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AFTER JAPAN'S EARTHQUAKE

THE IMPACT OF THE NUCLEAR CRISIS ON THE GLOBAL ENERGY SECTOR

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The Higashi Nihon earthquake and resulting tsunami triggered a catastrophic chain of events at Japan's Fukushima Daiichi nuclear plant. Safety experts rated the incident's severity at level 7—the most serious classification on the International Nuclear and Radiological Event Scale—making this the world's gravest nuclear accident since Chernobyl. Japanese authorities continue to monitor the situation closely and have considerably heightened their scrutiny of the country's remaining nuclear reactors.

The accident's reach has extended well beyond Japan. There has been upward pressure on global prices of some fuels, as Japan has turned to alternative sources to compensate for the loss of nuclear generation capacity. More significantly, the incident has prompted a number of governments around the world to reexamine their commitment to nuclear energy from a risk-reward perspective, potentially leading to significant long-term supply-demand shifts within the global energy sector.

Below, we take a high-level look at the implications of the Fukushima accident—for Japan, for nuclear energy specifically, and for the global energy-generation mix in the years ahead.

Short-Term Market Effects

Nuclear energy has long been central in Japan's energy mix. With few natural resources of its own, the country depends on imports for approximately 80 percent of its primary energy needs. Seeking to reduce this reliance, the government made the development of nuclear energy a priority in the 1970s, following the oil crisis of 1973. In 2010, nuclear energy accounted for 29 percent of the country's electricity production.

The accident at the Fukushima Daiichi plant and the government's subsequent closure of two of the plant's six reactors translated into a sizable immediate reduction of electricity generation capacity—approximately 70 terawatt hours' worth, or 28 percent of the country's nuclear genera-

tion capacity. This reduction was compounded significantly in the months following the accident by cautionary measures imposed by the government in the wake of its evaluation of the country's remaining reactors for earthquake and tsunami vulnerability.

Japan has three main options that can serve as substitutes for nuclear energy: coal; natural gas, including liquefied natural gas (LNG); and oil products, including diesel. (In 2008, these accounted for 28 percent, 24 percent, and 13 percent, respectively, of Japan's total electricity production.) After previous nuclear incidents, a mix of these three fuels was used to compensate for the loss of nuclear power. In 2007, for example, during the lengthy shutdown of the Kashiwazaki-Kariwa nuclear power station following an earthquake, LNG accounted for up to half the replaced capacity, while the two other fuels—particularly coal—made up the balance.

If, as seems likely, Japan were to place similar emphasis on LNG this time—the country is already the world's largest LNG consumer, representing 35 percent of the global market—the effect on the recently soft LNG market would be significant. Substituting for the capacity generated by the two Fukushima reactors alone would demand an additional 12 billion to 15 billion cubic meters per year, the equivalent of 5 percent of global LNG supply and, more important, around 20 percent of the so-called liquid LNG supply—the gas that is not committed under long-term contracts. Indeed, in the three weeks immediately following the disaster, global LNG prices rose by 13 percent.

How high LNG prices could ultimately rise in the medium term will hinge on a combination of factors. One is the number of nuclear reactors that the Japanese government shuts down temporarily or decommissions permanently for safety reasons. Another is the precise energy mix that Japan uses to substitute for the loss in nuclear generation capacity. A third is the country's overall energy demand during the reconstruction period. And another is a potential pickup in LNG demand by countries outside Japan that choose to halt nuclear generation in the wake of the accident.

Government Responses to the Accident

Governments around the world reacted quickly to the disaster. Most launched reviews of their current and planned nuclear operations. Japan halted construction of new plants and announced the separation of the country's Nuclear and Industrial Safety Agency (NISA) from the Ministry of Economy, Trade, and Industry, which is also responsible for promoting nuclear power. As of early July, the government was also weighing a material further tightening of safety standards for existing nuclear reactors, restrictions that could potentially lead to a complete shutdown of all the country's nuclear facilities within a year. But most governments—including those of the U.S., the U.K., and China, which initially announced the suspension of new projects—have expressed continued commitment to nuclear energy, while emphasizing the critical importance of learning from the Fukushima incident.

The notable exceptions are Germany and Switzerland. In May, Germany announced plans to close all of its nuclear plants—which provide a quarter of the country's electricity—by 2022. In their place, Germany will aggressively build up renewable-energy capacity and expertise, supplemented by an increase in gas-generated energy. In plans ratified in early June, renewables are to provide 35 percent of Germany's needs by 2020 and fully 50 percent by 2030. Offshore wind will play a particularly large role. The government is targeting capacity of 20 to 25 gigawatts—equivalent to almost 20 nuclear stations—by 2030 and is supporting that expansion with €5 billion in state investment.

Switzerland has opted to follow a similar path, despite the fact that nuclear energy currently provides almost 40 percent of the country's electricity. In May, the govern-

ment decided to abandon plans to build new nuclear reactors. It will allow existing reactors to continue to operate but will not replace them at the end of their life spans.

Were such measures to be adopted more broadly and adhered to, the implications would be huge. Currently, there are 131 reactors either planned or under construction globally, representing more than 900 terawatt hours of new capacity. Moreover, if governments choose to tighten the regulations governing the nuclear industry—and many are reviewing their regulations—this could ultimately translate into a range of costs, from one-time investments in order to upgrade plant designs and improve backup systems to recurring costs from more-stringent maintenance procedures and regulatory scrutiny.

Longer-Term Implications for the Energy Generation Mix

Until the Fukushima incident, a widely heralded "nuclear renaissance" had been under way. Momentum had grown in the past year, driven by environmental concerns stemming from the Deepwater Horizon disaster and worries about the security of oil supplies in the wake of the Arab Spring. The Japanese government had planned to expand nuclear energy's share of the country's energy-generation mix to 50 percent by 2030. Nuclear energy was slated to play an expanding role in the energy plans of a number of other governments as well.

The Fukushima accident halted that momentum. The question is, will the accident have lasting impact on the nuclear energy industry—and, by extension, on the broader energy sector? Previous nuclear accidents have had significant effects on public opinion and the industry's growth trajectory. The partial meltdown at Three Mile Island in 1979 proved a major and long-lived setback for nuclear energy in the U.S., with more than 50 on-order reactors canceled over the following five years and no new construction over the next two decades. The Chernobyl disaster in 1986 cast a similar pall over nuclear energy that lasted for decades.

Given the scale and seriousness of the Fukushima incident, we believe that many countries are likely to scale back their commitment to nuclear energy on a long-term basis. This will have significant ripple effects as governments turn to other energy sources to replace their nuclear capacity. In Japan, gas-fired power plants seem the likeliest option for medium-term capacity replacement. LNG infrastructure already exists, and new plants can be built relatively quickly—typically in less than two years. The government has also reactivated coal capacity to meet short-term needs, but a further buildup seems unlikely, as plant construction can take three years or more and additional coal-fired generation would be accompanied by an undesirable increase in carbon dioxide emissions.

Along with gas, renewable-energy sources will be boosted in Japan's future generation mix. In May, Prime Minister Naoto Kan announced a policy to increase renewables' share of the total power supply to 20 percent by the early 2020s. Solar and especially wind power will likely receive the greatest emphasis. Currently, Japan has only 2.3 gigawatts of installed wind capacity—compared with about 40 gigawatts in the U.S. and China and 27 gigawatts in Germany—due to limitations in the number of possible onshore sites. Offshore wind, however, holds much promise for Japan, and the survival of the country's offshore turbines through the tsunami is encouraging. Among other renewable sources, hydroelectric power already meets 8 percent of Japan's electricity needs. But most of the suitable hydroelectric sites in Japan are already developed, which will limit hydroelectric power's ultimate contribution.

Over the longer term, natural gas and renewable energy sources, especially wind and solar power, stand to be the favored alternatives to nuclear energy of many, if not most, other countries as well. Natural gas could be the biggest winner—it is

plentiful, readily available, and relatively clean. Greater emphasis on and demand for renewables, meanwhile, will speed technology breakthroughs, scale effects, and progress along the experience curve, leading to accelerated reductions in prices for these energy sources.

The precise mix of energy sources that countries pursue, and the timeline for implementation, will vary and be influenced by a combination of economic, political, and regulatory considerations. Such questions as the following remain to be answered:

- Will electric grids be able to deal with a high volume of renewables—especially wind and solar power, which are intermittent sources?
- Will governments that are committed to nuclear energy hold the course if voters' concerns about nuclear safety rise?
- Will governments that plan to phase out nuclear energy continue to do so if renewables prove more expensive than expected?
- How might carbon pricing, growing environmental concerns, and tightening emissions standards shape the debate?

Hence there remain many unknowns. What can be said conclusively, at this point, is that the Fukushima accident has left a permanent mark on the global energy landscape. Nuclear energy will represent a smaller portion of the world's generation mix in the years ahead than it otherwise would have, and its costs will be higher. The demand for compensatory sources of energy, especially natural gas and renewables, will be higher. And there will be increasing emphasis globally on energy efficiency as countries endeavor to do more with less.

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