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Assessing Politics in Market Projections: Restarting Japanese Nuclear Reactors and Global Gas Markets

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Key Points

This paper builds on the 2018 KAPSARC discussion paper, “The Policymaking Process to Restart Japanese Nuclear Power Plants,” which found that:

> There is growing political will among Japanese stakeholders to restart nuclear reactors for power generation. The current political trajectory indicates expanding political acceptance of nuclear power among municipal and prefectural political leaders.

> The process of regaining national support for nuclear power in Japan is likely to develop over several years.

This paper explores the value of explicitly integrating the modeling of political concerns into a model of energy market projections. This is achieved by assessing the impact on global gas markets of political constraints on restarting Japanese nuclear reactors. The 2018 KAPSARC discussion paper cited above utilized the KAPSARC Toolkit for Behavioral Analysis (KTAB) to determine the political will for such a policy decision. Japan’s unique political and legal structure also provides the ability to roughly gauge, through KTAB analysis, the timing of developing political will for specific reactors, leading to an estimate of how much nuclear energy could be restarted over time.

Following the Fukushima-Daiichi nuclear incident in 2011, Japan shut down all of its nuclear reactors and replaced most of its lost nuclear generation with imports of liquefied natural gas (LNG). Restarting nuclear power will almost certainly displace LNG, and those volumes will need to find a new home. Using Nexant’s World Gas Model (WGM), we estimate the changes in LNG flows and the impact of these on global spot prices, if any. The key findings of this study are:

> KTAB’s simulated timeline for restarting Japanese nuclear reactors is more rapid than WGM’s base case scenario. This implies more LNG displacement in the short and medium term, resulting in the displacement of LNG volumes greater than Japan is contractually obligated to accept. Japanese utilities can either divert United States (U.S.)-sourced LNG cargoes, due to their having more flexible contracts, or renegotiate the terms of existing non-U.S. contracts.

> Relaxing take-or-pay volumes on Qatari contracts by 10% can facilitate a faster restart of Japanese nuclear power. Incorporating this assumption into WGM shows more Qatari spot cargoes flowing to other parts of Asia, most noticeably India where LNG can compete with liquid fuels.

> Japanese utilities with contracted U.S. LNG in their portfolio can reroute the LNG to different locations, since U.S. LNG contracts do not have the destination or diversion clauses in Japan’s legacy contracts with other suppliers. In this scenario, the model diverts most of the unwanted cargoes to the European market – highlighting the status of Europe as the market of last resort for LNG.

> The faster pace of nuclear reactors coming back online when compared with WGM’s base case does not result in any significant impacts on regional gas spot prices. This is because, compared with WGM’s base case scenario, the displaced LNG is relatively minor on an annual basis, peaking at five billion cubic meters (bcm) by 2021.

Summary

Market projection models have traditionally been used to estimate market effects and pricing. However, in these models little quantitative attention has traditionally been paid to the political constraints and opportunities driving policymakers' decisions. Political motivations should not be discounted in analyst and researcher assessments, as the majority of energy policy decisions involve some level of political influence. Reintegrating nuclear energy within the Japanese power mix is favored by some Japanese officials, as it will enhance Japanese energy security and provide local economies with cheaper energy and higher-paying jobs. Restarting nuclear reactors may also lead to a reduction in carbon emissions, giving Japan a better chance to achieve its nationally determined contribution (NDC) under the Paris Agreement. The pace at which nuclear reactors come online can impact global liquefied natural gas (LNG) flows.

This study builds on the 2018 KAPSARC discussion paper, "The Policymaking Process to Restart Japanese Nuclear Power Plants," which utilized the KAPSARC Toolkit for Behavioral Analysis (KTAB) to assess the political feasibility of restarting Japanese nuclear reactors following the 2011 Fukushima-Daiichi nuclear disaster. This study expands on those results by also assessing the expected timing of restarting specific reactors. The results are then fed into the Nexant World Gas Model (WGM), leading to a set of results accounting for quantified political feasibility and a comparison of market projections. These results are compared with WGM's base case scenario, before incorporating the assumptions of KTAB on nuclear restarts into WGM.

The KTAB simulation results suggest a quicker pace of restarting nuclear reactors when compared with WGM's base case, which would lead to a more rapid displacement of LNG in the short and medium term. This may pose a challenge to Japanese utilities bringing nuclear plants online as they are also tied to the obligation to take LNG cargoes from suppliers under long-term fixed-destination contracts. The majority of these contracts were signed under highly constrained conditions, at a time when there was a sudden need for LNG in Japan following the unexpected disaster in 2011. The period after 2016 has seen Japanese firms contracting more LNG from the United States (U.S.), as these contracts do not include destination or diversion clauses and are much more flexible as a result.

When taking this contractual complexity into account, WGM demonstrates that by diverting U.S. LNG originally contracted to Japan elsewhere, the country can accommodate a rapid restart in the short to medium term. However, not all utilities in Japan have that option. Some have rigid non-U.S. LNG contracts within their portfolio and would have difficulties diverting those cargoes. This can be resolved if the off-take agreements between the utility companies and the suppliers are renegotiated to lower their take-or-pay obligations – the minimum volume of product the buyer is required to handle without paying the supplier a penalty.

There likely remains a long road ahead toward achieving the Ministry of Economy, Trade and Industry (METI) target of nuclear energy accounting for 20%-22% of the Japanese power mix by 2030. This study demonstrates the consequences of accelerating nuclear restarts in Japan under existing contractual agreements.

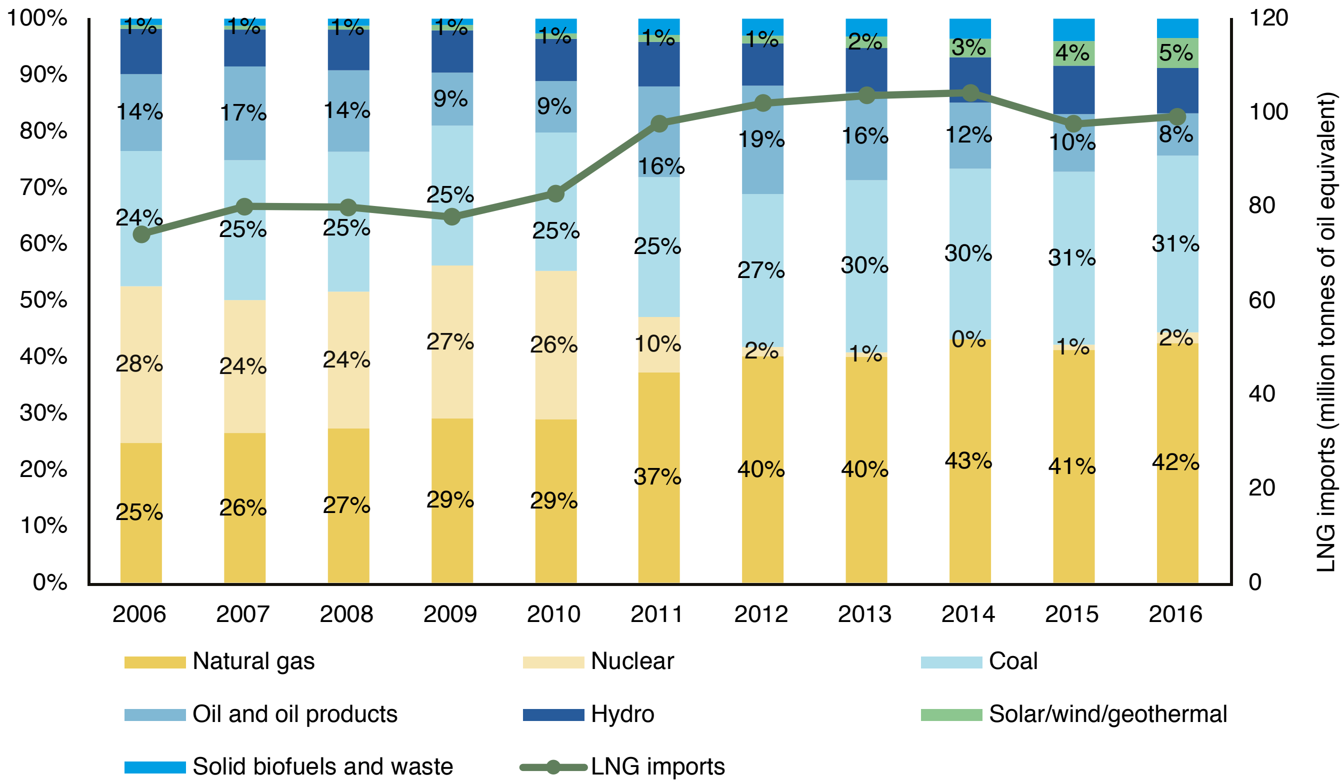
Introduction

This paper is one of a series of three KAPSARC discussion papers assessing the restart of Japanese nuclear reactors following their shutdown as a result of the Fukushima-Daiichi incident in 2011. The first paper of the series, “The Policymaking Process to Restart Japanese Nuclear Power Plants,” (2018) focuses on the political feasibility of restarting reactors, with simulation results that project the evolving political feasibility along with a rough estimate of the timing for restarting specific nuclear reactors. We extend the results in this prior paper by examining the impact of restarting Japanese nuclear reactors on local and global gas markets. More specifically, this paper determines how including a quantitative assessment of the political feasibility of restarting reactors may alter gas market projections. The majority of decisions regarding energy involve some degree of political consideration, yet such factors are typically not quantitatively accounted for when making market projections. This paper aims to shed light on the importance of political considerations when projecting future market trends.

Nuclear energy in Japan

The shuttering of 50 gigawatts (GW) of nuclear capacity in Japan following the 2011 incident in Fukushima led to an elimination of a quarter of the country’s power supply. Fossil fuels and, to a lesser extent, renewables propped up Japanese power generation to make up for the shortfall in supply from nuclear power. Natural gas, imported in the form of liquefied natural gas (LNG), helped lift most

Figure 1. Fuel ratio of power generation mix and LNG imports, Japan, 2006-2016.



Source: International Energy Agency (IEA), 2016.

of the burden on the power system by providing the largest offset to the absence of nuclear energy. As seen in Figure 1, the share of natural gas in Japan's power mix rose from 29% in 2010 to 37% in 2011, with the share later rising to 43% in 2014. Data from the Ministry of Economy, Trade and Industry (METI) showed imports of LNG increasing by about 15% from 61.2 million tonnes in 2010 to 70.1 million tonnes in 2014 (Bloomberg LP 2019).

Spot LNG purchases continued to feed into the power system and peaked in 2014 as nuclear reactors began to restart and once again play a role in Japan's power mix. At the time of writing, Japan has restarted nine nuclear reactors, while three other reactors have successfully passed safety inspections, making those reactors ready to restart (Sheldrick 2018). Japanese government plans assume that nuclear energy will play a significant role in its energy mix over the long term. For example, the 5th Basic Energy Plan from METI states that nuclear power is expected to make up a 20%-22% share of Japan's power mix by 2030 (World Nuclear News 2018).

The decision to restart individual reactors and how quickly they should be brought back online depend on many factors. The political will and level of support for restarting a nuclear reactor in each Japanese prefecture and city home to a reactor, along with national-level support, is critical to the country's decision-making process. Municipal mayors and prefectural governors each have an informal but universally followed veto, affording them the ability to halt the restart of any reactor within their jurisdiction. Local Japanese politicians are highly sensitive to the preferences of local populations on this matter, given their desire to be re-elected. There is also the possibility of groups from civil society using a court injunction to halt the restart of a reactor, further complicating the process. In other words, the support of local populations and governments is crucial to achieving the 2030 METI target. We have used KTAB to systematically and transparently assess the political feasibility of restarting the reactors, taking into account local and prefectural political considerations, along with the other influences on decision-makers at all levels of government.

KTAB and the Spatial Model of Politics

As mentioned earlier, this paper is part of a series of three papers that draw on KTAB simulation analyses to assess the political feasibility of restarting each Japanese nuclear reactor, which would help determine the rate of reintegration of nuclear energy into the power mix. A more complete description of the modeling process used can be found in Efird et al. (2018).

KTAB is a platform that enables collective decision-making processes (CDMPs) to be modeled and analyzed. CDMPs capture the political bargaining process, both explicit and implicit, among a set of actors – which can include individuals, institutions, constituencies or identifiable groups or 'blocs.' This paper presents an analysis of plausible outcomes for CDMPs using a specific instantiation of a model in KTAB, based on the Spatial Model of Politics (SMP), one of the most prominent and best-established models of CDMPs. The SMP simulates how actors interact with and influence one another over time to arrive at a 'feasible outcome' for the modeled question. This reflects a model-based view of the expected outcome of actors' collective support for – or opposition to – restarting nuclear reactors in Japan. Aggregate knowledge of the experts characterizes the current political landscape (referred to as turn 0), but all simulations beyond turn 0 are based purely on the KTAB SMP calculations. More technical information on KTAB can be found in Wise, Lester, and Efird (2015a) and Wise, Lester, and Efird (2015b). All papers, source code, the software and other information can be found at http://www.ktab.software.

The initial paper presented plausible conclusions for the CDMP on Japanese nuclear reactors (Efird et al. 2018). It showed that it is politically feasible to restart many more nuclear reactors in Japan. However, the process of generating broad-scale political will may take years. Another paper in this series identified several scenarios that could substantially reduce the amount of time needed to restart nuclear reactors in Japan (Al Muhanna et al. 2019).

Comparing Projections With and Without Quantitative Assessments of Political Feasibility

In order to assess the political support of veto-holding actors within the KTAB simulation, we considered their position regarding the restart of nuclear reactors over time. When an actor was estimated as taking a neutral or supportive position within the simulation, we inferred that they would support restarting the reactor in question, which we could then deem politically feasible. Note that this assessment is independent of exogenous factors needed to restart a reactor, such as approval from the Nuclear Regulatory Authority (NRA). Interestingly, results from the KTAB simulation showed that most actors would be willing to support nuclear reactors returning online within the short and medium term. Given the imprecise nature of time in the KTAB model, time estimates were grouped into three categories. Short term was defined as the period from 2018 to 2020, medium term from 2021 to 2025 and long term from 2026 to 2030. Table 1 shows the anticipated timing and subsequent capacities coming online from reactor restarts, based on KTAB results.

Quantitative assessment of nuclear restarts on Japanese LNG demand

To our knowledge, no assessment of Japanese gas demand has incorporated a quantitative model of the evolving political situation. Thus, in a novel approach, we have incorporated the KTAB results into the Nexant World Gas Model (WGM) (Nexant 2019) in order to estimate the impact of nuclear restarts on global gas trade flows. WGM is a partial equilibrium model, which includes a database covering all countries that produce, consume and transit gas. Nexant provides a comprehensive set of data, but users are free to overwrite Nexant's assumptions and/or add their own assumptions. The model optimizes supply and trade flows of gas to meet an exogenous demand for each node or country at the lowest cost. The marginal cost of gas supply to each node (shadow price) is also an output of the model.

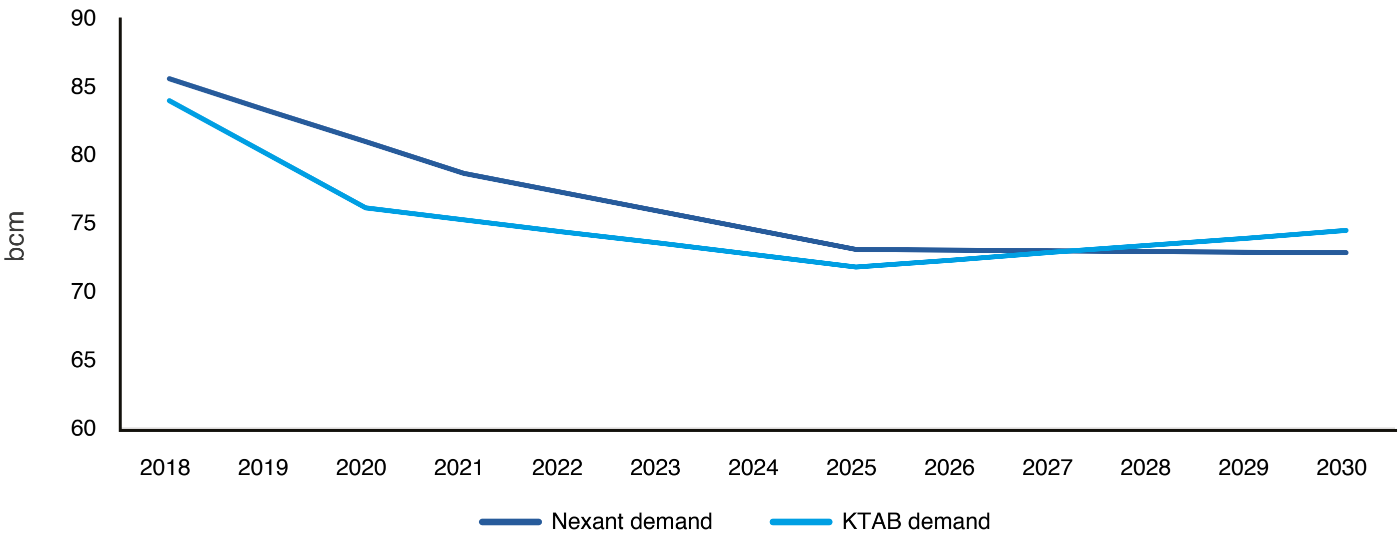
We use the WGM's March 2018 simulation as our base case scenario, before incorporating the implications of the KTAB simulation results regarding the speed of nuclear reactors restarting. WGM includes a gas supply and demand balance for each country by sector, up to the most recent available data point. WGM also provides a projection of the balances for each country to 2040. The forecast explicitly takes into account other fuels in the energy mix and other factors such as macroeconomic indicators and political considerations; however, they are exogenous to the model. In order to make an 'apples-to-apples' comparison with the base case scenario, Nexant was asked to generate and project a new Japanese gas demand profile,

Table 1. Number of reactors and total capacities expected to come online.

	Currently operational	Short term	Medium term	Long term	Total expected
GW	3.7	7	4.9	2.9	18.5
Number of reactors	5	11	7	3	26

Source: KTAB.

Figure 2. Comparison of natural gas demand for power generation in Japan as a result of nuclear restart, WGM and KTAB.



Sources: WGM, KTAB.

taking into account KTAB's results based on each reactor's historic capacity factor data (World Nuclear Association 2018). It was also assumed that Japan utilizes mostly combined-cycle natural gas plants with a heat rate of 7,870 British thermal units (Btu) per kilowatt hour (kWh). Estimated displacement data is detailed in the Appendix, Tables A1-A5.

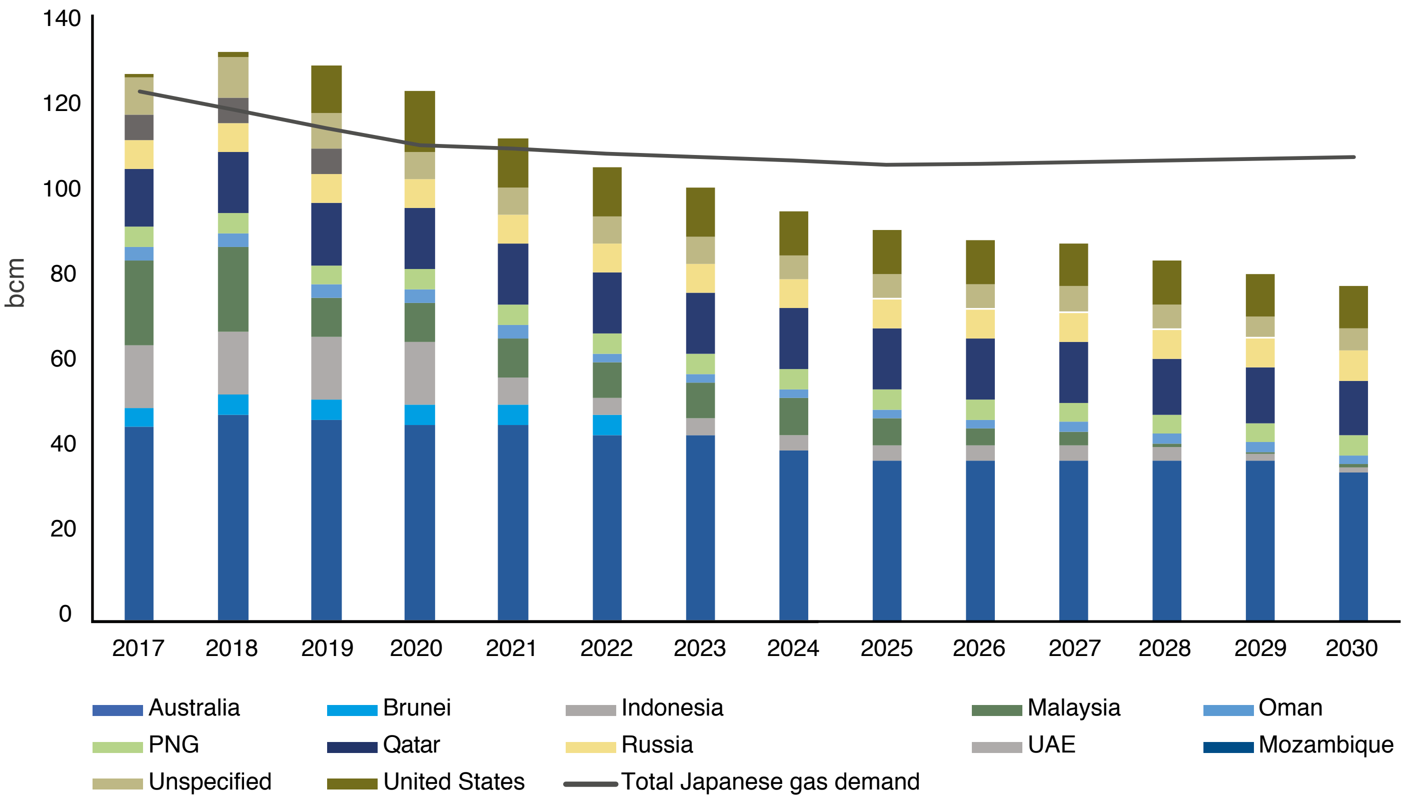
Figure 2 displays the comparison in Japanese gas demand between WGM's base case scenario and the KTAB-derived scenario. Although both KTAB and WGM project very similar gas demand profiles by 2030, the pace of restarting reactors based on the KTAB simulation shows a more front-loaded nuclear comeback, and therefore more LNG displacement in the short to medium term.

Comparing projected market effects when accounting for political feasibility

As Japan remains tied to long-term fixed-destination LNG contracts, a rapid displacement of LNG would be challenging. Figure 3 shows that the volume of LNG contracted by Japan far exceeds new gas demand. The oversupply is expected to last until 2021, when the majority of existing contracts are up for renewal and Japanese offtakers have leverage when negotiating new terms for future supplies. Until then, if the KTAB simulation is correct, the Japanese utilities need to find ways to manage excess LNG supplies to accommodate displacement by nuclear power.

The consequences of this overcommitment of LNG have started to prompt Japanese power utilities to rethink their near-term LNG requirements (Energy Intelligence 2019). Eight out of the nine reactors that have come online thus far have been concentrated in the southwestern part of Japan, forcing Kansai Electric and Kyushu Electric, the two utilities in the region, to deal with excess volumes of LNG. The

Figure 3. Contracted LNG by source and LNG demand under KTAB, Japan, 2017 - 2030.



Notes: PNG = Papua New Guinea; UAE = United Arab Emirates.
Sources: WGM, KTAB.

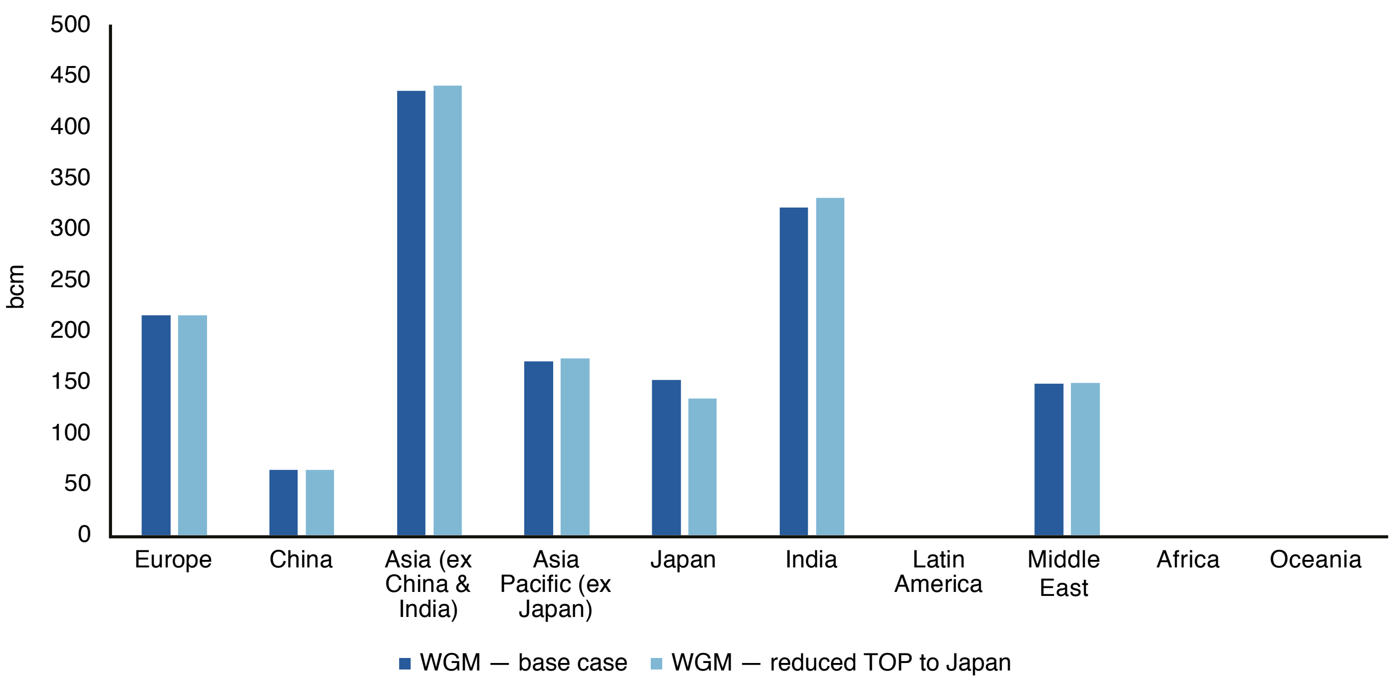
problem lies with the more rigid, long-term, contracts where take-or-pay (TOP) obligations are high and destination clauses are in place, forcing offtakers to lift the cargoes without the ability to divert them elsewhere. Incorporating new Japanese demand, based on KTAB-based inferences for WGM, while keeping TOP constraints unchanged, can generate unrealistically low shadow prices between 2018 and 2021 for Japanese-bound LNG cargoes as the model tries to signal unwanted cargoes.

One solution to meeting the new lower gas demand is for the Japanese utilities to renegotiate the off-take agreements by relaxing TOP requirements from sellers such as Qatar, Australia, Malaysia, Indonesia and Russia. Contract renegotiations have happened in the past, more recently with Indian offtakers renegotiating terms with Qatar, in which the latter demonstrated some willingness to revisit and amend certain contracts during the spot price collapse of 2015 (The Economist 2015). By contrast, several other utilities have contracted with United States (U.S.)-based LNG suppliers, which have been offering more flexible, destination-free contracts (i.e., the LNG offtakers have the choice to resell the cargoes elsewhere). LNG exports from the new and flexible U.S. contracts started flowing in 2016 and have emerged as one of the most competitive LNG sources due to the availability of cheap gas supplies and its low-cost liquefaction plants. In the United States about 38 billion cubic meters (bcm) of nominal liquefaction capacity had come online by the end of 2018, and it is projected to continue its growth to 98 bcm by 2022, according to WGM. Two scenarios were tested to assess the impact of the KTAB analysis on LNG flows and prices.

The first scenario assumes relaxing the Qatari TOP requirements of existing LNG contracted to Japan, which amounts to 15.8 bcm, by 10%. The second scenario gives the Japanese offtakers the option to divert or resell the U.S. cargoes (which would be optimally determined by the model). According to WGM's database (March 2018), Japanese offtakers have contracted about 15 bcm of LNG (or around 11 million tonnes per annum) from the U.S. that are destined for Japan by default.

As expected, the results from the first scenario, shown in Figure 4, demonstrate that flows into Japan from Qatar have been reduced now that Japanese utilities have some leeway to accommodate the displacement by nuclear power. Cumulative LNG flows from Qatar to Japan between 2018 and 2030 decrease by about 18 bcm – reducing not just the contractual volumes compared with the base case but also spot deliveries from Qatar to Japan. Interestingly, with spare LNG spot cargoes from Qatar, the model sends more cargoes to India and other countries in Asia. Although gas demand is exogenous to the model, WGM allows adjustments based on the prices of competing fuels. Qatari LNG, in this case, is seen as a much cheaper option for India to displace oil for feedstock and other industrial applications.

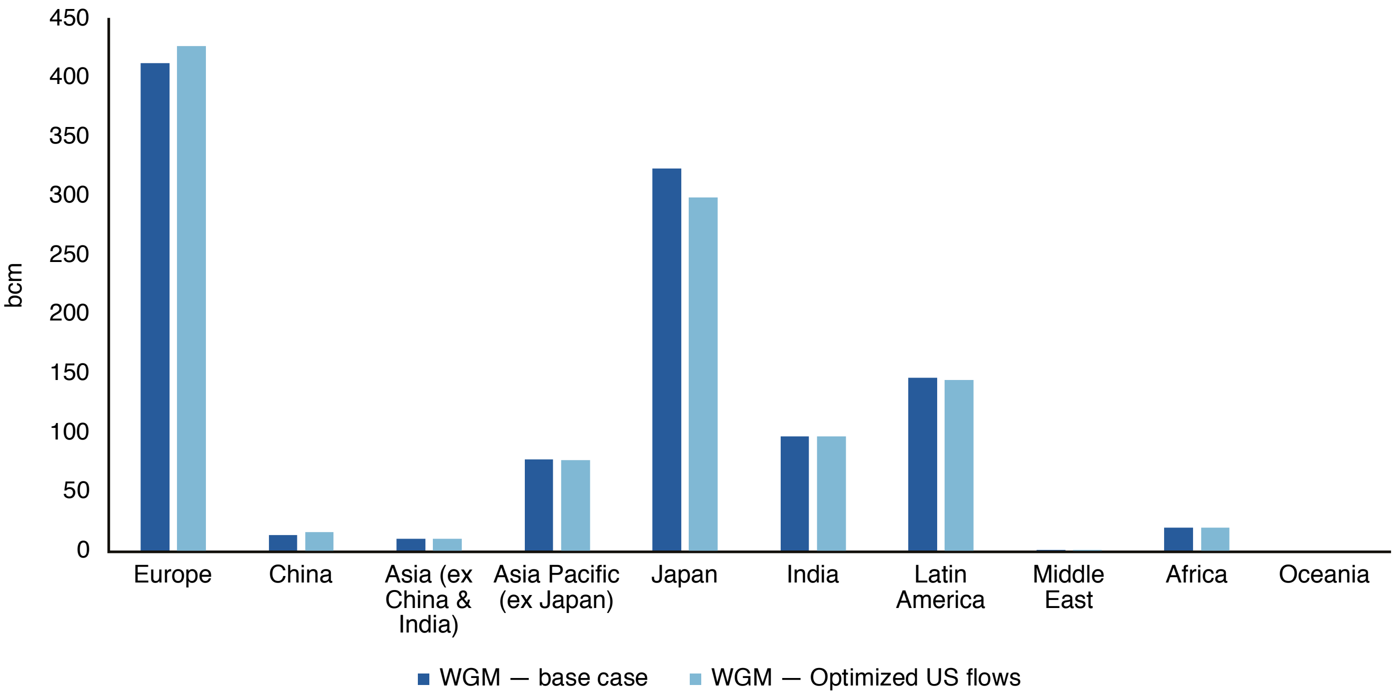
Figure 4. Cumulative LNG flows by destination, Qatar, 2018 - 2030.



Note: ex = excluding.
Sources: KTAB, WGM.

In the second scenario, which allows Japanese offtakers to exercise the option of diverting cargoes elsewhere, almost all of the displaced U.S. cargoes from Japan are diverted to Europe, as shown in Figure 5. This is expected, as Europe is widely known to be the market of last resort for its ability to absorb surplus global LNG. This is because Europe has spare LNG import capacity and the ability for LNG to substitute for alternative fuels and imported pipeline gas. This was demonstrated in the winter of 2018/19 when large volumes of U.S. LNG were diverted to Europe from Asia due to low demand and subsequent price falls in Asia (Jaganathan 2019).

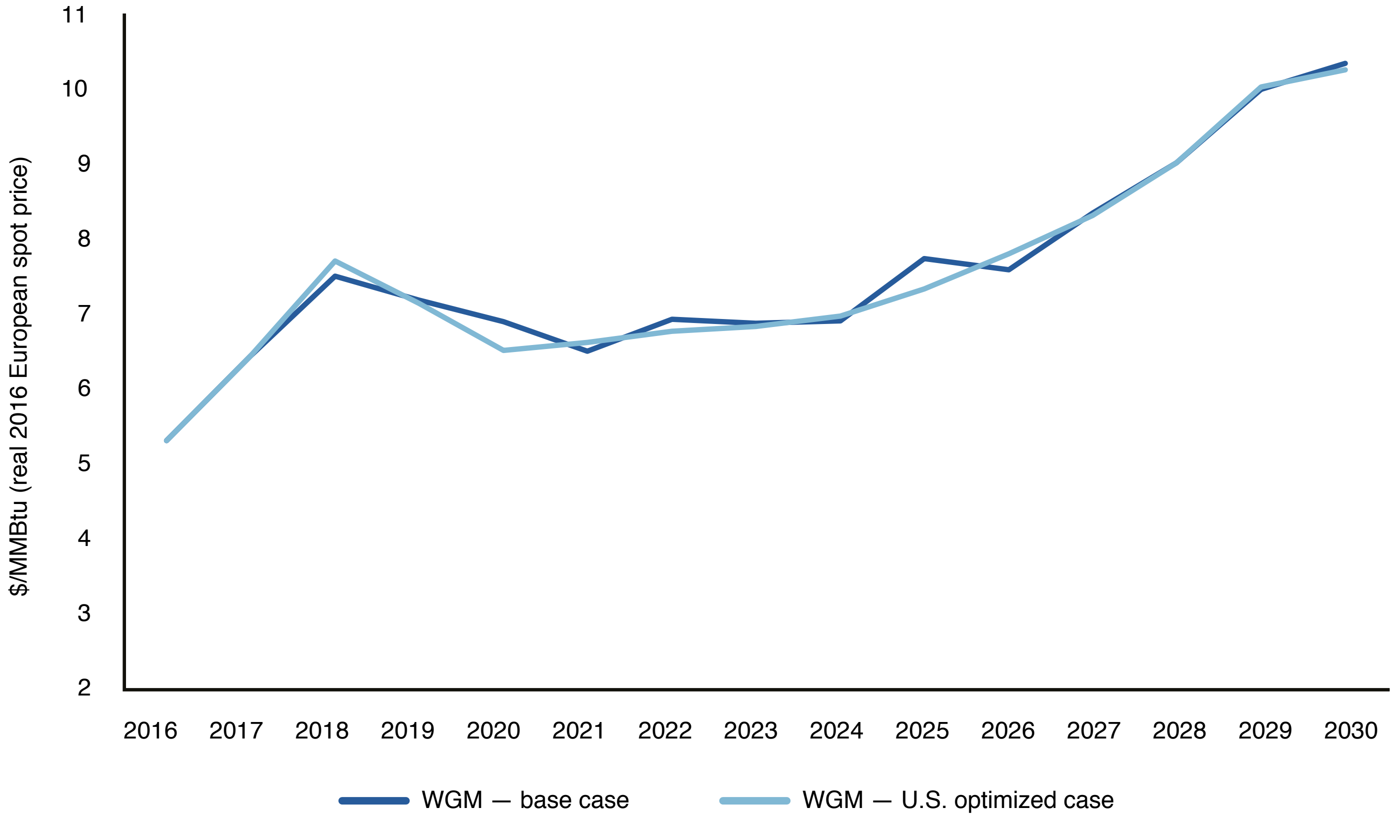
Figure 5. Cumulative LNG flows by destination, U.S., 2018-2030.



Sources: KTAB, WGM.

Compared with the WGM base case scenario, regional spot prices produced by KTAB inputs are almost identical in both the relaxed Qatari and U.S. cases. Since the difference in nuclear restart assumptions is small, this translates into a peak of 5 bcm difference in gas demand in a single year (2020). The most extreme movement in prices is seen in European spot prices under the U.S. optimized flows case versus the base case in WGM. As Figure 6 shows, the European market, on average, benefits from the displaced LNG cargoes from Japan, albeit slightly, as the surplus volumes imported into Europe put downward pressure on prices, especially from 2018 to 2025.

Figure 6. LNG spot prices, Europe, 2016-2030.



Note: MMBtu = million British thermal units.
Sources: KAPSARC, Nexant WGM.

Conclusions

Nuclear power in Japan remains a highly contentious issue. One of the most important constraints to restarting reactors is political sentiment at the municipal and prefectural level. While Asian prices for LNG have dropped significantly from the historically high levels between 2011 and 2014, Japanese officials may have other motivations behind restarting nuclear reactors beyond the economic calculus. Considerations such as providing local economies with cheaper energy and high-paying jobs at nuclear power plants, reducing emissions in order to meet the country's commitments under the Paris Agreement, in addition to energy security, may all prove to be of higher importance. This is balanced against strong public opinion against nuclear power. Nevertheless, KTAB simulations suggest that the political sentiment favoring nuclear power is expected to grow over time, including in key prefectures and municipalities, supporting the Japanese government's plans for nuclear energy to regain its place as a major component of Japan's energy equation.

After modeling the evolving political will to restart the reactors, results point toward an increasing political feasibility for a more rapid restart of reactors when compared with the WGM model's base case scenario. By combining the inferences from the KTAB simulation with Nexant's WGM model, it was found that rapidly restarting nuclear reactors in the short term may be challenging due to the utilities' overcommitment of LNG contracts up to 2021.

However, given the flexibility of U.S. contracts, diverting U.S. LNG cargoes during the period 2018-2021 provides Japan with significant 'wiggle room' to restart more reactors. Utilities that have not contracted with U.S. LNG suppliers may have to succumb to renegotiating the more rigid contracts to allow for the resale or the reduction of LNG offtake to properly accommodate for nuclear restarts.

The surplus of LNG can be absorbed by Europe or Asia depending on the source, and we could see a slight softening of European prices if low demand for LNG in Japan leads to a diversion of U.S. cargoes to Europe.

As the future of gas markets continue to develop, it will be useful to monitor this evolving situation as it progresses. For Japan, however, it appears that a nuclear comeback is on the horizon – bringing the country greater energy security in addition to giving it a fighting chance of achieving its environmental commitments. While this study presented possible options, exactly how Japanese utility companies intend to address the decrease in gas demand, despite their contractual obligations, remains to be seen.

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Notes

Appendix

Table A1. Operational reactors.

NPP/Reactor	Capacity (gross MWe)	Operation factor	Nuclear generation restart (kWh)	Gas displaced in bcm/y equivalent
		10-yr avg. (2001-10)		
Sendai-1	890	83.62%	6,519,349,680	1.40843519
Sendai-2	890	84.35%	6,576,263,400	1.42073079
Ikata-3	890	86.74%	6,762,597,360	1.46098623
Takahama-3	870	77.78%	5,927,769,360	1.28063064
Takahama-4	870	83.47%	6,361,415,640	1.37431525
Total			**32,147,395,440**	**6.94509810**

Notes: avg. = average; bcm/y = billion cubic meters per year; MWe = megawatt electrical; NPP = nuclear power plant; yr = year.

Table A2. Short-term reactors.

NPP/Reactor	Capacity (gross MWe)	Operation factor	Nuclear generation restart (kWh)	Gas displaced in bcm/y equivalent
		10-yr avg. (2001-10)		
Ohi-3	1,180	75.08%	7,760,869,440	1.67665215
Ohi-4	1,180	85.74%	8,862,772,320	1.91470638
Tsuruga-2	1,160	71.95%	7,311,271,200	1.57952130
Higashidori-1	1,100	81.33%	7,836,958,800	1.69309043
Shika-2	1,206	63.65%	6,724,342,440	1.45272167
Genkai-3	1,180	86.31%	8,921,692,080	1.92743536
Genkai-4	1,180	85.10%	8,796,616,800	1.90041419
Shimane-2	820	73.00%	5,243,736,000	1.13285261
Tomari-1	579	85.47%	4,335,072,588	0.93654568
Tomari-2	579	81.03%	4,109,874,012	0.88789396
Tomari-3	912	91.55%	7,314,039,360	1.58011933
Total			**77,217,245,040**	**16.68195306**

Table A3. Medium-term reactors.

NPP/Reactor	Capacity (gross MWe)	Operation factor	Nuclear generation restart (kWh)	Gas displaced in bcm/y equivalent
		10-yr avg. (2001-10)		
Kashiwazaki-Kariwa-6	1,356	63.50%	7,542,885,600	1.62955909
Kashiwazaki-Kariwa-7	1,356	62.25%	7,394,403,600	1.59748115
Tokai-2	1,100	71.65%	6,904,194,000	1.49157666
Onagawa-2	825	67.75%	4,896,292,500	1.05779119
Mihama-3	826	65.11%	4,711,203,336	1.01780467
Takahama-1	826	85.35%	6,175,721,160	1.33419796
Takahama-2	826	77.22%	5,587,453,872	1.20710915
Total			**43,212,154,068**	**9.33551987**

Table A4. Long-term reactors.

NPP/Reactor	Capacity (gross MWe)	Operation factor	Nuclear generation restart (kWh)	Gas displaced in bcm/y equivalent
		10-yr avg. (2001-10)		
Ohma	1,383	90%	10,903,572,000	2.35559914
Hamaoka-3	1,100	72.32%	6,968,755,200	1.50552441
Hamaoka-4	1,137	75.48%	7,517,898,576	1.62416091
Total			**25,390,225,776**	**5.48528446**

Table A5. Cumulative displacement.

Total figures				
	Operational	**2018-2020**	**2020-2025**	**2025-2030**
Nuclear generation restart (kWh)	32,147,395,440	77,217,245,040	43,212,154,068	25,390,225,776
Gas displaced in bcm/y	7	16.7	9.3	5.5
Cumulative gas displacement (bcm/y)	7	23.6	33	38.5

About the Authors

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About the Project

KAPSARC has developed the KAPSARC Toolkit for Behavioral Analysis (KTAB), an open source software platform, to support modeling and analysis of collective decision-making processes (CDMPs). KTAB is intended to be the standard platform for analyzing bargaining problems, generalized voting models and policy decision-making. It is our intent to use KTAB to assemble the building blocks for a broad class of CDMPs. Typical models in KTAB will draw on the insights of subject matter experts regarding decision-makers and influencers in a methodical, consistent manner; and then assist researchers to identify feasible outcomes that are the result of CDMPs.

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