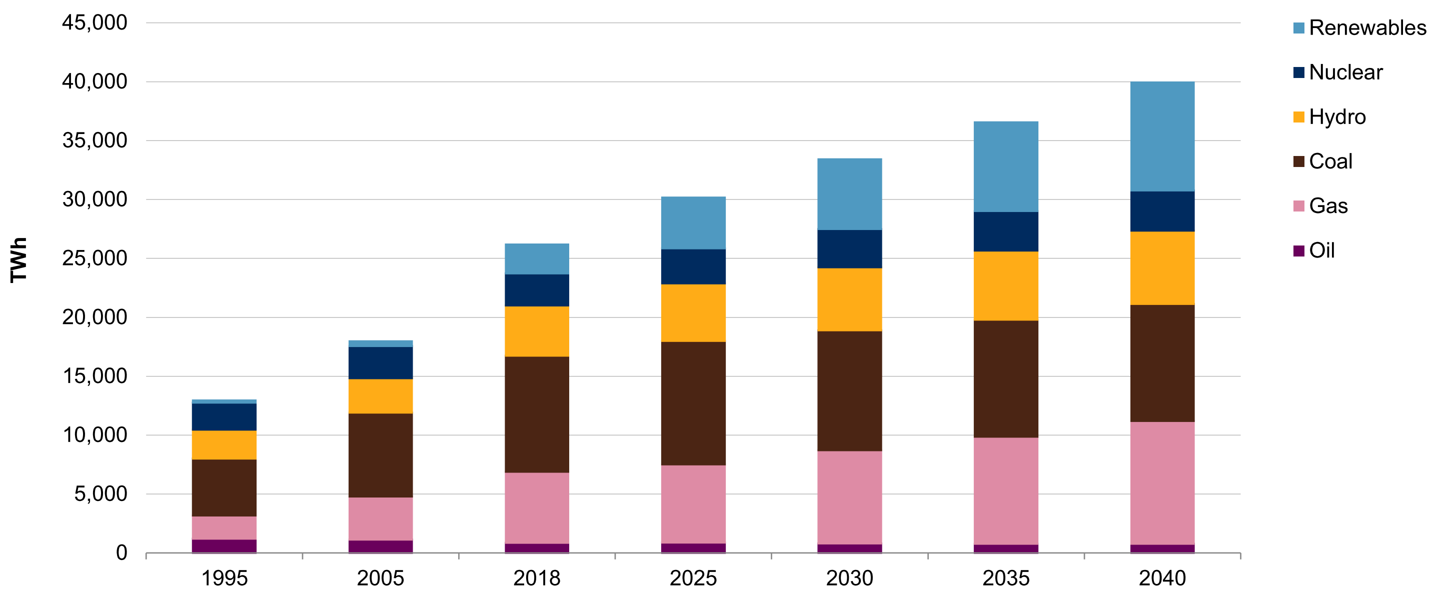
We expect the credit trajectories of nuclear companies worldwide to differ depending on national energy policies, market design, exposure and track-record of new nuclear builds, and the degree of state support for nuclear. Given its very long-term investment horizon, economic returns and cost competitiveness of nuclear power vis-à-vis other technologies are highly sensitive to construction costs (including to meet local safety regulations), applicable cost of capital, and availability of long-term revenues to support profitability (see our related report "The Energy Transition: Different Nuclear Energy Policies, Diverging Global Credit Trends," published Nov. 11, 2019, on RatingsDirect. State support, in particular, is key because nuclear generation is increasingly exposed to competitive and volatile energy markets, where renewables typically enjoy preferred treatment. State support may come through capacity sales as in Russia, high nuclear capacity utilization as in China, more supportive prices for the nuclear output as in Japan, contract for differences, or CO_2 prices. The U.K. delivers support through its contract for difference for Hinkley Point C (HPC) and CO_2 pricing mechanisms. France is considering re-regulating existing plants to justify life extension investments. The U.S. provides zero-emission credits as a stimulus.

Nuclear Production Will Shift To Emerging Economies

We believe future growth in global primary energy demand will increasingly be met by renewables. Yet, to accommodate continuingly growing electricity consumption--driven by electrification, population increases, and economic growth--nuclear energy generation will likely increase slightly in absolute terms. Nuclear will also be an essential zero-carbon-emitting generation source, according to S&P Global Platts Analytics Scenario Planning Service's "most likely" scenario (updated in September 2019) that predicts fossil-based generation will still represent 50% of the global generation mix by 2040 (from 64% in 2018), even assuming a steep 7% annual growth in renewable capacities (see chart 1).

Chart 1

Structure Of Global Power Generation Output: "Most Likely" Scenario

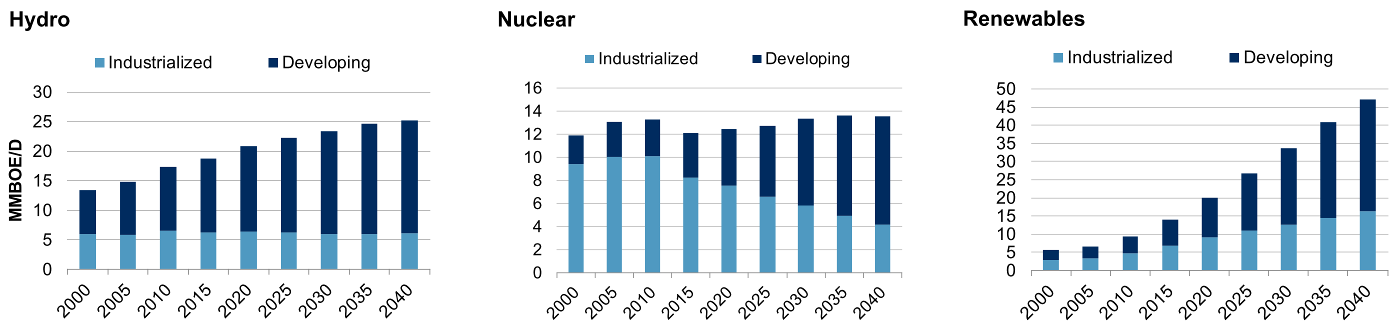


TWh--Terawatt hours.

Source: S&P Global Platts Analytics, Scenario Planning Service (September 2019).

We expect developing markets will drive global nuclear growth, especially China, which has embarked on a major nuclear new-build program (see table 1). By contrast, nuclear capacity in advanced economies could decline by two-thirds by 2040, according to the International Energy Agency (IEA), assuming no additional life extensions beyond those already approved or under discussion. The global nuclear asset base is aged: 67% of the nuclear power plants globally have been in operation for over 30 years, especially in the U.S. and Europe (84%). A typical reactor life is about 40 years, but could be subject to extensions (to 60 years typically for the U.S. fleet and to 50 years for certain plants in France, with more extensions under discussion).

Renewables, Not Nuclear, Dominate Future Non-Fossil Fuel Growth



MMBOE/D--Million barrels of oil equivalent per day. Source: S&P Global Platts Analytics, Scenario Planning Service (Septemer 2019).

Table 1

Nuclear Generation Is Concentrated In A Few Countries And Regions

Country	Total net nuclear capacity (MW)	Nuclear capacity under construction (MW)
Developed economies	307,872	15,987
United States	97,565	2,234
France	63,130	1,630
Japan*	35,947	2,653
South Korea	23,784	5,360
Canada	13,554	
Germany	9,515	
U.K.	8,923	1,630
Sweden	8,613	
Spain	7,121	
Belgium	5,918	
Other EU	16,901	2,480
Developing economies	104,072	36,672
China	45,518	10,922
Russia	28,355	4,589
Ukraine	13,107	2,070
India	6,255	4,824
Other	10,837	14,267
Total	398,887	53,659

*Includes large unused capacity. MW--Megawatts. Source: PRIS, IAEA.

In relative terms, however, the share of nuclear production varies widely (see charts 3 & 4). France,

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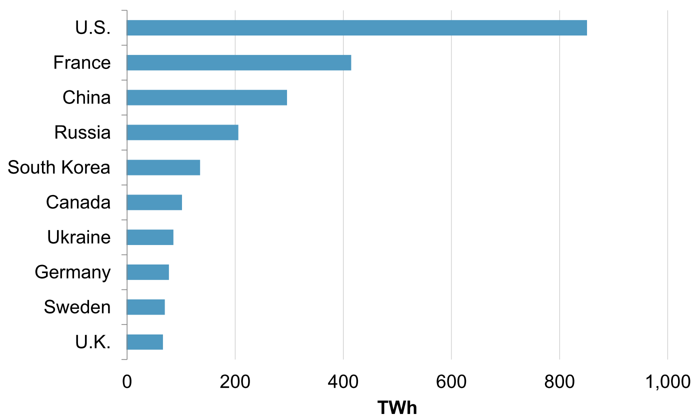
for example, relies heavily on nuclear to produce electricity, while China has a limited share of nuclear generation, despite being among the leaders in global nuclear production and new nuclear builds.

Chart 3

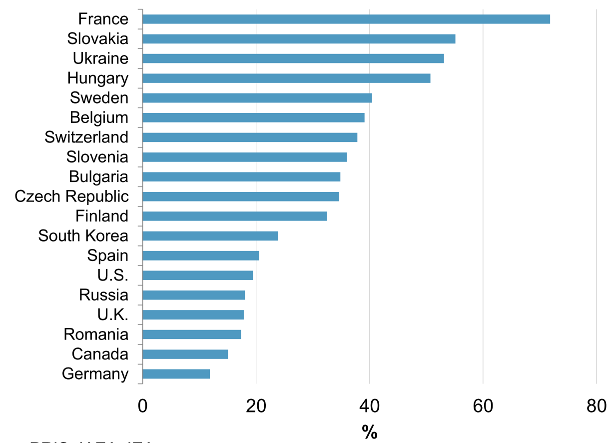
Top 10 World Nuclear Power Generators In 2018



TWh--Terawatt hours. Source: PRIS, IAEA, IEA.

Chart 4

Share Of Nuclear Power In Electricity Generation Per Country, 2018

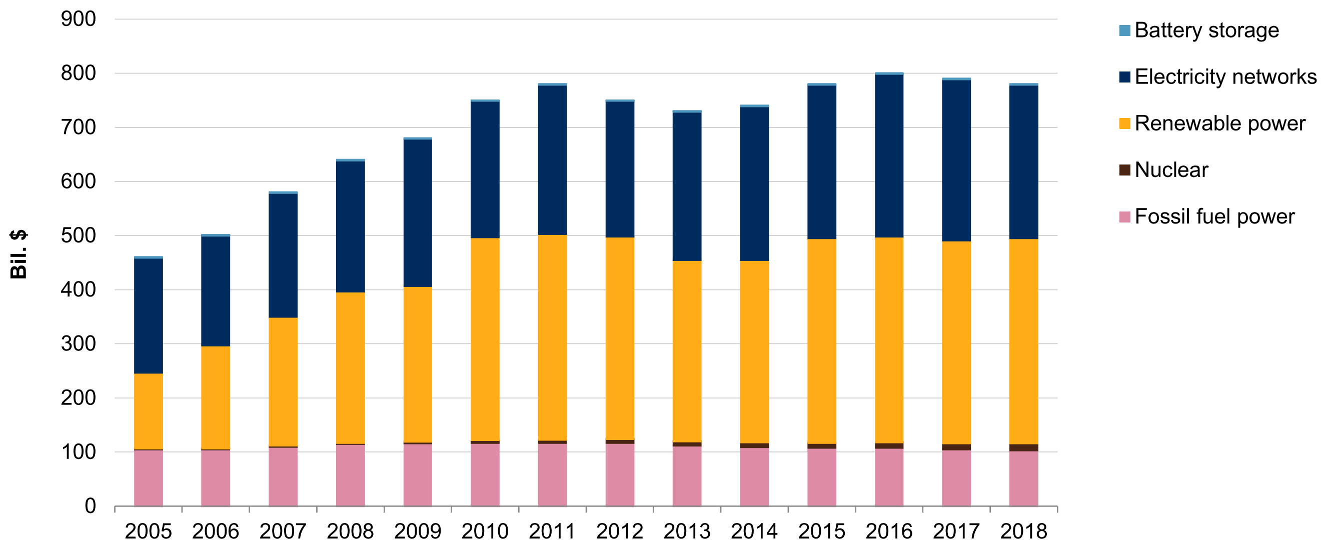


Source: PRIS, IAEA, IEA.

Most of the existing reactor fleet was built in the 1970-1980s. Notwithstanding the recent uptick in nuclear construction globally after 2014, the global trend in energy investments shows a clear preference for renewables, and investments in nuclear generation are several times smaller than renewable investments (see chart 5). This is fundamentally because public policies do not consider nuclear to be clean energy due to safety concerns and long-term nuclear waste issues, even though it results in zero direct CO2 emissions. In addition, new nuclear reactors require vast amounts of capital investment upfront and have high execution risks, long lead times, and very long asset lives. This makes private investors cautious about investing in nuclear amid lower and increasingly volatile power prices across major markets, and rapid and continued changes in the global energy system.

Chart 5

Investments In Nuclear Generation Are Far Smaller Than In Renewables
Global investment in the power sector by technology 2018



Data as of Dec. 31, 2018. Source: IEA World Energy Investment 2019.

In Western Europe And North America, Nuclear Is Increasingly Challenging But Life Extensions May Smooth The Energy Transition

In Western Europe and North America, nuclear power is suffering from increasing cost competitiveness of renewables. The IEA) estimates that, by 2040, the mean levelized cost of electricity (LCOE) for newly built green energy projects in North America (including investment tax credits) will have decreased sharply to $50-$60 per megawatt-hour (MWh), in some cases well below that figure. This is much lower than new nuclear-build projects, but comparable to, or slightly higher than the average cost of nuclear extensions, forecast at $40-55/MWh (see chart 6). LCOE calculates present value of lifetime costs (including capital costs, fuel costs, operations and maintenance costs) per unit of electricity generation over the asset's lifetime. LCOE includes the cost of constructing the generation asset, but not the cost of grid development.

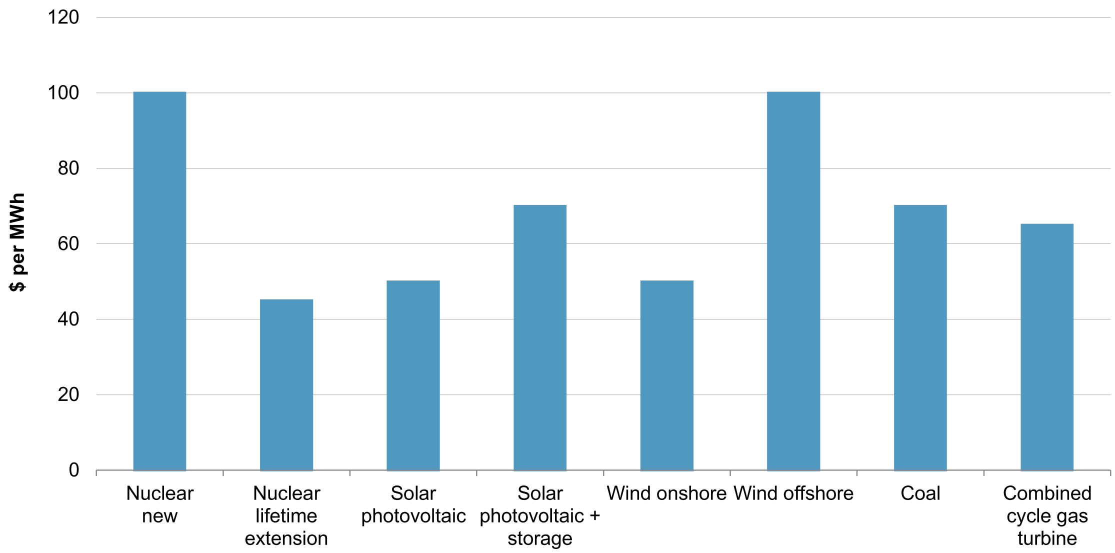
Despite the cost comparability of nuclear life extensions, we think future life extension decisions in the U.S. will be challenged by the support for renewables and the alternative of cheap gas-fired generation. We have observed that gas-fired generation is more competitive in winning capacity auctions in the U.S. While capital costs for nuclear are the main component of LCOE, LCOEs for gas-fired plants are mostly driven by variable costs, that is, by fuel-price assumptions.

For Europe, the IEA's study shows LCOE significantly higher for renewables than in the U.S., ranging between $80-$110/MWh. This provides greater economic support for nuclear life extensions. However, LOCE values vary significantly by country. The case for new nuclear in

Europe is in our view much more challenging.

Chart 6

Nuclear Life Extensions Should Still Be Cost-Competitive In 2040
Projected LCOE by technology



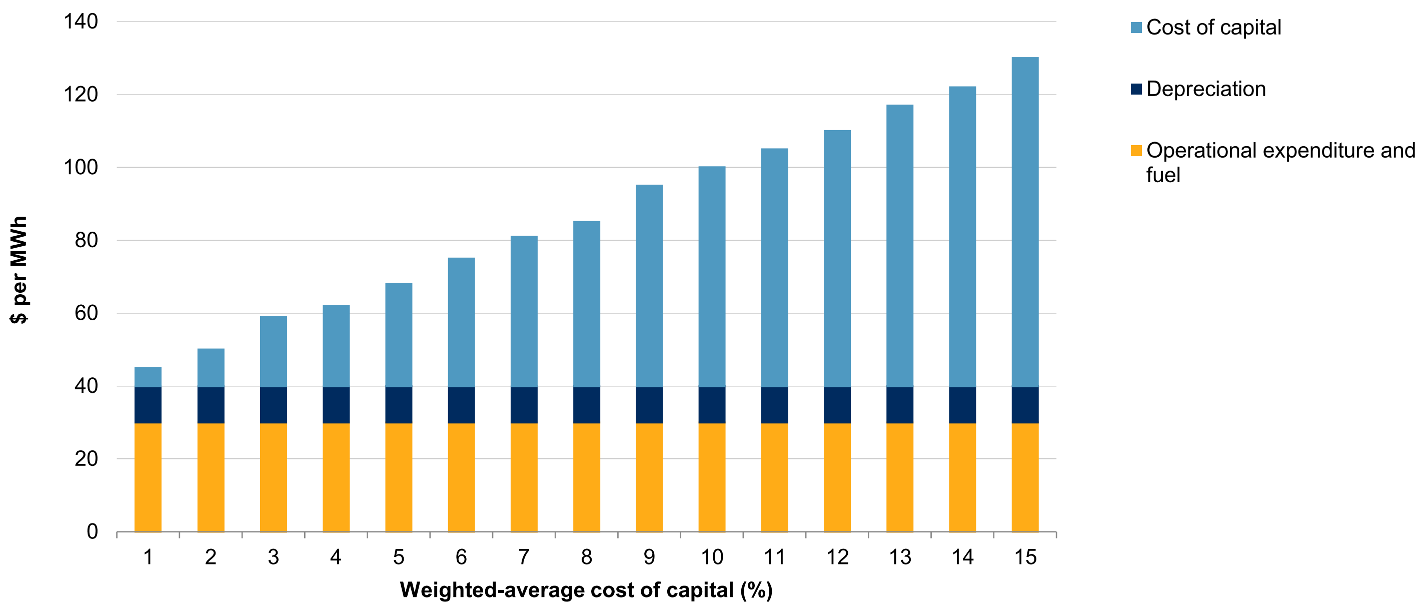
MWh--Megawatt hour. Data as of Dec. 31, 2017. LCOE calculates present value of lifetime costs (including capital costs, fuel costs, operations and maintenance costs) per unit of electricity generation over the asset's lifetime. LCOE includes the cost of constructing the generation asset but not the cost of grid development.
Source: IEA 2019, U.S.-based.

Yet, beyond economic drivers, we see other reasons for nuclear life extensions, at least as a transitionary measure over the next two decades in Europe and the U.S. Even if policies stimulated faster expansion of renewables than in the "most likely" scenario in chart 1, we believe countries would find it more difficult to cope with the supply gap if both coal-fired and nuclear generation baseload were rapidly phased out at the same time. Nuclear extensions may also prevent construction of new gas units, giving time for renewables to fill the void. In addition, a too fast nuclear phaseout would pose other challenges, including the huge impact on $CO2$ emissions, security of electricity supply, and grid stability while adding to decommissioning costs.

The capital costs of new nuclear represent a major share of its LCOE, therefore making it very sensitive to cost overruns, construction delays, and assumptions about cost of capital and future asset lives given the very long-term investment horizon. Under a hypothetical capital cost assumption of about 9%-10%, the cost competitiveness of new plants is clearly questionable at approximately $100/MWh LCOE, which assumes investment costs come down significantly to $4,500/kW (as per the IEA) and before risk-adjusting for construction cost-overruns (see chart 7). The study shows, however, that if lower-cost funding is available, for example from state-owned banks as typically the case in emerging markets, LCOE could be much lower (for example $60-$70/MWh) even when capex and opex are the same. Nuclear projects also face major uncertainty about future decommissioning costs many years ahead.

Chart 7

Capital Costs Of New Nuclear Represent A Major Share Of Costs
Illustrative LCOE of a new nuclear power plant project depending on the cost of capital



Based on a theoretical example of a 1 gigawatt plant with an investment cost of $4.5 billion. Source: IEA (2019).

New nuclear plants have become much more expensive in developed markets, mainly because of construction cost hikes (including due to the lost expertise and limited recent new builds) and complex design to enhance safety and security. Technical, safety, and security requirements have become increasingly complex and costly after Fukushima, and most new projects are the first of a new kind. Many recent emblematic projects in Europe and North America, such as Flamanville in France and Olkiluoto-3 in Finland, have experienced significant cost escalation, major hurdles, and delays when significant parts of an already constructed asset had to be remade, triggering financial woes for the nuclear operators Areva and Westinghouse.

The IEA's assumption of new-build costs of $4,500 per kilowatt (kW) for future projects (see chart 6) is much lower than actual first-in-kind projects that have experienced large cost overruns. For example, Flamanville-3 in France is now estimated at about $8,600/kW. HPC in the U.K. had an initial capital budget of about $7,000 per kW, but costs have since been revised upward to about $8,800 per kW. EDF's CEO recently stated that costs of the EPR (European pressurized reactor) should come down materially once experience of first-in-kinds have been leveraged and synergies from building multiple plants on one site are taken into account. The troubled Vogtle project in the U.S. is now estimated to cost about $10,000 per kW.

In addition, nuclear operations economics in Western Europe and North America are affected by growing maintenance downtime, volatile merchant power markets, and sometimes by additional nuclear taxes. Renewables, meanwhile, have almost zero marginal costs, enjoy priority access to the market, and often benefit from additional support schemes such as feed-in tariffs or long-term fixed price contracts.

The nuclear industry's woe has nevertheless triggered new discussions about whether it should receive more support and re-regulation of certain parts of the nuclear industry. This is illustrated by the supportive contract for difference for the new HPC, subsidies (through zero emission credits) for ailing nuclear plants in the U.S., and ongoing discussions about more predictable market design and prices for French nuclear generation as part of the life extension program. In the future, a surge in carbon prices could support nuclear economics in Western Europe. If CO2 prices increase, for example to $100 per ton in the future from about $25 per ton in Europe today, fossil fuel resources, especially coal, will become very expensive and drive power prices up (see "The Energy Transition: Different Nuclear Energy Policies, Diverging Global Credit Trends," published Nov. 11, 2019.

In Developing Markets, Lower Nuclear Costs And State Support Make Nuclear Economical

In contrast to Western Europe and North America, governments in many developing markets view nuclear generation as a way to reduce carbon emissions while meeting soaring primary energy demand (for example in China and India), addressing security of supply (such as in Ukraine), and offsetting natural constraints on renewable expansion (Eastern Europe). Nuclear generation in emerging markets remains economically attractive, and often considerably cheaper than in developed markets. This often results in nuclear LCOE being below that of other technologies. Compared to HPC's initial capital budget of about $7,000 per kW, construction costs of new reactors in China have come down due to the learning curve effect, a complete supply chain (with 85% localization for reactors designed in China), and good project management that reduces execution risks. The first-in-kind third-generation (G-III) imported reactors, such as EPR and AP1000, experienced delays and cost overruns, but their costs were still much lower than projects of similar design in other markets, such as Europe or the U.S. Construction costs of Taishan (EPR) and Sanmen (AP1000) were about (renminbi (RMB) 25,000/kW ($3,800-4,000/kW), and RMB21,000/kW (or $3,200-3,400/kW), respectively. China has four reactors of its own G-III design, HPR1000, under construction. Their budgeted costs are about RMB16,000/kW ($2,300-$2,500/kW). In Russia, we estimate the cost of recently completed units (VVER) at about $2,000/kWh, whereas the cost of Russian-built Akkuyu plant in Turkey, with a similar design, is budgeted at about $4,200/kWh, and Paks in Hungary at about $5,500 (the difference reflecting higher costs of construction abroad).

The key reasons for the much more attractive nuclear economics in developing markets are as follows:

- Lower construction costs. Although all countries are subject to standard International Atomic Energy Agency (IAEA) safety requirements, local regulations and their actual implementation by country differ, and local labor or land cost could be significantly lower as well. Serial and learning curve effects from many recent new-builds help reduce costs and time of construction, as both companies and regulators have relevant recent experience and use standard engineering solutions. For Russian and Chinese companies, vertical integration through the nuclear supply chain, R&D ability, and over 80% localization of nuclear power equipment helps to control costs and manage execution risks.

- State support and attractive financing packages. Accessing capital markets for nuclear projects might not be easy, particularly for emerging market issuers. Many new nuclear projects in emerging markets are therefore funded with loans from government-related banks or with intergovernmental loans, occasional equity contributions, or government guarantees. For example, Russia provided intergovernmental loans to Belarus, Hungary, India, and Bangladesh to support nuclear power plant construction by Russian companies. It also provided ad hoc equity contributions to the Russian nuclear power operator Atomic Energy Power Corp. (BBB-/Stable/A-3) for domestic and some international nuclear construction (Akkuyu in Turkey and Hanhikivi in Finland). In China, new nuclear construction is primarily funded with long-term syndicate loans from government-related banks. In China and Russia, a large portion of nuclear liabilities rests with the government and not the nuclear operators.

- Return expectations will strongly diverge depending on the weighted average costs of capital applied, which in turn will vary substantially (see chart 7). Although usually, theoretical LCOE comparison across fuel types in most studies uses similar discount rates, in reality, risk premium and even availability of capital for a certain energy project depends on investors' perception of energy transition uncertainties, and investment strategies are increasingly shaped by ESG considerations. Most new nuclear projects in developing markets globally are handled by government-related entities, often with some form of state funding or loans from government-related banks.

- Favorable contractual arrangements for future electricity sales. Despite recent overcapacity in the power market, China implements the minimum facility utilization hours to safeguard nuclear power as base load. In Russia, new nuclear plants benefit from attractive capacity supply mechanisms that ensure 10.5% return on actual investments over 25 years. The Akkuyu plant currently under construction in Turkey will benefit from a long-term power offtake arrangement at an attractive fixed price.

Global Warming Or Nuclear Waste?

Nuclear energy has faced mounting criticism over security concerns, especially in the aftermath of the Fukushima disaster on March 11, 2011. Nuclear operators face unique risks of low-probability, but high-impact catastrophic events. As a consequence, operators face increasing political and social pressures on safety, waste disposal, and storage. While profitability remains a key pillar of our business risk assessment of nuclear operators, we equally take these other risks into account. Furthermore, nuclear-related long-term liabilities typically represent a large portion of nuclear operators' overall S&P-adjusted debt.

Nevertheless, nuclear remains a stable source of low-carbon electricity, which is important to reach ambitious climate goals. Operating nuclear fleets and nuclear life extensions, at least as a transitionary measure, result in massive CO_2 savings (see table 2). Furthermore, migrating from nuclear too quickly may raise questions about long-term energy affordability and grid stability. According to an IEA 2019 study, achieving climate targets in developed economies in its "nuclear fade" scenario is possible but would require $1.6 trillion higher investments for the advanced economies compared to the IEA's sustainable development scenario, including interconnections, energy storage, and additional renewable generation. The IEA nuclear-fade case assumes no new investments in nuclear lifetime extensions or new projects in advanced economies beyond projects already under construction, while the IEA sustainable development scenario focuses on achieving internationally agreed objectives on climate change, air quality, and universal access to modern energy.

We believe that the long-term future of the nuclear industry will depend on the pace of new technical solutions in energy storage, carbon capture, and nuclear waste management, as well as on their large-scale commercial deployment. Currently, relatively limited capacity of energy storage (such as batteries and pump storage) on major markets is one of the factors constraining wider penetration of renewables. Carbon capture, on the other hand, could extend the life of fossil-fuel assets. Small modular nuclear technology could potentially offer some benefits of serial production and lower upfront investment needs. But, so far, they remain expensive compared to other fuel types and do not address the fundamental nuclear waste and safety issues.

Table 2

Carbon Dioxide Emissions Avoided Through Use Of Nuclear Power

Energy	Average lifecycle greenhouse gas emissions (tons/GWh)	Emissions produced from generating 2,563 TWh of electricity (mil. tons)	Additional emissions avoided through the use of nuclear electricity in place of fossil fuel
Coal	888	2,276	2,202
Gas	499	1,278	1,204
Nuclear	29	74	0

GWh--Gigawatt hours. TWh--Terawatt hours. Source: World Nuclear Association.

Diverging Policy Trends Will Shape Nuclear Operators' Credit Trajectories

Nuclear operators' financial performance is highly dependent upon remuneration frameworks and regulation in place. This is because construction costs are high, lead times are long, and there is a fundamental mismatch between long nuclear asset lives and increasingly volatile electricity markets: a rising share of renewables with zero marginal costs weigh on long-term power average power prices).

Because of safety, security, and geopolitical concerns, nuclear generation is even more a political decision than for other energy sources. Worldwide policies on nuclear diverge considerably, and so do key challenges and opportunities for the nuclear players' credit quality (for further details see "The Energy Transition: Different Nuclear Energy Policies, Diverging Global Credit Trends," published Nov. 11, 2019.

The U.S. nuclear producers face increasing competition with low-cost gas-fired and renewable generation. This has resulted in low electricity prices and already prompted early closures of smaller and less efficient nuclear plants. Although there are no official phaseout policies, nuclear regulations have tightened and became more costly, while energy policy favors renewable generation and exposes nuclear to very volatile, and sometimes negative, electricity prices. We therefore expect nuclear generation to gradually decline for economic rather than political reasons. Still, recently, we have seen examples of state support (such as subsidies), which could be important for preventing early closures and for protecting the economics of the U.S. nuclear sector in general.

Most Western European countries plan to reduce or phase out nuclear energy, while increasing the share of renewables in the generation mix. France, for example, targets a reduction in nuclear from 72% today to 50% by 2035. Although regulators and public opinion in Western Europe have shifted clearly in favor of renewables, with ambitious goals for 32% of primary energy, further expansion of green energy requires large investments, while a too rapid nuclear phaseout poses questions as highlighted above, resulting in the risk of missing CO2 goals. The European nuclear operators' credit quality will therefore significantly depend on public policies and a degree of regulatory support. In Germany, for instance, the nuclear reform transferred long-term nuclear storage liabilities to the state (even if at a premium), while France is seeking to re-regulate EDF's existing nuclear generation capacities in light of its life extension program. A potential increase in CO2 emission trading system (ETS) prices could also considerably improve nuclear economics given its CO2 free baseload generation profile.

Many Eastern European countries (such as Slovakia, Czech Republic, Hungary) and some former Soviet Union countries (Ukraine) view nuclear as a way to ensure self-sufficiency in energy generation. They will likely invest in life extensions or replacements of existing reactors. This is largely to avoid becoming too dependent on electricity imports, or being overly reliant on imports of Russian gas, or already high coal-fired generation. Moreover, many Eastern European countries have limited natural and financial resources for wind and solar development. Given the typical size of nuclear investments, state support for replacements or new builds will be the key to preserve the nuclear companies' credit quality.

Japan has seen its nuclear share decrease dramatically following Fukushima's disaster. The initial push into renewable penetration has seen its limitations, including because of transmission and distribution as well as land constraints and affordability issues. Even if the government's 2030 plan seeks to have major idle capacity return to the market, we believe the road is likely to be long and challenging. The key credit-positive for the nuclear operators is that the regulator allows them to pass through massive costs of meeting tighter safety requirements.

South Korea, one of the most reactor-dense countries globally, has been shifting toward renewable energy sources from coal and nuclear since 2017. Following Fukushima, and as part of the green agenda, the government tightened safety requirements for reactors and decided not to approve any further extension of nuclear plant life. Also, the country saw the first nuclear reactor retirement in 2017, and a second one in 2018, even though construction of already started reactors continues and two reactors have been commissioned this year.

China doubled its nuclear production between 2007 and 2017 and aims to become the nuclear superpower in the near future. We believe, however, it will have to accelerate the construction of new nuclear power plants to achieve its ambitious 2020 target of having 58 gigawatts (GW) of nuclear capacity in operation (from 45GW in 2019). China supports nuclear power to reduce carbon intensity and dependency on hydrocarbon imports. China promotes advanced proprietary technology with higher safety standards (G-III). The balance between massive costs of new construction (often funded with debt from government-related banks) and state support will be the key for companies' credit quality.

Many other Asian countries, notably India, see nuclear as an efficient option to meet soaring domestic energy demand fired by economic and demographic trends, as well as to reduce heavy reliance on air-polluting energy resources, notably coal. We understand that in most cases, new nuclear power plants construction is financed by government-related entities or benefit from intergovernmental loans.

Russia is set to continue gradual replacement of old nuclear units with new ones. At the same time it is maintaining broadly constant energy mix with very limited contribution from renewables other than traditional hydro. Still, we believe that a significant expansion in local nuclear capacity is unlikely due to demand and affordability constraints. The government supports nuclear energy generation to ensure stable domestic production, security of supply, and to expand exports of nuclear power plant construction services and fuel to other emerging markets. Russian nuclear operators' credit quality is supported by solid financial headroom, ongoing state support via favorable market design, and vertical integration, while ambitious international nuclear power plant construction plans are the main risk.

Appendix: Nuclear Sector And Government Policy Trends In Selected Countries

Nuclear Sector And Government Policy Trends In Selected Countries

U.S.	The U.S. remains the world's largest nuclear generator, with 97GW capacity at 97 reactors, and about 19% nuclear share in total electricity generation.
	Merchant nuclear power plants face increasing competition from cheap gas-fired and renewable generation, which has led to closures of several smaller and less efficient nuclear plants.
	Although there is no specific phase-out plan, the share of nuclear generation could gradually decrease from current 19%, and new builds are unlikely due to cost overruns on recent nuclear projects and abundance of low-cost gas and renewable resources.
France	The government expects to decrease the share of power produced from nuclear sources from about 72% now to 50% by 2035 (2018 Energy Transition for Green Growth bill).
	France has 58 operable nuclear reactors, with a combined net capacity of 63.1GWe. In 2018, nuclear generated 72% of the country's electricity.
	One reactor is currently under construction in France – a 1,750MWe EPR at Flamanville.
Germany	Germany has 9.5 GW capacity at seven reactors, corresponding to 12% of 2018 electricity output.
	In 2011 the German Parliament, pressured by a growing public opposition towards nuclear energy, approved an acceleration of the phase-out program, now to be completed by 2022.
	The country plans to expand its renewable generation and phase out coal. In 2015, Germany emitted 730Mt CO_2, and remained the world's sixth-biggest emitter of CO_2.
Ukraine	Ukraine's 15 reactors with 13.1GW of installed capacity generate 53% of the country's electricity, while renewables are nascent.
	The strategy approved in 2017 envisages a nuclear share to remain broadly stable, at 50% in 2035, with a significant growth in renewables and gradually reducing dependence on fossil fuels. Ukraine performed life extensions.
U.K.	The U.K. has 15 operable nuclear reactors, with a combined net capacity of 8.9GW.
	The country's nuclear fleet is aging, and the government plans to retire half of the current nuclear capacity by 2025 and replace it with new nuclear builds.
Sweden	Sweden has eight operable nuclear reactors, with a combined net capacity of 8.4GWe.
	The country is closing down some older reactors, but has invested heavily in operating lifetime extensions and uprates.
China	According to the 13th Five-Year Energy Development Plan, China aims to achieve the nuclear power target of 58GW in operation and 30GW under construction by 2020.
	Nuclear energy is expected to have an important role in the reduction of the country's reliance on fossil-fueled electricity and is seen as an effective instrument to reduce air pollution.
	Total capacities and generation of nuclear power keeps growing in China. In 2018, there were 44 reactors in operations with total capacities of 44.65GW, in which 8.84GW were new capacities. Nuclear generation had year-on-year growth of 18.6% in 2018, but represents a relatively modest 4.2% of national generation (versus 3.6% in 2017).

Nuclear Sector And Government Policy Trends In Selected Countries (cont.)

	China has imported Western technology but is investing in the improvement and upgrade. It has developed the Hualong One (HPR1000) and CAP1400 which has China's own G-III propriety technology. The first of its kind demonstration reactors of Hualong One is expected to commission commercial operation in 2021.
Japan	After the 39% increase of CO2 intensity in Japan at the end of 2012, Japan has decided to reopen nuclear plants to achieve its goal of low carbon.
	The 5th Basic Energy Plan, approved in July 2018, maintains the same electricity percentages as agreed in mid-2015 of 45% of electricity generated coming from nuclear and renewables. It presents nuclear power as "an important base-load power source contributing to the stability of the long-term energy supply-and-demand structure," and states that necessary measures will be taken to achieve nuclear power's share of 20%-22% in the 2030 energy mix. Toward 2050 it proposes moving to a low-carbon scenario.
	That said, as of July 2019, only nine of the nuclear reactors in Japan have restarted after the Fukushima No. 1 nuclear accident. Solar and wind power generation account for less than 5%. Accordingly, the 2030 energy mix target is quite challenging for the industry, which is heavily relying on LNG-fired thermal power plants.
India	India has 22 reactors with 6.2GW capacity, corresponding to only cover 3% of energy production, while the country's energy demand is set to grow.
	The Indian government is committed to growing its nuclear power capacity with 7 new reactors in construction since early 2018 aiming at 22.5GWe nuclear capacity by 2031.
Republic of Korea	With 23.8GW capacity at 25 reactors, South Korea is 24% reliant on nuclear in its electricity production.
	The government elected in May 2017 is sceptical about the nuclear development plan and is planning a phase-out favouring investment in green and clean sources of energy.
	According to the 8th Basic Plan for Long-Term Electricity Supply and Demand (2017-2031) and the government's announcement, five new reactors are expected to begin operations by 2022 with no more addition. And reactors will start to shut down one by one from 2023. Share of nuclear in power generation will go down 24% by 2030 from 30% in 2017.
Russia	The government plans to maintain a broadly stable share of nuclear in the overall energy mix by continuous replacements of ageing reactors with new ones.
	Russia has 35 operable nuclear reactors, with a combined net capacity of 29.1GWe, and is an important global player in nuclear fuel and uranium enrichment.
	Russia's nuclear industry is currently involved in a number of new international reactor projects in Belarus, China, Hungary, India, Bangladesh, Turkey, and Uzbekistan among others.
	The country invests heavily in development of new and more efficient technology (fast neutron reactor) and small modular reactors.

EPR--European pressurized reactor. GW--Gigawatt. GWe--Gigawatts electric. LNG--Liquefied natural gas. Mt--Million tons. MWe--Megawatts electric.

Related Research

- The Energy Transition: Different Nuclear Energy Policies, Diverging Global Credit Trends, Nov. 11, 2019
- Energy Transition: Renewable Energy Matures With Blossoming Complexity, Nov. 8, 2019
- The Energy Transition: What It Means For European Power Prices And Producers, Nov. 7, 2019
- What Makes Russia's Nuclear Sector Competitive, July 11, 2019

This report does not constitute a rating action.

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