

THE GEOPOLITICS OF ENERGY PROJECT

THE GEOPOLITICS OF NATURAL GAS

REPORT OF SCENARIOS WORKSHOP OF HARVARD UNIVERSITY'S
BELFER CENTER AND RICE UNIVERSITY'S BAKER INSTITUTE
ENERGY FORUM

CO-DIRECTORS

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energyforum
James A. Baker III Institute for Public Policy • Rice University

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Statements and views expressed in this report are solely those of the authors and do not imply endorsement by Harvard University, the Harvard Kennedy School, or the Belfer Center for Science and International Affairs.

ACKNOWLEDGEMENTS

We are grateful to the participants of the workshop and to all those who have assisted in preparing this report. Our special thanks to workshop facilitator Wim Thomas, Chief Energy Advisor for Shell International, and workshop rapporteurs Keily Miller, Jonas Meckling, and Likeleli Seitlheko.

NOTE

Readers should note that while this report is broadly supported by all workshop participants, only the directors are responsible for the specific wording of the global scenarios described below. Individual participants may disagree with one or more of the events that comprise these scenarios.

INTRODUCTION

Some of the most dramatic energy developments of recent years have been in the realm of natural gas. Huge quantities of unconventional US shale gas are now commercially viable, changing the strategic picture for the United States by making it self-sufficient in natural gas for the foreseeable future. This development alone has reverberated around the globe, causing shifts in patterns of trade and leading other countries in Europe and Asia to explore their own shale gas potential. Such developments are putting pressure on longstanding arrangements, such as oil-linked gas contracts and the separate nature of North American, European, and Asian gas markets, and may lead to strategic shifts, such as the weakening of Russia's dominance in the European gas market.

Against this backdrop, the Energy Forum of Rice University's James A. Baker III Institute for Public Policy and the Geopolitics of Energy Project at Harvard University's Kennedy School have launched a two-year study on the geopolitical implications of natural gas. The project is co-directed by Amy Myers Jaffe and Meghan O'Sullivan and brings together experts from academia and industry to explore the potential for new quantities of conventional and unconventional natural gas reaching global markets in the years ahead. The effort draws on more than 15 experts on producer and consumer countries who will assess the prospects for gas consumption and production in the country in question, based on anticipated political, economic, and policy trends. Building on these case studies, the project will formulate different scenarios and use the Rice World Gas Trade Model to assess the cumulative impact of country-specific changes on the global gas market and, more broadly, on geopolitics.

On May 9-10, 2012, the Geopolitics of Natural Gas study held its third workshop to develop scenarios for the geopolitics of natural gas.¹ At this gathering, the members of the two-year project met at Rice University's James A. Baker III Institute for Public Policy in Houston. The two-day session brought together experts on major gas producing and consuming countries, economists specializing in gas trade modeling, and industry representatives. On day one of the workshop, the group explored the dynamics of the politics and economics of gas in major world regions. The discussion helped participants better understand trends and links between regions.

¹ To access research presentations from the previous workshops, see "The Changing Geopolitics of Natural Gas," James A. Baker III Institute for Public Policy, Rice University, Houston, Texas, <<http://www.bakerinstitute.org/programs/energy-forum/research/the-changing-geopolitics-of-natural-gas-the-rise-of-unconventional-gas-and-its-implications-for-global-natural-gas-markets-geopolitical-relations-and-u.s.-energy-security>>.

On day two, Wim Thomas, Chief Energy Advisor of Shell, facilitated a scenario planning exercise on the future of natural gas, looking at the time horizons to 2015, 2020, and 2030. Participants developed four global scenarios. The scenario planning exercise offered critical insights into distinctly different trajectories for the future of gas markets. Over the next year, the research team will refine these global scenarios.

This report proceeds as follows: First, we present key results of a preliminary reference scenario offered by the Rice World Gas Trade Model (RWGTM). This reference scenario includes inputs developed at prior study workshops. The reference scenario offers initial insights into changes in natural gas trade flows that might come about in the coming decades based on a projection of current and expected geopolitical factors. Then the report offers four global scenarios, which differ along two dimensions: the level of success of bringing unconventional gas to the market and the level of liberalization of global gas trade. These scenarios are the result of two days of deliberations about the changing geopolitics of natural gas and their impact on market and pricing. This report reflects parts of the discussion of the expert group to stimulate discussion on the topic. It is not meant to provide a comprehensive treatment of global gas politics and markets.

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REFERENCE SCENARIO

The past decade has yielded substantial change in the natural gas industry. Specifically, a rapid development of technology has allowed the recovery of natural gas from shale formations. Since 2000, strong growth in the production of natural gas from shale formations in North America has dramatically altered the global natural gas market landscape, with significant implications for liquefied natural gas (LNG) suppliers and the geopolitics of energy.

Utilizing the Rice World Gas Trade Model (RWGTM), we have constructed a reference scenario that quantifies the impacts of geopolitical influences on the development of a global natural gas market within a framework grounded in geologic data and economic theory. The RWGTM is a dynamic spatial general equilibrium model that evaluates commercial criteria under a defined set of geopolitical and other constraints, keeping supply and demand balanced at each location in each time period such that all spatial and temporal arbitrage opportunities are eliminated.

The model, therefore, probes and develops resources, constructs transportation routes and associated infrastructure, and calculates prices to equate demands and supplies while maximizing the present value of producer rents within a competitive framework. New infrastructure must earn a minimum return to capital for its development to occur. The RWGTM, therefore, evaluates commercial criteria under a defined set of geopolitical and other constraints to develop supplies, pipeline transportation routes, and LNG delivery infrastructure. Thus, the model provides a framework for examining the effects of critical economic and political influences on the global natural gas market within a framework grounded in geologic data and economic theory.

Since geopolitical influences can alter market outcomes in many different ways, the non-stochastic nature of the RWGTM facilitates analysis of multiple scenarios and allows the model to characterize how events alter current and future investment decisions. In this way, the inter-temporal nature of the RWGTM allows a complete analysis of the impact on investment decision pathways of specific scenarios. This follows from the fact that capacity and reserve expansions are determined by current *and* future prices along with capital costs of expansion, operating and

maintenance costs of new and existing capacity, and revenues resulting from future outputs and prices.²

Knowledge of the shale gas resource is not new. Geologists have known about the existence of shale formations for years but accessing those resources was long held to be an issue of technology and cost. In the past decade, innovations have yielded substantial cost reductions, making shale gas production a commercial reality. In fact, shale gas production in the United States has increased from virtually nothing in 2000 to more than 10 billion cubic feet per day (bcfd) in 2010. Rising North America shale gas supplies have significantly reduced US requirements for imported LNG and contributed to lower US domestic natural gas prices. The natural gas supply picture in North America will have a ripple effect around the globe that will expand over time, not only through displacement of supplies in global trade but also by fostering a growing interest in shale resource potential in other parts of the world.

The importance of the commercialization of shale cannot be understated from a geopolitical, environmental, or market development perspective. Given the assumption that known shale gas resources will be developed according to their commercial viability in North America and elsewhere, the reference scenario projects shale gas production could more than quadruple over the next two decades, accounting for over 50 percent of total US natural gas production by the early 2030s. Still, the countries of the former Soviet Union will collectively be the largest supplier of natural gas (conventional and unconventional) by 2040, with North America a close second. The reference case anticipates the strongest supply of shale gas will be in North America, where the recoverable shale resource comprises more than a quarter of the world's 4,024 trillion cubic feet (Tcf) and is rivaled in size only by the shale plays in Asia and Oceania.

These supply trends will have a significant impact on gas trade flows. Not only will the United States be able to avoid growth in LNG imports for the next three decades, but the reference case projects that North America will export 720 million cubic feet per day of LNG by 2030. Australia will rival Qatar as the world's largest LNG exporter by 2030. Qatar and Australia will remain the

² For more detailed information about the model, see "Shale Gas and US National Security," James A. Baker III Institute for Public Policy, Rice University, Houston, Texas, <<http://www.bakerinstitute.org/programs/energy-forum/publications/energy-studies/shale-gas-and-u.s.-national-security>>

largest LNG exporters through 2040, collectively accounting for about 40 percent of global LNG exports.

LNG supplies whose development was anchored to the belief that the United States would be a premium market will continue to be diverted. In the reference case, the US market remains the lowest priced major market region in the world throughout the model time horizon. Many US terminals once expected to be actively utilized will remain relatively empty. During the period from 2013 to 2015, US terminals see some growth as new volumes from Australian LNG development push African LNG cargoes to the US market—a trend exacerbated by growth in LNG supply from West Africa in the 2014-2015 period.

The reference case projects that consumers in Europe will receive a double benefit from the rise in global gas supply. Not only will Europe increasingly find alternatives to Russian pipeline supplies, but these alternative supplies will exert pressure on the status quo of indexing gas sales to a premium marker determined by the price of petroleum products. In fact, Russia has already had to accept lower prices for its natural gas and is now allowing a portion of its sales in Europe to be indexed to spot natural gas markets, or regional market hubs, rather than oil prices. This change in pricing terms signals a major paradigm shift.

Yet as Europe moves to gas-on-gas pricing, global marker prices in the reference scenario fail to converge through 2040. Europe's price premium will hover at more than \$1 above Henry Hub prices, even as Europe develops its own shale resource and diversifies sources of supply.

Shale gas eventually makes up 20 percent of European market. European shale gas production begins in earnest in 2020s, and approaches 20 percent of the total market by 2040. LNG import growth is the second fastest growing source of European supply. The availability of shale gas under the reference case means that Caspian flows will not make economic sense as a competing supply to Europe. The Nabucco pipeline project, for example, is not constructed until lower-cost Iraqi gas is able to flow into the line.

Under the reference case, the major growth opportunity for LNG exports emerges, with booming gas demand in China and India. Both countries have limited domestic natural gas resources, meaning projected demand growth must be met by imports. In Asia, the growing dependence on LNG renders markets less competitive to price pressure from shale gas. China may try to use its commercial leverage in Australian commodity markets to gain better price terms for its LNG

purchases, but, significantly, Asian spot prices are projected in the reference case to maintain a premium of over \$2 above Henry Hub prices.

China becomes a major importer of natural gas via LNG under the reference case. In fact, China is the largest driver of growth in LNG trade. Like the United States, China benefits from growing shale gas production. However, its lowest cost shale gas resources are not sufficient to match projected demand growth, meaning that it still becomes increasingly reliant on LNG imports. The sources of supply for LNG to China are diverse, with Qatar and Australia being the largest sources of incremental supplies to meet burgeoning Chinese demand.

In terms of global demand, natural gas will replace coal as the greatest fuel component of the world's total primary energy required (TPER) by 2040. Global gas demand will nearly double between 2012 and 2040. Asian demand, particularly from China and India, sets the trend for global natural gas demand growth, surpassing North America as the largest gas consuming region by 2030. In both China and India, growth in natural gas demand will outpace growth in demand for any other fuel source, comprising more than 15 percent and 13 percent respectively of domestic TPER by that same year. These countries will also represent the major growth opportunity for LNG exporters. China will grow increasingly dependent on LNG imports, passing Japan as the largest importer in the mid-2020s. India approaches China's LNG import volumes by 2040.

Under the reference case, the global LNG market proves to be diverse and competitive, with available supplies not concentrated in any one geographical region. This diversity, along with the availability of large supplies of shale gas, will limit the possibility of a successful collusion among suppliers. In effect, the elasticity of supply of natural gas in countries outside the Gas Exporting Countries Forum (GECF) is very large, which is a pivotal factor in reducing the monopoly power that can be exerted by a coalition of countries within the GECF countries. In addition, global requirements for natural gas exports from the Middle East do not rise dramatically for many years, limiting the commercial market opportunities for Iran, Iraq, or Saudi Arabia to develop substantial gas export operations for the next two decades.

GLOBAL SCENARIOS

At the Houston workshop, the group of country experts, economic modelers, and industry representatives brainstormed four scenarios for the future of gas markets. Unlike the reference scenario described above, these scenarios have not been generated with the use of the model, but instead through a scenario planning exercise. These scenarios vary along a grid with two dimensions: low vs. high success in developing unconventional gas (UCG) and low vs. high levels of market liberalization and integration.

		Success of Unconventional Gas	
		High	Low
Liberalization	High	Scenario 1	Scenario 3
	Low	Scenario 4	Scenario 2

Scenario 1 envisions a world with an extensive global shale gas revolution and highly liberalized and increasingly integrated global gas market (high success of UCG/high liberalization). Scenario 2 paints a world where development of shale gas remains relatively limited and gas markets remain segregated to national or regional boundaries (low success of UCG/low liberalization). Scenario 3 imagines a future of gas markets in which the shale gas revolution stalls, but overall liberalization of gas markets continues to spread globally (low success of UCG/high liberalization). Finally, Scenario 4 sees a world where shale resources are comprehensively developed where they are located but in the absence of expanded market liberalization, and where national and regional markets remain segregated and there is no movement toward global market integration (high success of UCG/low liberalization). For each of these scenarios, participants looked at two time horizons: 2012 to 2020 and 2020 to 2030.

In building these four scenarios, we acknowledge the possibility of new, game-changing uncertainties, which have been a constant theme in global energy markets over the past several decades. The transformative results of the breakthroughs in shale technology were not anticipated in the 1990s, and it is very difficult to predict what technological breakthroughs we may see going forward. Variance is the most important element in forecasting, and there are an infinite number of uncertainties that cannot be captured in a forecasting model. Interdependence is a key to the geopolitics of gas, and policy questions depend chiefly on market events and their feedback effects. The different storylines presented below were designed to help study participants consider the variety of uncertainties and their interactive effects given the highly reactive nature of interdependent global gas markets.

SCENARIO 1: HIGH UCG SUCCESS, HIGH LIBERALIZATION

We begin Scenario 1 with global gas producers feverishly developing unconventional gas resources. In the United States, recent Environmental Protection Agency (EPA) regulations restricting coal use are taking their toll, and public distress in anticipation of high electricity prices has pushed environmental concerns about hydraulic fracturing out of the national debate. The state economies of Pennsylvania, Ohio, North Dakota, Wyoming, New Mexico, Oklahoma, Texas, Louisiana, and even Florida are experiencing breakneck growth as the drilling industry brings about jobs and new sources of state revenue, creating constituencies in support of expanded investment. Tumbling natural gas prices in the oversupplied US market are driving a national manufacturing boom. Protectionist policies are philosophically on the wane in the United States, and so politicians do not move to block LNG exports from the United States. But the opportunities for sales of US LNG to Europe are constrained by intense competition for market share among global gas suppliers in the face of declining EU energy demand given depressed economic conditions and already established renewable energy inputs.

Indeed, on the other side of the Atlantic, Europeans are observing the US manufacturing boom with envy. Frustrated citizens in France and the United Kingdom take to the streets in protest over high electricity prices and slow industrial growth. Crowds across the continent follow suit, shouting their disgust over energy market distortions that leave Europe's cost of living and economic competitiveness at the mercy of weather conditions and Kremlin politics. As elections in the United Kingdom and France roll around, lawmakers respond to public pressures by further liberalizing energy markets, reversing anti-fracking legislation and stripping away remaining

vestiges of expensive renewable subsidies that are becoming increasingly difficult to justify in difficult economic times. Germany and Bulgaria follow suit, and shale production slowly rises in Germany, Poland, the United Kingdom, and Eastern Europe, closing the arbitrage window for proposed LNG shipments from the United States to Europe and lowering the demand for Russian pipeline imports. Europe's largest energy firms—EON, RWE, ENI, and Gaz de France— begin to recognize Gazprom's dwindling leverage over the European market. UK pipeline gas exports to the European continent reemerge and competition among gas suppliers in Europe intensifies. As local shale production and African LNG increasingly offer a counterweight to Russia, arbitration between Gazprom and the European firms over pricing reaches an unexpected conclusion: Gazprom capitulates. Trading hubs emerge, driving Russia toward gas-on-gas pricing and, much to Putin's displeasure, gas market privatization takes hold not only in Europe but looks poised to take place inside Russia itself.

The tremendous success of North America's shale industry has also ignited Argentina's economic imagination. As Bolivia descends into a bloody civil war that pins the military against drug trafficking organizations and militiamen with purported ties to the Shining Path, Argentina is suffering the consequences of energy dependency. Two recent pipeline blasts have temporarily cut off supplies of Bolivian gas. President Cristina Kirchner, having consolidated her populist reputation through the expropriation of the YPF, must act decisively. With a little extra capital from Chinese investors, she stages a swift and discreet return to her free market roots, relaxing local content rules and price subsidies for unconventional gas producers. Foreign investment in Argentine shale pours in with renewed confidence, and unconventional gas production quickly begins to offset the Bolivian losses. With pipeline infrastructure in the Southern Cone poised for Argentina's development as a regional gas exporter, surpluses of natural gas find a ready home in South American markets. Even Bolivia begins to import Argentina's gas, reversing the flow of the existing pipeline.

Amidst the proliferation of global gas players, it is China, not Europe, that is grabbing the attention of major LNG exporters. With Western hemisphere supply booming and the European economy still in the doldrums, China has a plethora of LNG supplies to choose from and therefore is less concerned about quickly producing its own domestic share resources. China seems now willing to increase its dependence on international natural gas markets, especially in light of rising supplies from Australia and Argentina, yet is still forging ahead with plans for alternative energy and conservation policies. China's regulators are working to put in place new

market-oriented domestic pricing policies and infrastructure investments to prepare for the wider development of its own shale resources, but Chinese planners recognize that it will take time to construct the pipeline and storage infrastructure necessary for the development of accessible competitive markets. China inks long-term LNG contracts with every new source it can get its hands on, utilizing infrastructure projects and LNG contracts as a means to forge alliances with border states and high risk, high reward markets in East Africa and Latin America.

Even with the traditional contract structure still in place, Asian markets are benefitting from the downward trend in gas prices. China finds some competition for LNG supplies from Japan, which is phasing out its fleet of nuclear facilities due to long-term safety concerns and related public opposition to nuclear power. Buyer competition in Asia means that Asian gas sellers can still attain a security premium based on traditional oil-linked contracts, given ongoing uncertainty about the Middle East. But natural gas prices and perceptions of ample long-term supplies from outside the Middle East are still attracting new buyers to natural gas. As a result, oil demand has failed to grow as fast as anticipated in Asia, as natural gas has eaten away at oil's end-use markets by serving as a substitute fuel for regional electric power and industrial sectors. Problems in the Middle East are similarly laying the groundwork for future demand destruction as consuming countries seek to shield themselves from unrest in the Persian Gulf by instituting new transportation policy initiatives that include alternative fuel vehicles and increased land use planning and public transportation. Part and parcel to these new policies is the institution of carbon taxes in the US, Europe, and China, which are increasingly willing to tackle the challenge of climate change, given a generational shift in attitudes about the environment.

The year is now 2020, and the Middle East alone has not benefitted from the success of global unconventional gas markets. Rising gas production and exports have transformed markets across Europe, North America, and Latin America. Russian industry privatization is gaining momentum as regions are becoming more autonomous from the Kremlin, whose grip is waning in the face of falling oil and gas revenues. The decentralization of power inside Russia is contributing to regional industry restructuring and pricing reforms. With new sources of natural gas pouring in from around the world, the industry is seeing renewed consolidation, but analysts say the bottom is nearing as new centers of demand for natural gas are growing rapidly, helped along by carbon pricing.

New transportation policies promoted during the last decade based on insecurity about Middle East supplies are now taking hold, and more and more US vehicle fleets are shifting to natural gas. China is also turning to natural gas for buses and trucks. Japan, with its penchant for the high-tech, has developed exports of natural gas vehicles, and Japan and Argentina are seeing more and more natural gas cars on the road. These vehicles find a ready market in China, whose shale gas sector looks poised to rival that of the United States. China's infrastructure and storage projects, planned a decade earlier, are reaching completion, and local governments and their state energy enterprises have succeeded in wresting authority from the national oil companies (NOC). China's free market economic concepts have been accompanied by greater political freedoms and democracy across the country, and regional political leaders are increasingly being elected to office through local elections or town meeting frameworks. Regional politicians are more assertive about their autonomy from Beijing and a more federal system is emerging. This changing political scene is driving more localized investment in shale resources. The regions have brought local entrepreneurs together with foreign investors for more active exploitation of the country's shale resources. Thus, the scale-up of China's shale production has progressed at a rapid pace. The increased interest in investment in the resources of water-scarce China has led to technology breakthroughs including breakthroughs in waterless fracking and gasification of in-situ coal.

Technological breakthroughs have also taken place in tight oil development; even though oil is ceding share to natural gas in many markets, Western tight oil producers are still able to be profitable at lower oil prices through cost cutting and improved drilling techniques. Overall, demand destruction has, generally speaking, hit oil producers in the Persian Gulf the hardest of all by leaving gaping budget deficits driven by rising populations and falling oil revenues. Saudi Arabia has drawn down its foreign assets. Four of the six Gulf Cooperation Council (GCC) states—Saudi Arabia, Kuwait, the United Arab Emirates, and Oman—have had no choice but to cut fuel subsidies and public sector wages. Spending reforms have driven inflation, food shortages, and high unemployment. The celebrated mega-projects of the previous two decades have come to a definitive standstill, a throwback to 2000s recession-era Dubai. This time, though, the recession is sprawled across the Middle East. Civil unrest has been fragmented so far, but the coincident deaths of Oman's Sultan Qaboos and Saudi Arabia's newly appointed king smell of conspiracy. A dual succession crisis erupts, and both countries descend into violence bordering on civil war, with spillover effects across the region. The outbreak of conflict in the Persian Gulf

region accelerates the global switch to electrification of vehicles, further encouraged by the US, Europe, and China through the implementation of carbon pricing policies. This time around, commentators are talking about a final transition away from oil to natural gas and eventually to renewable energy as the main sources to drive economic activity in the coming decades.

SCENARIO 2: LOW UCG SUCCESS, LOW LIBERALIZATION

Scenario 2 opens with a series of ill-fated events that spell a troubling future for global gas markets. We begin, once again, in the United States, where the EPA has found itself tied up in arbitration that is delaying the transition away from heavy reliance on coal to new combined cycle natural gas plants. With old coal plants in the throes of amortization and new coal plants facing difficulties in securing bank loans given continued regulatory uncertainties, the delay is problematic. Renewed political backlash about continued business failures and financial scandals related to solar venture capital and federal loan guarantees has inspired the 2013-2014 Congress to cut renewable subsidies by two-thirds, causing a new round of bankruptcies in the solar industry. As US domestic natural gas demand plateaus, coal plant closures and supply limitations have failed to protect the natural gas industry from exposure to downside risk. With gas prices falling below the cost of production, overleveraged gas companies are either being bought up by oil majors or following American solar companies on the path to insolvency. The industry is further set back when in the autumn of 2014, a public panic follows a succession of widely disseminated, unconfirmed reports claiming 17 recent deaths in Pennsylvania—including two elementary school children—were caused by poisoned well water. As news of the deaths hits CNN, it deals a death blow to the country's already financially shaky shale industry. EPA testing is inconclusive, but the public outcry gains so much momentum that the governor of the state authorizes a moratorium on fracking. Industry efforts to disclaim the incident as a one-off and to point to safe operations elsewhere fall on deaf ears and fracking bans are proposed in most other producing states except Texas and Louisiana. Weeks later, a major hurricane cuts gas production further, and coal plants petition to be recommissioned. Americans conclude that carbon emissions are preferable to poisoned water supplies, and the petitions are approved.

With all hopes of US-sourced LNG destroyed, Europe and Asia turn their focus to bilateral producer-consumer relationships. Iran has been successful in acquiring a nuclear weapon, which has fostered an atmosphere of permanent instability in the Middle East and fueled an increase in hegemonic behavior by Iran in the region. Iran's supreme leader is threatening to attack Qatar's

North Field, and rumors abound that Iran is behind a failed assassination attempt on the emir of Qatar. Iran has warned Qatar repeatedly to cease all production in the North Field, which it now claims is fully in its territory. All regimes in the region are under pressure, given the fall of both the Syrian and Bahraini governments and intensified regional instability. Eager to avoid war at all costs, Qatar temporarily halves its production from the field, citing technical maintenance issues, but many suspect that the action is aimed to appease Iran. The drop in production from Qatar's North Field is just one more seemingly secure source of gas temporarily knocked off the market. Europe remains locked into a regional supply system comprised of Norwegian, Russian, and Algerian gas, giving those producers leverage to charge higher and higher prices. Alternative gas supplies from Africa are either being gobbled up by desperate Asian buyers or delayed by unstable local conditions. The European market continues on the costly path of oil-linked long-term contracts and entrenched monopolies dominating wholesale markets. The sudden dearth of competition among gas exporters has blocked all political momentum toward creating a regional transport network. Russia has decided to strand Turkmen gas by denying access to pipeline transit, cutting off European consumers from a potentially significant source of supply and consolidating the dominance of Gazprom in the region.

As a consequence of rising instability in the Middle East, oil and gas prices continue to trend upwards, creating a comparative advantage for coal. Resource nationalism in Latin America is having adverse impacts on shale development in Argentina and Venezuela, and the death of Hugo Chavez sends Venezuela into political chaos. Gas and oil production are temporarily shut in. All too familiar with the power that protesters hold over their country's leaders, Argentina watches the Venezuelan unrest with trepidation. Domestic fuel subsidies have long undermined the commercial feasibility of Argentine shale development, but with elections on the horizon, political leaders are unwilling to accept the risk that subsidy reform entails. Instead, fuel prices drop. By expanding the state's subsidy regime and lowering gas prices vis-à-vis a bullish international market, the Argentine president has purchased political stability for the price of Argentina's long-term fiscal and economic health.

Meanwhile, instability in the Middle East and Latin America has forced the developing world to turn increasingly to coal. As coal consumption increases, global carbon dioxide emissions rise, but a strained gas market, coping with unexpected disruptions, offers little alternative. Asian markets are soaking up the limited remaining supply of LNG on the global market. India's share of LNG imports grows compared with other markets, but available volumes cannot keep pace

with domestic demand. As India and Japan compete for LNG, China braces for energy shortages that will slow the country's economic growth. China's government consolidates power by rallying its population around more aggressive international policies to secure energy supplies. China's uncertainty over Qatari gas supplies, previously considered a given when formulating medium-term development plans, drives China to take uncharacteristically politicized decisions. Determining that Iranian intransigence and erratic behavior are now obstructing natural gas supplies from both Iran and Qatar and under pressure from Saudi Arabia, China begins to tilt its Middle East policy in favor of the Sunni Gulf states that are responsible for the majority of its oil and gas supplies. Facing the threat of energy insecurity, China negotiates an agreement to build naval bases in Qatar and Saudi Arabia in exchange for larger oil and gas trade and investment deals; in the search for hydrocarbons, China also grows more aggressive in the South China Seas. Both developments raise tensions between the United States and China, and bilateral relations deteriorate as the two powers fail to coordinate their responses to energy supply disruptions.

By 2020, prospects for international trade are bleak, as major economies are increasingly taking protectionist economic strategies. The Middle East has descended into a series of protracted intrastate wars, pushing oil output in the region to its lowest level in decades. The existence of nuclear weapons in major Middle East countries renders the ongoing conflicts a major threat to global peace, creating an even larger war premium for oil prices. With Saudi Arabia unable to perform its role as a swing producer, oil shortages stimulate an international push away from conventional oil. Global shortages of both oil and gas have caused prices to skyrocket. Coal, cheap by comparison, continues to gain market share, but rising carbon emissions are fueling serious environmental and health-related concerns. Scientific evidence points to a conclusive link between the rise in emissions and severe droughts that have taken the lives of millions across the Southern Hemisphere over the course of the year. China uses this new scientific climate information to defend a major initiative in geo-engineering that the US suspects could be used strategically, or at a minimum might pose unintended environmental risks. China's announced program further increases tensions between the US and China. Still, the mounting evidence of climate change serves as a wake-up call for many of the world's developed economies, sparking sweeping enthusiasm for renewable energy sources and stringent carbon pricing schemes. This leads governments to launch expensive crash investment programs in clean energy, geo-engineering, and nuclear energy—the latter in particular in the US and Asia. Japan announces a

major national initiative in fourth-generation nuclear power facilities that greatly reduce the chances of nuclear weapons proliferation.

For more than a decade, Russia has been teetering on the brink of dissolution following a succession of unsuccessful authoritarian leaders in Moscow. The year 2030 delivers the final blow. No longer able to sustain internal weaknesses and mounting political dissent despite rising oil and gas income, the country collapses into a loose series of warring autonomous federations and loses all credibility as a gas supplier. Europe now finds itself stripped of its primary source of gas. Facing economic stagnation and an overstretched military, the United States launches an Energy New Deal with France that promotes micro-nuclear energy, creating competing technologies to those being launched in Japan. The program meets with some success, and nuclear energy becomes a more significant part of the energy mix in Europe, Japan, and the US. Developing economies that cannot pursue expensive nuclear programs grow more internally focused, resulting in low levels of trade and low economic growth. Global standards of living have deteriorated, and poverty is on the rise.

SCENARIO 3: LOW UCG SUCCESS, HIGH LIBERALIZATION

Local communities in the Northeast and Midwest US are growing increasingly hostile to the influx of gas developers disrupting their local infrastructure and environment. New evidence of methane leakage during gas production drives a series of grassroots environmental campaigns in several states that increase calls for fracking bans. With Northeast and Midwest communities already hostile, the campaigns are effective. A temporary ban on fracking is imposed in four states. Unconventional gas development plummets, driving Henry Hub prices above \$7 per million Btu for the first time since 2008. In order to offset the losses of domestically produced gas, the US increases pipeline gas imports from Canada.

European and Asian markets, too, turn to cross-border trade to offset higher energy prices. Unconventional supplies may be scant, but competition between conventional gas suppliers has prevented Europe and Asia from becoming captive markets. Russia sees itself as the dominant player in Europe, but its market share—and thus its leverage—is mitigated by increasing LNG deliveries from Qatar, which in turn is losing market share in Asia to Australian gas suppliers. The priority in Europe, ever wary of Russian capriciousness, is to protect its energy security through the development of a regional gas transport network and increased electricity trading and grid connections. EU leaders are growing tired of Russia's hegemony in central Europe and,

under Germany's leadership, coordinate a new regulatory framework for the construction and long-term coordination of a cross-border pipeline system. The creation of trading hubs and futures markets by the EU is gaining momentum as a pricing point. In the spirit of coordination and integration, the EU offers a declaration in support of the Trans-Caspian pipeline, and a detailed intergovernmental agreement is quickly formulated.

Furious at losing authority over Caspian gas flows and European pricing, Russian leaders once again resolve to create a "gas OPEC." Russia taps the growing sentiment regarding resource nationalism being fueled across Latin America, the Middle East, and Africa as oil and gas prices rise. Declining conventional production in North America and the North Sea increases reliance on Middle East supply, bolstering Iran's gas market share now that Iran is out from international sanctions in the wake of a diplomatic resolution to the nuclear standoff between Iran and Western powers. By 2020, an increasingly import-dependent US is seeing its global power and economy wane. China's economy is still growing, enhancing Beijing's position as a global trading partner. Against this backdrop, formal negotiations between Russia, Iran, and Qatar result in the formation of an infamous new gas cartel, underpinning both oil and natural gas prices. Russia, Iran, and Qatar become the "Saudi Arabia" of natural gas. Desperate to neutralize the pricing power of the gas oligopoly, the international community turns its focus toward promoting energy efficiency in order to moderate demand. With oil prices above \$100 per barrel and little penetration of natural gas into the transport sector, oil producing states in the Middle East have succeeded in developing some of their trickier non-associated conventional gas fields, but soaring domestic demand and an obstinate refusal to reform price subsidies have limited the gas export capacity of the GCC. Expectations are that new supplies will remain scarce, and firms begin to make bigger bets on renewable energy and carbon sequestration technologies as natural gas is no longer viewed as a reliable transition fuel.

At first, the larger Western economies scramble to uncover new sources of conventional gas in the Arctic, deepwater, and Australia. Facing the adverse impacts of tight energy fundamentals on its trade surplus and GDP growth, China aggressively pursues conventional gas projects in Latin America, Africa, and the Caspian. Ignoring commercial considerations, China presses ahead with the development of gas resources previously considered stranded assets. China's attempt to lock up many remaining resources prompts Europe and the US to rethink their own energy strategies. By 2030, reluctant to abandon liberalized markets and increasingly convinced that something must be done to stem global warming, the Organization for Economic Co-operation and

Development (OECD) makes large bets on renewable energy and coal gasification to avoid global conflict over increasingly limited conventional oil and gas resources. Western governments refuse to share new alternative energy technologies with China and Russia to try to regain the economic competitive edge in the global economy, but China, too, begins to make headway on the energy technologies it invested in back in the 2000s.

SCENARIO 4: HIGH UCG SUCCESS, LOW LIBERALIZATION

The year is 2015, and Saudi Arabia is undergoing a major leadership transition following the successive deaths of several of the kingdom's older generation leaders. As the Allegiance Council is struggling to produce a consensus over succession for key posts, interested parties release damaging corruption stories about the wide array of political leaders within the royal family vying for power. Technocrats and some conservative religious leaders start to weigh in publicly, leading to higher uncertainty about the kingdom's future leadership. The United States intensifies its calls for more aggressive political reform, hoping it will provide a better path forward, but the regime ignores such nudges, and the Saudi public grows increasingly restless. The Saudi situation encourages opposition parties in Bahrain, who finally grab power away from the ruling family there by defying Saudi military intervention and rallying calls from the international community for a peaceful transition. The success in Bahrain prompts Shi'ites in Saudi Arabia's Eastern Province to more vociferously demand greater political representation. Autonomous jihadi militias also begin to stage protests against democracy activists around the country and isolated disturbances begin to escalate and spread across the nation. Soon, Saudi Arabia is in the grips of a full blown civil war. Saudi Aramco's oil output dips only slightly at first, but even the moderate supply disruption is sufficient to send a price shock reverberating through the oil market. Some Saudi oil workers initiate work stoppages, and a full blown crisis ensues. Countries around the world are quick to point out the long-term consequences of the Saudi crisis, and policymakers turn their attention to promoting natural gas as a substitute for oil.

In the United States, politicians praise past efforts to promote natural gas use in the United States. As US lawmakers grow more concerned over the nation's energy security, calls intensify for a federal ban on natural gas exports. The fracking debate has largely dissipated as oil prices have climbed. An end to US natural gas exports pushes down gas prices in the United States, leading the way for substitution effects. Independent natural gas producers across North America are being bought out by larger companies, moderately slowing production in the short term. Still, low

gas prices relative to oil have given rise to an energy-intensive manufacturing renaissance in the US and by 2020, oil supply cuts resulting from the protracted succession crisis in Saudi Arabia are quickly pushing natural gas into the US transportation market. Americans are rushing to get compressed natural gas (CNG) vehicles, which are increasingly available from Japan. Companies also begin to invest substantially in gas-to-liquids technologies, and stranded gas in Canada and Alaska is increasingly being liquefied for sale as refined products to the US market.

Countries react to the US decision to cut off natural gas exports by initiating strategies of their own. Japan announces that it will be rekindling its nuclear industry and China, India, and Japan all mend fences with Iran, which begins to benefit from a natural gas investment boom. China and India also reform natural gas prices to promote domestic exploration and increased LNG imports to shift away from oil to natural gas for transportation, petrochemicals, and power generation. Soaring oil prices bring about a global recession, which curbs energy demand growth and gives some breathing room for natural gas to meet lost oil supply.

Hard hit by rising oil import costs, EU leaders are under pressure to create protectionist policies of their own. The continent's reliance on Russian gas has become frustrating and more alarming than ever, given the primacy natural gas now holds in Europe's energy mix. Europe abandons its previous bans on fracking and rethinks plans to phase out nuclear power. Following a period of massive investment in shale, unconventional natural gas output across central Europe and the United Kingdom begins to displace some Russian gas. But momentum to liberalization and gas trading slows as each individual European producer moves to ensure that domestic supplies stay at home, causing localized prices to fall in key countries like Germany, Poland, and the United Kingdom. Russia reacts by rerouting its gas to Asia, leaving certain energy-scarce European countries vulnerable to gas shortages.

Anxious to take advantage of the vast new opportunities in global markets, especially in Asian markets not as severely hit by the recession, Qatar lifts the moratorium on the further development of its North Field gas reservoir. Iran, too, is eager for new markets and, seeing a weakening in the international coalition against its nuclear program in the face of global energy shortages and US protectionism, enters into a series of negotiations for the construction of the Iran-Pakistan-India pipeline. Tehran issues a surprising announcement that India has finally agreed to participate in the project, and construction of the Iran-India-Pakistan pipeline proceeds. Development of gas resources in East Africa comes too late to grab important export markets, and

producers are therefore forced to build major infrastructure projects to use the gas for local consumption in Africa. Latin America also develops its own gas resources for local use and Argentina becomes a major supplier of shale gas to the southern cone.

After a five-year effort to reform the country's pricing regime and deregulate feedstock allocations, India begins to develop its own shale resources. China similarly pursues a regulatory overhaul and a massive infrastructural investment program that allow the country to develop shale. The rise of plentiful shale gas supplies means Asian buyers can demand lower prices for imported natural gas, and oil-linked pricing comes under pressure from competing shale supplies. With domestic sources of production supplemented by Qatari and Russian supplies, China finds little incentive in pursuing oil-related commercial activities in Latin America, and China largely withdraws from the region. As a result of low gas prices, coal-fired power generation shuts down eventually, in particular in the US and China.

CONCLUSION

This report offers preliminary insights into key drivers and trends for the future of gas markets based on the discussion at the Baker Institute-Harvard Scenario Workshop in Houston. The four global scenarios paint vastly different futures for gas markets depending on the success of the shale gas revolution and the level of market liberalization. Throughout the discussion of global scenarios and regional dynamics, a few critical drivers featured prominently.

GEOPOLITICS A CRITICAL FEATURE

Geopolitics are affected by the trajectory of gas markets as much it shapes that trajectory. Geopolitics play a significant role in whether a number of gas projects are realized and come online and where pipelines are built. As each scenario demonstrates, individual country decisions about natural gas resources can have dramatic impacts on responses in international discourse.

GREAT POWERS AND THEIR INTERACTIONS ARE DIRECTLY AFFECTED

Each of the scenarios demonstrates how developments in global gas markets are either spurred by the actions of great powers or trigger changes to their relative positions. The relative fortunes of United States, Russia, and China – and their ability to exert influence in the world – are tied in no small measure to global gas developments and vice versa.

CRITICAL EVENTS AS POLICY TRIGGERS

The scenarios frequently point to critical events such as natural disasters, political change, accidents, or new scientific information as potential triggers of energy policy change. If associated with natural gas specifically, such events could lead to more stringent environmental and safety regulations, to a shale gas moratorium, or to new uses for natural gas.

REGIME STABILITY

The collapse of political regimes in major energy-producing and consuming countries could significantly alter the landscape of gas and oil markets. The scenarios explicitly consider the collapse of the regimes of producer countries such as Russia, Saudi Arabia, and Venezuela. Potential effects include short- to medium-term supply shortages or significant changes in

demand growth in response to price changes. On the consumer side, an economic and political collapse of China would seriously reduce global demand for gas.

GASIFICATION OF POWER AND TRANSPORT SECTOR

The power and transportation sectors are critical determinants of total natural gas demand. While the gasification of the power sector is well underway, it remains unclear whether natural gas will be adopted widely in the transportation sector. Geopolitical or environmental drivers are likely to play a critical role in the pace of gas substitution in power and transportation if a transformation is to occur.

RENEWABLES AND CARBON PRICING

Renewable energy policy will critically shape the future of natural gas and vice versa. Climate policies or energy security considerations could play a major role in influencing the competition among fuels, as these scenario stories demonstrate. Geopolitics and renewable energy policy could greatly influence the window for natural gas as a potential bridge fuel. Alternatively, frustrations over developing gas resources could combine with other factors in leading to a renaissance for coal, with all its attendant problems.

RESOURCE ACCESS AND NIMBY

Access to shale gas reserves cannot be taken for granted. While France already has a moratorium in place, it is in the realm of the possible that some US states might also enact a moratorium—for instance, in case of an accident or a general “not-in-my-backyard” (NIMBY) sentiment. Alternatively, litigation over acreage and ownership might significantly delay shale gas development.

FINAL THOUGHTS

The above-mentioned drivers are only a few essential factors shaping the trajectory of natural gas markets in general and shale gas development in particular. Based on this initial scenario-building workshop, the joint Baker Institute-Harvard Geopolitics of Natural Gas study will systematically develop full-fledged scenarios for natural gas markets and their interaction with alternative geopolitical futures. Most importantly, the study will identify crucial policy levers that could have a critical impact on the direction gas markets and politics take in the next decades.



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