BROOKINGS

BROOKINGS ENERGY SECURITY AND CLIMATE INITIATIVE
NATURAL GAS TASK FORCE

NATURAL GAS ISSUE BRIEF #4:

An Assessment of U.S. Natural Gas Exports

JULY 2015

Tim Boersma
Charles K. Ebinger
Heather L. Greenley

ACKNOWLEDGMENTS

The authors would like to thank Ben Schlesinger, Lex Huurdeman, Jim Jensen, and Geert Greving for their careful reviews and/or helpful suggestions. The authors would also like to acknowledge the members of the Brookings Natural Gas Task Force for their time and helpful contributions during the October 2014 session upon which this issue brief is based. They are also grateful to Jennifer Potvin, Shams Haidari, and the Brookings Foreign Policy communications team for their editorial assistance and work on the production of this brief.

ABOUT THE BROOKINGS ENERGY SECURITY AND CLIMATE INTITIATIVE

The Energy Security and Climate Initiative (ESCI) at Brookings is designed to encourage the development, discussion, and dissemination of high-caliber energy security and climate research. ESCI, through its research and convening efforts, seeks to examine three key substantive aspects of energy security: the geopolitics of energy; the economics of energy; and the growing environmental imperative of balancing increasing global economic prosperity in a carbon-constrained context.

Contact for ESCI:
Jennifer Potvin
Project Coordinator
(202) 797-4389
jpotvin@brookings.edu

PREFACE

In May 2011, the Brookings Institution Energy Security and Climate Initiative (ESCI) assembled a Task Force of independent natural gas experts, whose expertise and insights inform its research on various issues regarding the U.S. natural gas sector. After the first series of meetings, Brookings released a report in May 2012 analyzing the case and prospects for exports of liquefied natural gas (LNG) from the United States. The Task Force now continues to meet periodically to discuss important issues facing the gas sector more broadly. With input from the Task Force, Brookings will continue to release periodic issue briefs for policymakers.

The conclusions and recommendations of this report are those of the authors and do not necessarily reflect the views of the members of the Task Force.

An Assessment of U.S. Natural Gas Exports

Tim Boersma
Charles K. Ebinger
Heather L. Greenley[1]

Introduction

Increased natural gas production in the United States has fueled a lively debate on the future of natural gas exports. This debate has focused so far predominantly on exports of liquefied natural gas (LNG). At the same time, the debate is clouded with many confusing statements about the regulatory regime related to natural gas exports with many foreign nations and even some domestic observers having the erroneous belief that the United States has severe restrictions on exports, when in fact no project has to date ever been rejected. In addition, estimates about the amount of U.S. natural gas that will be competitive in global markets vary widely, in part because a number of new supply sources are expected to enter the market in the coming years. There are also many uncertainties regarding global demand for LNG going forward. Finally, declining natural gas sales to the United States have incentivized Canada's provincial and federal authorities to search for opportunities to market its product elsewhere in the world, though unconventional gas development in Canada trails U.S. production, and in some parts of the country gas infrastructure is less developed than in most parts of the United States.

This policy brief provides an assessment of U.S. natural gas exports in the coming years, as well as its competitive position vis-à-vis other suppliers that are emerging worldwide. It does so by briefly outlining the existing regulatory framework related to LNG exports from the United States. It then proceeds with a timeline for LNG export projects that are being developed.[2] The policy brief then turns to what are currently considered major (potential) rivals of U.S. LNG, before it concludes with some final observations regarding the competitive position of U.S. LNG as of June of 2015.

This paper builds on extensive discussions within the Brookings Institution's Natural Gas Task Force (NGTF), along with our analysis of available literature on existing natural gas production trends, price formation, and legal and infrastructural limitations. We are grateful for the rich debates that have occurred in our NGTF. Despite the generosity and valuable contributions of all our speakers and participants, this policy brief reflects solely our views, and any errors remain our own.

---

[1] The authors are all members of the Energy Security and Climate Initiative at the Brookings Institution. Tim Boersma is a fellow and acting director; Charles K. Ebinger is a senior fellow; and Heather L. Greenley is a senior research assistant.
[2] We have used data that were available in early June 2015, or before.

The global LNG market

For many years, the outlook for natural gas has been very positive, and the outlook for LNG was similarly optimistic. A golden age for natural gas was near, according to the International Energy Agency in 2011. Today, that same agency reports that the outlook may still be bright, but is not set in stone.[3] Falling oil prices have knock-on effects on gas production worldwide, and, perhaps more importantly, demand for natural gas in 2014, particularly in Asia, proved to be substantially more moderate than anticipated.

Recent high regional prices, in both Europe and Asia, have incentivized the construction of significant additional LNG capacity additions. By 2020 additional LNG capacity additions totaling 164 billion cubic meters (bcm) will have come into the market, of which 90 percent will come from Australia and the United States. This, combined with slowing demand, has led to a situation of oversupply, which is expected to last until at least 2017.[4] It is against this background that we write our report. **Table 1** shows some key characteristics of global LNG markets, before we turn to the U.S. regulatory framework.

United States regulatory framework

The evolution of the U.S. LNG export licensing process

All U.S. LNG export projects must receive approvals from both the Department of Energy's Office of Fossil Energy as well as the Federal Energy Regulatory Commission (FERC) per the statutory provisions of the 1938 Natural Gas Act (NGA) Section 3(15 USC§717b).[5] Prior to 2014, this process required an initial application to the Department of Energy (DOE) and a national interest determination finding that LNG exports were within the public interest. This process was then followed by a FERC review after which if the project met all regulatory considerations an approval for the construction of an export facility followed.

Exports to countries holding free trade agreements (FTA) with the U.S. are automatically deemed in the public interest, and therefore licensable by the DOE. For exports to countries without an FTA with the United States, the Office of Fossil Energy was still required to issue an export permit unless, after publishing the application in the Federal Register, seeking public comments, and receiving protests against the sale or notices of intervention by parties opposed to the sale, such exports could be detrimental to the public interest. However, a major shortcoming of this process was the very vague grounds used to determine what was meant by the "public interest." Additionally, under the regulatory process, DOE had the ability to issue permits up to a certain cumulative volume of LNG exports and then to deny subsequent applications if it perceived that tight market conditions made such additional exports in contravention of the public interest. Finally, the DOE's low-cost, undemanding application process soon became bogged down with dozens of export applications.

Following DOE's approval, authorization by FERC was (and still is) also necessary for any LNG export facilities requiring the siting, construction, or operation of those facilities, or to amend an existing FERC authorization. Certain additional regulatory

[3] International Energy Agency (IEA), Gas: Medium-Term Market Report 2015, by Costanza Jacazio et al. Paris: OECD/IEA, 2015.
[4] Ibid., 94.
[5] For a more in-depth assessment of the process for approval for LNG exports prior to 2014, see: Charles Ebinger et al., "Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas," Brookings Institution, May 2012, http://www.brookings.edu/~/media/research/files/reports/2012/5/02%20lng%20exports%20ebinger/0502_lng_exports_ebinger.pdf.

TABLE 1. THE GLOBAL LNG MARKET[6]

KEY CHARACTERISTICS OF THE GLOBAL LNG MARKET

LNG has been the fastest growing source of gas supply, averaging 7 percent annual growth since 2000. However, over the last three years, LNG trade has been stable at just below the peak of 241.5 million metric tons per annum (mtpa) reached in 2011. LNG in 2013 met 10 percent of global gas demand.

In 2013, the Middle East supplied 42 percent of global LNG supplies, while the Asia Pacific supplied 30 percent. Around 65 percent of the world's liquefaction capacity is held in just five countries: Qatar, Indonesia, Australia, Malaysia, and Nigeria.

Most LNG demand growth has been in the Asia Pacific region, particularly due to increased consumption in China and South Korea. Japan remains the world's dominant importer, utilizing 37 percent of global imports.

Though interregional trade patterns have intensified in recent years, a single price structure for global LNG does not exist. In fact, current investments in the sector are based largely on the premise that these price differentials will remain in place (and incentivize arbitrage).

Historically, LNG trade was based on long-term contracts and oil-indexation, in order to manage risks associated with high upfront costs of liquefaction, transport in specialized tankers, and regasification. However, in 2013, 33 percent of global trade was not long-term (referring to cargoes that are not supported by 5+ years Sales and Purchase Agreements, cargoes diverted from their original/planned destination, and cargoes above take-or-pay commitments). Several factors have contributed to this trend, including the growth of contracts with destination flexibility, and the lack of domestic production or pipeline imports in Japan, Korea, and Taiwan (as a result, sudden changes in demand following for instance a phase out of nuclear capacity have to be covered in the spot market). In addition, the continued price differentials between various regions, and the fact that LNG volumes have been freed up due to a loss of competitiveness vis-à-vis coal (Europe) and shale gas (United States) has facilitated shorter-term trade.

Re-exports of LNG likely remain an important feature of global LNG markets, as described above. In 2013, re-exports grew for the fourth year in a row, to 4.6 megatons (MT) and continues to grow today. Another market development has been the introduction of new pricing formulas by U.S. firms (based on North American spot market prices, instead of oil-indexation). Even though U.S. pricing formulas are currently unique, and low oil prices may take away the immediate incentive for more widespread change, it seems likely that in due time hub-based pricing will become more common. Next to these developments, a number of technological innovations may drive further changes in global LNG markets going forward, such as floating LNG, small scale LNG, high-efficiency liquefaction plants, and LNG ice breakers which would facilitate Arctic transportation.

approvals for offshore facilities involving the export of LNG are on occasion also needed from the Coast Guard as well as the Department of Transportation. If a favorable verdict was made by these agencies, then applications were issued a Certificate of Public Convenience and Necessity allowing the project to proceed to construction and operation.

Environmental review and assessment

The approval of the Office of Fossil Energy and of FERC additionally required an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA of 1970). All projects were to have an EIS for every proposed major federal action that

[6] Based on International Gas Union, *World LNG Report – 2014 Edition* (Fornebu, Norway: International Gas Union, 2014), 23, http://igu.org/sites/default/files/node-page-field_file/IGU%20-%20World%20LNG%20Report%20-%202014%20Edition.pdf.

was thought to have a significant impact on the environment, in accordance with NEPA's requirements. Even projects with less significant impacts still required documentation. For example, even if the environmental impacts were indeterminable, an EIS would have to be done in order to conclude if an EIS was necessary. If the ensuing EIS determined that the proposed project had no significant environmental impacts, then a Finding of No Significant Impact (FONSI) report was provided. Finally, projects perceived to have no significant impacts on the environment could be processed as Categorical Exclusions alleviating any requirement to provide either an EIS or a less robust Environmental Assessment (EA). In preparing all the documentation required by NEPA, both the Department of Energy and the FERC were also charged with identifying any other compliance requirements pertinent to the project such as the Clean Air Act, the Clean Water Act, the Endangered Species Act, and the National Historic Preservation Act, as well as any approvals under these or state-related requirements that fell under these federal statutes. In addition to the environmental requirements, LNG export projects can be subject to the oversight requirements of other agencies such as the Department of Transportation's Office of Pipeline Safety, the National Fire Protection Association, and the Federal Emergency Management Agency.

This seemingly simple, but realistically complex regulatory approval process was made more convoluted by the uncertainty of how long it would take, particularly for those applying to export to non-FTA countries. Again, prior to 2014, the DOE reviewed applications to export LNG to countries without a free trade agreement in the order in which they were received, resulting in a cumbersome and painstakingly time-consuming process. This provided industry with little or no certainty that their projects would be approved if they were way down the applicant list, even if they had excellent technical partners, sound balance sheets, committed customers, and strong prospects for certain financing. While the DOE, per its legal mandate, intended to process these applications in a timely manner (at an average of one every eight weeks), by March 2014 the escalating number of applications had prolonged the approval process by nearly four years, regardless of the project's environmental complexities or lack thereof. "The result was that projects which might make it through the environmental review, led by the Federal Energy Regulatory Commission (FERC) or the U.S. Maritime Administration (MARAD) depending on jurisdiction, might not be considered until they came up in the queue, possibly years later, or might be rejected altogether because they exceeded the soft cap of 12 billion cubic feet per day (Bcf/d)."[7]

On May 29, 2014, the DOE announced a modification of the application process for LNG exports to countries without a U.S. free trade agreement. First, the DOE effectively terminated conditional verdicts to export to non-FTA countries without a NEPA review. "DOE typically issued these conditional authorizations after completion of the notice and

[7] David L. Goldwyn, "DOE's New Procedure for Approving LNG Export Permits: A More Sensible Approach," Brookings Institution, June 10, 2014, www.brookings.edu/research/articles/2014/06/10-doe-approving-lng-export-goldwyn-hendrix. The existence of the so-called soft cap grew out of a study commissioned in 2012 by the DOE with the goal of determining how much LNG could be exported from the United States within the public interest. Finally issued in 2014, the DOE's study, authored by NERA, found inter alia that the more LNG the United States exports, the greater the public interest, thus in effect depriving the DOE of any stopping point, based on its own required criteria and its own study. Because the highest volume scenario NERA examined was 12 Bcf/d of exports, this justified a "soft cap" of 12 Bcf/d in the eyes of some observers. The cap was, indeed, soft because NERA soon privately updated its study, finding public interest in a 19 Bcf/d scenario.

comment process, but before completion of NEPA review."[8] As discussed earlier, prior to this time many projects had to wait in queue in the order in which they were received; some of these were still undergoing environmental review because this assessment could be highly complex, while other projects that had no environmental impact still waited in line. Following the change in policy, the DOE only issues public interest approval for projects that have secured their NEPA requirement, streamlining the DOE approval process. Furthermore, the DOE eliminated the queue system and now approves applications based on when an application "has completed the pertinent NEPA review process and when DOE has sufficient information on which to base a public interest determination."[9]

Despite this attempt to clarify and streamline the approval process, industry still remains a bit concerned over how the changes will work in actuality. Moreover, the issue of what criteria DOE uses and what weight each criterion is given in determining what constitutes the "public interest" is not fully guaranteed by the issuing of an export permit. The United States government still reserves the full right to withdraw export permits determined not to be in the public interest.[10] Unfortunately, this determination is outside the DOE's jurisdiction and can only be changed or clarified by an act of Congress. Nonetheless, with the change in policy, DOE has made a vast improvement in the approval process providing industry with noticeably more confidence in the approval timeline, once they have undergone their NEPA review.

Current trade flows and North American export projects under construction

Since 2007, Canadian gas pipeline exports to the United States have been in a sluggish decline as new U.S. domestic supplies, largely from unconventional gas, and the construction of new pipelines to distribute them are quickly obviating the need for Canadian gas imports. In 2013, virtually all U.S. imports of natural gas came from Canada, totaling 2,785 Bcf.[11] Given these market trends and the absence of new export markets, Canadian gas production likely will remain stagnant, serving only the domestic economy and some select niche U.S. regional markets. It is worth noting however, that those niche markets also may evaporate for two reasons. First, U.S. domestic infrastructure investments continue to expand, bringing previously stranded gas supplies to market. To give an example, in 2013 Canadian imports into the northeastern United States dropped by almost 12 percent, due to the increase in production from the Marcellus shale and expanded pipeline capacity.[12] Second, gas market growth in California, a highly important niche market for Canadian gas, is in decline as large renewable energy projects increasingly dominate electricity generation capacity, gradually pushing out gas.

In response to this Canadian "existential" gas market crisis and the perception that the United States is a "low cost" gas producer, the Canadian gas industry has embarked on ambitious schemes

---

[8] Procedures for Liquefied Natural Gas Export Decisions, 79 Fed. Reg. 32262 (proposed June 4, 2014), https://federalregister.gov/a/2014-12932.
[9] Ibid.
[10] The right to withdraw export permits due to the determination of not being in the public interest is unlikely to be exercised. This issue becomes moot once natural gas export prices reach the point of no longer being in the public interest, the price of exporting U.S. natural gas becomes too expensive and therefore uneconomic.
[11] U.S. Energy Information Administration, "U.S. Natural Gas Imports & Exports 2013," May 28, 2014, http://www.eia.gov/naturalgas/importsexports/annual/.
[12] Ibid.

to ship Canadian gas to Asian markets where gas prices have historically been high. Currently, there are no fewer than 19 proposed LNG projects along the coast of British Columbia.[13] There are also two more in Oregon that, if built, would be supplied by gas from Western Canada, and several liquefaction plants have been proposed in Canada's Maritime Provinces on its Atlantic coast.

To date, however, no final decision has been made for any Canadian LNG export project and none have been built. Malaysia's Petronas has decided to continue to move forward with its project in British Colombia, yet final investments are still waiting for federal and provincial approval.[14] Much of the delay in Canada relates to the relatively long distances over which wholly new gas pipelines have to be constructed to enable LNG exportation. These long pipeline routes (e.g., over 600 miles in British Columbia) have drawn significant environmental backlash, complicated by protracted negotiations with the First Nations and recent revisions to the tax regime in British Columbia. Recently, several First Nations, including the Lax Kw'alaams, have voted against LNG plans in British Columbia as it interferes with traditional territories, leaving significant environmental and ecological concerns which need to be addressed.[15] With these delays possibly curbing potential investment, Ottawa has announced a federal tax break for proposed LNG terminals in British Columbia, which intends to spur investment by making British Columbian LNG more competitive and to alleviate some economic uncertainty.[16]

In the United States, the euphoria brought on by the unconventional gas revolution has been astounding as estimates of technically recoverable natural gas resources have ascended to over 2,200 trillion cubic feet (Tcf), an amount in excess of 87 years supply at current consumption levels.[17] The magnitude of these resources has led to FERC's approval of several LNG export terminals, five of which are under construction (**Figure 1**).[18] Furthermore, there are 21 additional proposed projects in the continental United States and one in Alaska pending review by U.S. regulatory authorities, including several existing import terminals that are requesting to be converted into export facilities, i.e., for which substantial gas infrastructure components are already in place. In addition, it is estimated that there could be 11 more potential facilities in terms of available sites.[19]

---

[13] For a list of British Columbian projects see: "Explore B.C.'s LNG Projects," Government of British Columbia, http://engage.gov.bc.ca/lnginbc/lng-projects/. For a list of Canadian projects applying for an LNG export terminal license with the Government of Canada, see: "Canadian LNG Projects," Natural Resources Canada, last modified September 23, 2014, http://www.nrcan.gc.ca/energy/natural-gas/5683.

[14] Chester Dawson, "Shell-Led Natural Gas Export Project in Canada Clears Environmental Hurdles," *The Wall Street Journal*, June 17, 2015, http://www.wsj.com/articles/shell-led-natural-gas-export-project-in-canada-clears-environmental-hurdles-1434584827.

[15] Justine Hunter, "Lacklustre Support from B.C. First Nations Signals Trouble for LNG Facility," *The Globe and Mail*, May 10, 2015, http://www.theglobeandmail.com/news/british-columbia/lacklustre-support-from-bc-first-nations-signals-trouble-for-lng-facility/article24361708/.

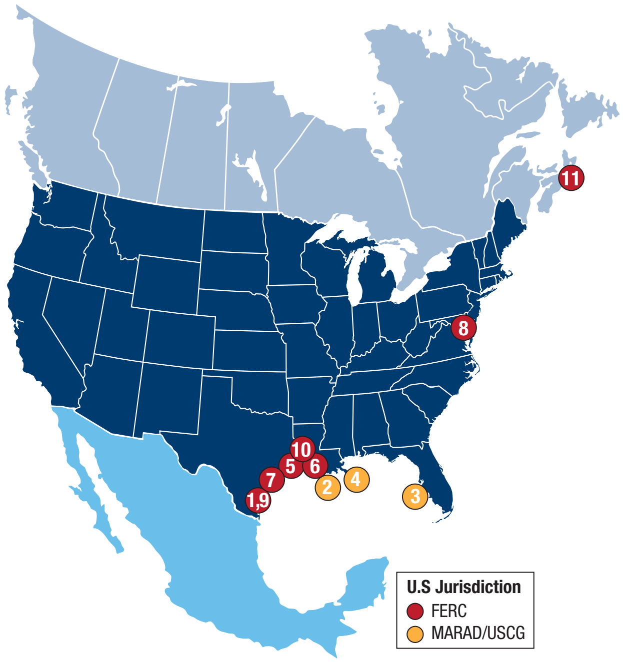
[16] Brent Jang and Ian Bailey, "Ottawa Grants Tax Breaks for LNG Sector in BC," *The Globe and Mail*, February 19, 2015, http://www.theglobeandmail.com/news/british-columbia/harper-announces-tax-breaks-for-lng-industry-in-bc-to-spur-job-growth/article23106853/.

[17] "Frequently Asked Questions: 'How much natural gas does the United States have and how long will it last?,'" U.S. Energy Information Administration, last modified December 3, 2014, http://www.eia.gov/tools/faqs/faq.cfm?id=58&t=8.

[18] Likewise, proved U.S. gas reserves have reached record levels of 354 trillion cubic feet as of year-end 2013: U.S. Energy Information Administration, "U.S. Crude Oil and Natural Gas Proved Reserves," December 19, 2014, http://www.eia.gov/naturalgas/crudeoilreserves/.

[19] "LNG," Federal Energy Regulatory Commission, last modified June 18, 2015, http://www.ferc.gov/industries/gas/indus-act/lng.asp.

FIGURE 1. NORTH AMERICAN LNG IMPORT/EXPORT TERMINALS APPROVED



As of June 18, 2015

Import Terminal

APPROVED - UNDER CONSTRUCTION
U.S. – FERC
1. **Corpus Christi, TX:** 0.4 Bcfd (Cheniere – Corpus Christi LNG) (CP12-507)

APPROVED – NOT UNDER CONSTRUCTION
U.S. – MARAD/Coast Guard
2. **Gulf of Mexico:** 1.0 Bcfd (Main Pass McMoRan Exp.)
3. **Offshore Florida:** 1.2 Bcfd (Hoëgh LNG – Port Dolphin Energy)
4. **Gulf of Mexico:** 1.4 Bcfd (TORP Technology–Bienville LNG)

Export Terminal

APPROVED – UNDER CONSTRUCTION
U.S. – FERC
5. **Sabine, LA:** 2.76 Bcfd (Cheniere/Sabine Pass LNG) (CP11-72 & CP14-12)
6. **Hackberry, LA:** 1.7 Bcfd (Sempra – Cameron LNG) (CP13-25)
7. **Freeport, TX:** 1.8 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction) (CP12-509)
8. **Cove Point, MD:** 0?82 Bcfd (Dominion – Cove Point LNG) (CP13-113)
9. **Corpus Christi, TX:** 2.14 Bcfd (Cheniere – Corpus Christi LNG) (CP12-507)

APPROVED – NOT UNDER CONSTRUCTION
U.S. – FERC
10. **Sabine Pass, LA:** 1.40 Bcfd (Sabine Pass Liquefaction) (CP13-552)

APPROVED – NOT UNDER CONSTRUCTION
Canadian
11. **Port Hawkesbury, NS:** 0.5 Bcfd (Bear Head LNG)
12. **Kitimat, BC:** 3.23 Bcfd (LNG Canada)

Source: Federal Energy Regulation Commission, U.S. Department of Energy

While the projected number of North American LNG export facilities is massive, closer examination of the projects' financial realities offer a more nuanced story. Almost all of the existing analysis and forecasts have been based on three central tenants. First, that spot market prices at Henry Hub will continue to be at record low levels. However, in reality, Henry Hub prices, while remaining relatively low, are projected in most forecasts to rise steadily in the coming years, albeit gradually. Unless the costs of the liquefaction process, transportation, and regasification of natural gas can be reduced, and there are currently few indications that they can, those marginal differences in hub prices may become more significant in determining how attractive U.S. LNG exports will be.[20] The second supposition is that prices in Asia and Europe will remain high, creating ample room for arbitrage. Currently, Henry Hub prices have remained low at around $3/Mcf. Meanwhile, spot prices in Asia (roughly $6-7/mmBtu for 2015-2016)[21] and Europe have tumbled over the course of 2014 (because they have been tied to world oil prices, which declined precipitously, because of a slowdown in economic growth, and because natural gas faces stiff competition from other fuel sources, negatively impacting demand) to levels where it would be increasingly difficult for North American LNG to be considered profitable. The third supposition is the continued

[20] International Gas Union, *World LNG Report - 2014 Edition*.
[21] Osamu Tsukimori, "Japan Feb LNG Spot Price Falls a Quarter to $7.60/mmBtu," Reuters, March 10, 2015, http://www.reuters.com/article/2015/03/10/lng-japan-spot-idUSL4N0WC1JL20150310.

practice outside the United States of indexing the price of LNG to the oil price, coupled with the general assumption that oil prices will remain high. Consequently, when oil prices fell by 50 percent after October 2014, many LNG projects' fiscal solvency were called into question. Even with prices having slightly rebounded, investors remain increasingly cautious about new projects. U.S. projects that are currently under construction are unique in that their pricing formulas are based on spot-market prices at Henry Hub, unlike other LNG projects around the world which are in some form indexed to oil or oil-related products. With the fall in oil prices, rivals to U.S. LNG projects, in particular those in Australia (which are discussed in more detail later in this brief) have become more competitive than they were just one year ago, but it is uncertain how the oil price will develop going forward.

In addition, there are many other uncertainties worth considering:

1. The pace at which China ramps up pipeline imports, particularly from Russia;
2. The rate at which many countries with large shale gas resources (China, Argentina, South Africa, and Algeria, to name a few) successfully develop them;
3. Inter-fuel competition from other sources such as coal and renewables with LNG, especially in the Asian power market;
4. Whether or not Russia will also initiate large scale pipeline exports to Japan and the Koreas, owing partially to the pace and scale of Russian LNG exports from its Arctic regions, as well as how much Russian LNG from Yamal and Sakhalin will continue to flow;
5. The speed and degree to which Japan determines whether or not to bring its nuclear reactors back online, and to what extent nuclear outages in South Korea continue to spur LNG imports;
6. To what extent Japan will continue its support schemes for renewable electricity and significantly expand in particular its solar capacity;
7. The ability to utilize LNG as a transportation fuel, particularly in the Chinese and Indian markets where pollution and health concerns are growing;
8. Whether the United Nations Framework Convention on Climate Change meeting in Paris in late 2015 reaches a global agreement on reducing CO_2 emissions and the nature of that agreement; and,
9. To what extent the major economies in Asia, in particular China and India, decide to reduce the share of coal in their electricity generation, especially if there is no serious agreement to reduce CO_2 at the Conference of the Parties meeting. In such a scenario coal will remain very competitive with LNG.[22]

Faced with the foregoing uncertainties, U.S. LNG export projects are actually poised to compete favorably with new LNG projects coming to the world market from other locations. U.S. construction costs are comparatively low, especially for brown-field liquefaction projects, i.e., that will convert existing import terminals that have already secured environmental approvals for existing facilities. Additionally, low U.S. energy prices provide a construction cost edge, and the United States offers significant skilled labor at a reasonable cost.[23] Finally, depending on global oil prices, the U.S. LNG pricing structure,

[22] Brian Songhurst, "LNG Plant Cost Escalation," The Oxford Institute for Energy Studies, February 2014, http://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/02/NG-83.pdf.
[23] Leonardo Maugeri, "Falling Short: A Reality Check for Global LNG Exports," Harvard Kennedy School, December 2014, 21, http://belfercenter.ksg.harvard.edu/files/Falling%20Short-LNG%202014.pdf.

based on Henry Hub spot market prices, may give U.S. projects a competitive advantage going forward by providing buyers with lower cost LNG and price index diversity.

Yet the success of U.S. projects is not guaranteed. First, capacity costs are not fixed and can rise with an increased demand for material and skilled labor, as the overall economy improves.[24] Second, the oil price level plays an important role. Leonardo Maugeri of Harvard's Kennedy School makes a compelling case that U.S. LNG projects are likely less competitive at an oil price (Brent) level of $80/bbl compared to $100/bbl. With other LNG projects indexed to the price of crude, the current price level would make LNG from Australia more competitive vis-à-vis U.S. LNG in Asia.[25] It is worth noting that Australian projects that are competitive are not per definition profitable. Some estimates suggest that Australian LNG projects break even at around $85/bbl, though of course every case is unique.[26] Third, with respect to Europe in general, LNG producers have to wonder what will be the absorptive capacity of the market. In Europe, LNG competes with cheap coal, support mechanisms for renewables, and very competitive pipeline gas from Russia, Norway, and Algeria (notwithstanding declining domestic production from the Netherlands, for example). It is not unlikely that, even if large amounts of U.S. LNG make it to the European market, traditional suppliers would start a price war rather than give up market share.[27] There is some empirical evidence that U.S. LNG could be very competitive in the more liquid parts of the European market, in particular the UK and Netherlands. Fourth, given all these uncertainties, possible constraints, and the fact that a significant amount of projects are permeating the market in the coming years, it may be increasingly difficult to finance additional projects going forward.

For all proposed LNG projects worldwide, timing is crucial. According to M.C. Moore et al., of the University of Calgary, "delays beyond 2024 risk complete competitive loss of market entry for Canadian companies. Already British Columbia is behind schedule on the government's goal of having at least one terminal in operation by 2015."[28] Moore et al. argue that if Canadian facilities lag behind the projected entry of U.S. LNG facilities, they are at considerable risk for losing out on market share competitiveness by 2024 because of their relatively high delivered-product costs. Thus, it is still highly uncertain what amount of North American LNG will actually make it to the market. We observe that at this point in time, the number of firm export projects in the United States can be counted on one hand, while in Canada there are currently no projects under construction. We also note that even full regulatory approval from FERC and DOE does not guarantee that a project will eventually be built. In addition to regulatory approval, a project requires financing, and at current price levels with more LNG (particularly from Australia and the U.S.) coming on stream, we believe that it is increasingly unlikely that new projects other than fully licensed and financed ones will make it to the market before the early 2020s. Even for the five U.S. projects that have received all green lights over the course of 2014, it is important to keep in mind that

---

[24] Ibid., 23.
[25] Ibid., 33.
[26] Bob Lamont, "Falling Oil Prices Set to Hit Future LNG Price," *The Observer*, November 4, 2014, http://m.gladstoneobserver.com.au/news/cheap-oil-to-hit-lng-price/2441170/.
[27] Tim Boersma et al., "Business as Usual: European Gas Market Functioning in Times of Turmoil and Increasing Import Dependence," The Brookings Institution, October 2014, 22, http://www.brookings.edu/~/media/Research/Files/Papers/2014/10/european-gas-market-import-dependence/business_as_usual_final_3.pdf?la=en.
[28] M.C. Moore et al., "Risky Business: The Issue of Timing, Entry and Performance in the Asia-Pacific LNG Market," *The School of Public Policy SPP Research Papers* 7, no. 18, July 2014, http://policyschool.ucalgary.ca/sites/default/files/research/moore-lng-onl.pdf.

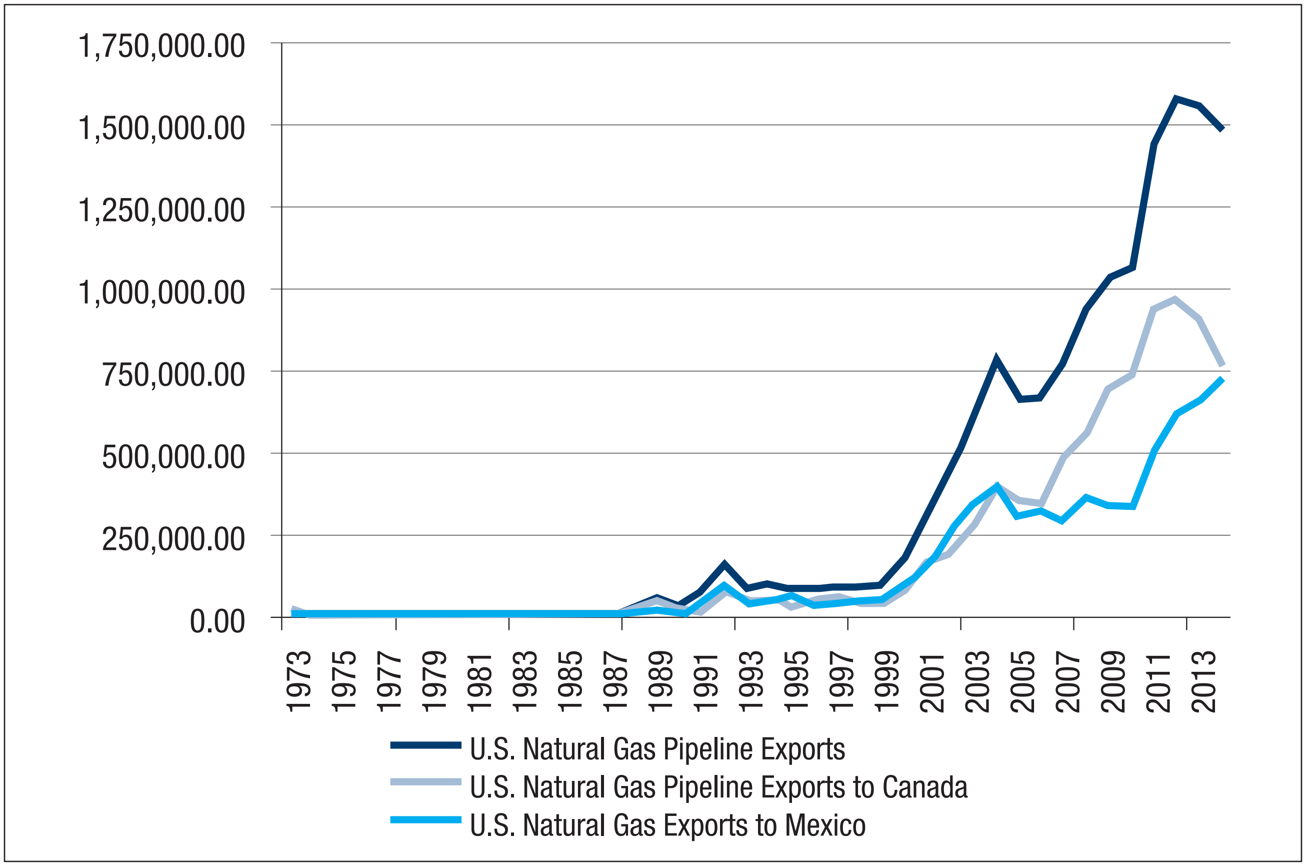
with an estimated brownfield construction time of four years, the earliest achievable start dates will be in late 2018/early 2019,[29] other than the initial four trains (2.2 Bcf/d) of the Sabine Pass LNG export project, which are nearing completion and expected to enter service beginning November 2015. We believe that the trend of increased regional pipeline gas exports will continue however, resulting in particular in vastly increased pipeline exports from the United States to Mexico (**Figure 2**), and a further erosion of Canadian–U.S. gas trade. This leaves an open question where Canadian producers can market their gas going forward.

Competition for U.S. LNG: The cases of Australia and East Africa

Australia

Australia has moved fast to break into the LNG market. With three major facilities already in operation and seven more prepared to go online in the next couple of years, Australia is poised to exceed Qatar as the world's largest LNG exporter in terms of export volumes. However, the Australian projects face significant cost increases, amongst others because production costs turned out higher than anticipated,

FIGURE 2. U.S. NATURAL GAS EXPORTS AND RE-EXPORTS BY COUNTRY



Source: U.S. Energy Information Administration

[29] Ibid.; International Gas Union, *World LNG Report – 2014 Edition, 23*.

and labor costs rose significantly. Because of that, combined with the fact that Australian LNG prices have been linked to oil, it remains to be seen how competitive Australian LNG will be. Regardless of their competitiveness, with huge sunk costs, the Australian projects are still expected to compete in the global market space.

Australia has approximately 43 Tcf of proven natural gas reserves with an additional 437 Tcf of technically recoverable shale gas reserves.[30] Much of the domestic need for natural gas was previously provided by Eastern Australia, but recently there has been a shift and the eastern market has begun exporting LNG. This increase in exports has had an upward effect on domestic prices. As a result, populist voices have emerged, calling to keep natural gas in the country in order to keep domestic prices low. However, the Australian government does not support this policy, arguing that reserving natural gas for domestic use will inhibit innovation, limit diversity of supply, and discourage new investment opportunities.[31] Furthermore, the domestic Australian natural gas market is small, with coal currently dominating the electricity sector at about 64 percent of generation capacity.[32] In addition, foreign investment in the development of the Australian natural gas export market has been beneficial to the Australian economy. The new LNG export facility in Queensland alone has provided the country with 30,000 construction jobs and 12,000 permanent positions through at least 2020.[33] The Queensland Curtis LNG plant is the world's first large scale plant to convert coal-bed methane to LNG. In January 2015, it sent its first tanker carrying LNG to Singapore, Chile, China, and Japan.

Notwithstanding the economic benefits, the Australian projects have generated public concern. A shortage of skilled labor has resulted in delays and cost increases. The projects require skilled labor and Australia's labor pool is limited. However, labor unions in Australia and governmental restrictions over temporary work visas have made it difficult to bring in foreign workers. The labor unions in Australia are powerful and have been able to interrupt the construction of a project under the "right-of-entry" provision.[34] Additionally, labor unions have negotiated for higher wages, on top of already high salaries due to a strong Australian dollar. That strong currency also contributed to skyrocketing prices for construction materials, such as steel, in the early stages of the development of some of these projects. All of these issues contributed to delays in expected completion times as well as significant cost overruns. For example, the Gorgon project, with a capacity of 15.6 mtpa, has been delayed from an original completion date of 2014 to late 2015, while its costs have increased by 40 percent.[35]

Australian LNG projects target Asian markets. They have a major advantage vis-à-vis North American exports in terms of proximity, as transportation costs are lower. Conversely, Australian projects have

---

[30] "Australia Overview," U.S. Energy Information Administration, last modified August 28, 2014, http://www.eia.gov/beta/international/analysis.cfm?iso=AUS.

[31] Australian Government Department of Industry and Science, *2015 Energy White Paper*, (Canberra, Australia Capital Territory: Canberra ACT Department of Industry and Science, April 2015), http://ewp.industry.gov.au/sites/test.ewp.industry.gov.au/files/EnergyWhitePaper.pdf.

[32] Ibid.

[33] Ibid.

[34] David Ledesma et al., "The Future of Australian LNG Exports: Will Domestic Challenges Limit the Development of Future LNG Export Capacity?" Oxford Institute for Energy Studies, Oxford University, September 2014, http://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/09/NG-90.pdf.

[35] Ledesma et al., "The Future of Australian LNG Exports: Will Domestic Challenges Limit the Development of Future LNG Export Capacity?"

negotiated contracts based on the price of oil, a formula that may lose its competitive edge in comparison to U.S. projects if oil prices start to rise again. In addition, low Henry Hub prices have sparked a debate amongst Asian buyers whether oil-indexation should still be the preferred pricing method for LNG. There have also been discussions about the development of an Asian benchmark, a stance that is actively supported by the U.S. Department of State. The drop in oil prices has eroded some of the urgent needs of Asian buyers to address the oil-indexation of LNG cargoes, though we do not expect that desire for changes in pricing formulas to disappear. At the same time, it is too early to claim that non-oil based contracting practices marks a widespread disruption of the current system.[36]

Australian LNG faces uncertainties regarding Asian demand. Japan is currently determining how many nuclear power plants it can bring back online since the shutdown of its nuclear fleet after the disaster in Fukushima. In 2013, 80 percent of Australian LNG exports went to Japan, and in 2012 Australia was the largest source of LNG for Japan.[37] Next to the more mature markets in Japan and South Korea, most growth in LNG demand is expected in China and India. However, growth in China in 2014 was weaker than anticipated due to the overall economic slowdown.[38]

Nevertheless, Australia is still on schedule to takeover Qatar to become the world's primary LNG supplier before 2020. One major contributing factor has been that Australia secured contracts before the U.S. shale gas revolution took off in full. Australia's potential for exports is enormous: "LNG exports rose in 2013 to 22.3 mtpa (30.5 Bcm), up by 9% from 2012 and by 2018 the proportion of Australian produced gas exported for LNG is projected to rise to 81%."[39] However, new investments have become uncertain, with other projects coming on stream and global demand in the nearby future possibly being weaker than expected.

East Africa

Over the past decade, both Tanzania and Mozambique have made significant offshore natural gas discoveries. With reports indicating discovered gas at over 140 Tcf in Mozambique and another 46 Tcf in Tanzania, East Africa can become a major competitor in the world LNG market. Although these two countries can produce LNG at relatively competitive rates due to largely conventional deposits and East Africa's close proximity to Asian markets, both Tanzania and Mozambique have substantial barriers to overcome concerning domestic regulations and political stability as well as the lack of available infrastructure to get this natural gas to market.

Both Tanzania and Mozambique must develop infrastructure in order to secure financial investment. The governments of Tanzania and Mozambique have worked with LNG project developers to design a "unitization initiative" in order to cut costs by sharing LNG production facilitates while also effectively curbing construction time.[40] The infrastructure issue becomes even more compounded with the remote

---

[36] Ibid.; International Gas Union, *World LNG Report – 2014 Edition*, 14.

[37] "Australia Overview," U.S. Energy Information Administration.

[38] BG Group, "Global LNG Market Outlook 2014-15," BG Group, http://www.bg-group.com/480/about-us/lng/global-lng-market-overview-2013-14/.

[39] Ledesma et al., "The Future of Australian LNG Exports: Will Domestic Challenges Limit the Development of Future LNG Export Capacity?"

[40] International Energy Agency, The Asian Quest for LNG in a Globalising Market, by Anne-Sophie Corbeau et al. Paris: OECD/IEA, 2014, http://www.iea.org/publications/freepublications/publication/PartnerCountrySeriesTheAsianQuestforLNGinaGlobalisingMarket.pdf.

location of many of these LNG facilities. In Tanzania, LNG project completion is currently estimated anywhere from 2021 to 2023 with expected international investments of $20 to 30 billion. While Mozambique LNG is officially still estimated to come to the market by around 2018 to 2019, there is a growing consensus that delays could move the completion date back to the mid-2020s. Companies working in the area, such as Eni and BG, have expressed their concerns over the infrastructure challenge being resolved in time to meet the 2018 target.[41]

Additionally, both countries are struggling to attract an adequate, skilled labor force to develop this infrastructure, with the local median age hovering around 17 years. Mozambique has attempted to quell this issue by instituting the Decree Law of December 2014, which outlines specific qualifications for bringing in skilled foreign workers. This decree, among other things, eases restrictions on hiring foreign workers, yet stresses the need to give job priority first to qualified Mozambicans. Additionally, the decree suggests that foreign workers should not be hired for unskilled jobs or those that are not technically complex as these should be reserved for the local population.

Tanzania and Mozambique have also considered using these natural gas resources to meet their domestic needs. The Tanzanian government has made it clear that it will prioritize the domestic market over exports. According to the Natural Gas Policy of Tanzania 2013, "Tanzania aims to have a reasonable share of the resource for domestic applications as a necessary measure to ensure diversification of the gas economy before [development of an] export market."[42] While the Tanzanian domestic market for natural gas is relatively small in comparison to its reserves, this policy could pose a significant barrier to investment. In Mozambique, the new Petroleum Law introduced by Parliament established a 25 percent domestic supply obligation.[43] The national market of Mozambique will not be able to absorb this amount in the long term; therefore, an open question is whether to allow South Africa to be part of this "national market."

East Africa faces the stigma of historic political instability, which could influence both future investments as well as physically impact production. While Tanzania has been a peaceful nation for over 50 years, Mozambique ended a nearly 20-year civil war in 1992 with the signing of a peace agreement. Despite the formal peace, there have been new periods of unrest. Starting in October 2012 and continuing throughout 2013, new skirmishes warranted a second peace deal, which has been in place since September 2014. Still, there continues to be concerns over the ability of the government to maintain political stability and protect against uprisings that could impact future investment in Mozambique.

Despite this uncertainty, at this point Mozambique is comparatively better positioned to export LNG than Tanzania. Mozambique has developed a much more specific regulatory framework and does not have any qualms with exporting the majority of its natural gas. The government recognizes the need for strong regulation and control over how energy resources are managed within the country in order to guarantee domestic revenues. Responsible planning and the reorganization of tax and regulatory poli-

[41] International Energy Agency, *Medium-Term Gas Market Report: Market Analysis and Forecasts to 2019*, Paris: OECD/IEA, 2014.
[42] The United Republic of Tanzania, *The Natural Gas Policy of Tanzania – 2013*, Dar es Salaam: October 2013, 14, http://www.tanzania.go.tz/egov_uploads/documents/Natural_Gas_Policy_-_Approved_sw.pdf.
[43] William Felimao, "Mozambique Passes Petroleum Law and Tax Break for Eni, Anadarko," *Bloomberg Business*, August 15, 2014, http://www.bloomberg.com/news/articles/2014-08-15/mozambique-passes-petroleum-law-and-tax-break-for-eni-anadarko.

cies are necessary in order for Mozambique's natural gas resources to be developed. The government recognizes that Mozambique has the ability to come out of poverty through the development of its energy resources. Standard Bank estimates that LNG could add 15,000 direct jobs and $39 billion in gross domestic product per annum to the Mozambique economy by 2035.[44] The government of Mozambique has issued documentation considering issues such as transparency, regulatory clarity, revenue usage, infrastructure, education, and environmental protection to be priorities when determining the future development of their local natural gas resources.[45] While these are indeed noble intentions, there is still much work to be done in order to overcome rampant corruption, such as rent seeking, which could undermine development.[46]

Even amidst these challenges, there still remains significant interest from Asian investors in developing this LNG. Together both Tanzania and Mozambique make East Africa an attractive investment opportunity. Their location makes their export potential to India and South Asia viable. Companies that operate in Mozambique, such as Eni and Anadarko, plan to have LNG projects online around 2018 with an estimated capacity of 27.2 bcm/year.[47] Even though completion of these projects before the end of the decade may be optimistic, if these plans are implemented and successful, in due time they could result in making Mozambique and Tanzania significant LNG exporters.

Final observations

From this brief overview, we reach the following conclusions:

Though the U.S. regulatory processes for LNG exports to countries with which the United States does not have a free trade agreement are convoluted, lengthy, expensive, and could be further streamlined, there is no outright ban to sell natural gas to any country. To date, no project has been rejected by either DOE or FERC. Thus, it is essentially up to the market to figure out how much room there is for exports of natural gas from the U.S.

We believe that the U.S. LNG projects that are currently under construction, totaling close to 10 Bcf/d in capacity, will make it to the market by 2020, but additional projects are at this point increasingly uncertain. As noted, factors that are important to consider are alternative suppliers of LNG about to enter the market, as well as competition from existing suppliers, such as Qatar, and pipeline supplies from Russia, Norway, and Algeria, and perhaps by the mid-2020s, Iran. Demand in Asia will be affected by the success or failure of additional intercontinental pipeline projects. Russia continues to expand to new markets in Asia, particularly in China, the Koreas, and Japan. Additionally, Central Asian countries continue to add new production and pipelines to the Asian power and industrial markets. Demand will also be affected by the likelihood of at least some

[44] Standard Bank and Conningarth Economists, *Mozambique LNG: Macroeconomic Study*, (Johannesburg, South Africa: Standard Bank, 2014), http://www.mzlng.com/content/documents/MZLNG/LNG/Development/2014-MozambiqueLNGReport-ENG.pdf.

[45] ICF International, *The Future of Natural Gas in Mozambique: Towards a Gas Master Plan* (Washington, DC: Public-Private Infrastructure Advisory Facility, December 20, 2012): ES-17, 18, http://www.ppiaf.org/sites/ppiaf.org/files/publication/Mozambique-Gas-Master-Plan-executive-summary.pdf.

[46] Anne Frühauf, "Mozambique's LNG Revolution: A Political Risk Outlook for the Rovuma LNG Ventures," The Oxford Institute for Energy Studies, April 2014, http://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/04/NG-86.pdf.

[47] International Energy Agency, *Medium-Term Gas Market Report: Market Analysis and Forecasts to 2019*.

countries tapping into their own unconventional gas reserves in the coming years. If a country like China is successful in this endeavor, this will likely have a downward effect on LNG demand. Prices would also be affected. If, for example, a country like Argentina or Algeria is successful with new quantities of gas beyond their domestic requirements, then more supplies will reach at least regional markets putting a downward pressure on prices. Furthermore, the degree to which Japan (and to a lesser extent, South Korea) utilizes its nuclear capacity, can have a dramatic impact on LNG demand and the availability of supplies in the next couple of years. Finally, it remains to be seen whether there will be a global agreement to curb carbon emissions, as many energy forecasts seem to assume, and if so, what kind of agreement emerges, e.g., carbon pricing and GHG restrictions tend to favor natural gas and LNG, although outright requirements for or subsidies to renewables may have the opposite effect. Absent such an agreement, coal remains very competitive against LNG, especially in Asia's burgeoning electricity market. And then there are uncertainties in the LNG market itself, most prominently to what extent arbitrage between the different pricing regions in the market remains attractive, and whether promising technological advances like floating LNG facilities, small scale LNG, and usage of LNG in marine and transportation sectors become more widely dispersed.

Owing to strong environmental opposition by First Nations groups, leading local and international environmental organizations, and fishing interests, less rapid unconventional gas extraction, and less developed infrastructure, it is unlikely that Canada will have a LNG terminal up and running before the end of the decade. Canadian projects are opposed on a number of grounds (siting, impact on fisheries, adding to CO_2 emissions, pipelines serving the projects crossing wilderness areas in British Columbia), and in the current market constellation we believe it will be increasingly difficult to finance new projects, because demand in the coming years can likely be met by existing capacity in combination with those plants that are currently under construction.

In terms of foreign competition, Australia with early market entrance will be paving the way for the future shape of LNG exports. Despite budgetary and project setbacks, Australia's LNG exports are coming online before most of the North American projects. In the coming years we expect to see fierce competition between different LNG suppliers, as supplies outgrow demand, turning the LNG market into a buyers' market. In addition, in areas such as electricity generation, LNG competes with pipeline gas and other fuel sources. As described, there are many different factors that will determine the amount of the future growth of LNG demand, and we would be cautious to take the unprecedented growth figures that we have seen until 2011 for granted.

The jury is out on whether or not Tanzania and in particular Mozambique can become significant producers of natural gas, though there is enormous potential. With many investors interested in developing this region, the lack of infrastructure, rent-seeking, and the ability to complete construction are among the greatest risks to East African LNG market development in the short term. It is worth noting that in the current market environment, and keeping in mind the local challenges in East Africa, constructing greenfields may be increasingly challenging. At the same time, it has been done before, recently, for instance, in Papua New Guinea. LNG coming out of East Africa in due time may well have the ability to compete cost-effectively against North American LNG exports.

The U.S. projects that are currently under construction are unique in their price setting. Even though in the current modest oil price environment the immediate imperative for a more widespread adoption of this pricing formula may have faded, we believe that in the longer run it is likely that more gas producers will abandon the traditional model of oil-indexation. In northwestern Europe in 2008 and 2009 we saw a shift away from oil-indexation, incentivized by oversupply, and the supply glut that is anticipated in the coming years may well have similar effects. For major buyers of natural gas it is important to keep in mind though that spot-price indexation does not equal guaranteed lower prices, and more volatility is certainly one possible outcome.

In sum, the United States is poised to become a major global supplier of LNG, but its operators will face significant competition from a variety of suppliers, in terms of alternative LNG, pipeline gas, domestic production, and alternative energy sources. A number of Australian and U.S. projects are ahead of the curve and will come to the market in the coming years. In combination with slowing demand for LNG these developments will lead to a situation of oversupply, which is expected to last at least until 2017. Therefore, going forward, despite the presence of abundant resources worldwide, we believe it will be increasingly difficult to finance new LNG projects, due to high upfront costs in combination with a substantial number of uncertainties which influence supply and demand. That does not prohibit some of the aforementioned projects in for instance Canada or Mozambique to come to the market, as in due time surely we expect a new investment cycle that results in new liquefaction and regasification capacity coming on-stream.

ABOUT THE AUTHORS

Tim Boersma

Dr. Tim Boersma is a fellow and acting director in the Energy Security and Climate Initiative, part of the Foreign Policy Program at Brookings. His research focuses on energy policy coordination, energy security, gas infrastructure and regulation, and unconventional natural gas extraction.

From 2011 to 2012, he was a Transatlantic Academy fellow in Washington, D.C. Before starting his career in research, Tim spent five years in the private sector, working as a corporate counsel to the electricity production sector in the Netherlands. In November 2014 Tim published a Routledge monograph with Philip Andrews-Speed, Raimund Bleischwitz, Corey Johnson, Geoffrey Kemp, and Stacy D. VanDeveer called "Want, Waste, or War? The Global Resource Nexus and the Struggle for Land, Energy, Food, Water, and Minerals." In addition, his manuscript entitled "Energy Security and Natural Gas Markets in Europe: Lessons from the EU and the United States," is scheduled to be published in the series Routledge Studies in Energy Policy in September 2015. Boersma holds a Ph.D. in international relations from the University of Groningen.

Charles Ebinger

Dr. Charles K. Ebinger has nearly forty years' experience dealing with international and domestic natural gas issues. In 1977, Dr. Ebinger conducted a pioneering study for the American Gas Association (AGA) on the prospects for LNG imports into the United States. In 1983, he conducted another pioneering study for AGA examining the prospects for Natural Gas Vehicles in the U.S. market. During the early to mid-1980s Dr. Ebinger, as Director of the Georgetown University energy program at CSIS, was deeply involved in the policy debate on the pros/cons of Europe becoming more dependent on exports of natural gas from the Soviet Union for the NATO alliance, an issue he has continued to be involved on to this day. Dr. Ebinger has been involved in numerous studies focused on natural gas issues for the World Bank, the Asian Development Bank and USAID. Dr. Ebinger has served as a member of the Board of Directors for the Kokomo Gas and Fuel Company, an Indiana based natural gas distribution utility and North Coast Energy, an oil and gas production company.

Heather L. Greenley

Heather L. Greenley is a senior research assistant with the Energy Security and Climate Initiative. While at Brookings, she has written pieces on the U.S. crude oil export ban, global coal markets, and Arctic development. Her research on international policy issues includes global electricity markets, cybersecurity, and various aspects of energy security with regional focuses in the Arctic and China. She has a M.S. in Global Affairs from New York University where she served as president of the Energy Policy International Club and was awarded the 2014 AFCEA Intelligence Graduate Scholarship for her work on cybersecurity and the North American electricity grid. She has a B.A. in East Asian Language & Literature (Mandarin Chinese) from the University of Florida.

BROOKINGS
The Brookings Institution
1775 Massachusetts Ave., NW
Washington, D.C. 20036
brookings.edu