THE CENTURY FOUNDATION

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THE RISKS OF UNLIMITED EXPORTS OF NATURAL GAS

LOSING CONTROL OF OUR ENERGY FUTURE

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Natural gas has become a preferred fuel for power generation and residential and industrial heating applications. It burns very efficiently, leaves a lower carbon footprint than other hydrocarbon fuels, and produces minimal amounts of particulates, heavy metals, or other toxic emissions. The air pollution crises in rapidly industrializing nations have added momentum to a trend toward wider gas adoption.

The United States traditionally relied on indigenous supplies of natural gas. When its reserves began to shrink in the late 1990s, energy-intensive industries such as steel, refining, paper, cement, fertilizer, and others were hard hit. Chemical manufacturing, which uses hydrocarbons for both fuel and feedstock, was especially disadvantaged.

But over the past decade, the shale gas revolution has America suddenly swimming in cheap gas. Most other advanced manufacturing countries, especially those in the fast-growing economies of Asia, import much or all of their gas, usually at oil-indexed prices two to three times higher than those in America, net of transport costs.

Not surprisingly, American chemical exports are rising rapidly, and a parade of foreign chemical companies are opening operations in the United States. Similar patterns are visible throughout the heavy manufacturing sector. Because of their long supply lines and transportation requirements, such industries are also potent job-multipliers. The potential recovery of heavy manufacturing also dovetails nicely with a nascent "reshoring" opportunity due to rising costs in China and other outsourcing centers. Substantial recent efficiency-oriented investment by American companies enhances the opportunity. A comprehensive analysis by economists at Citigroup, combining findings from several smaller studies, forecast the creation of between 2.2 million and 3.6 million net new jobs by 2020.[1]

The price differential between American and overseas gas has also created an enticing arbitrage opportunity for the energy industry. Federal permits are generally required before exporting gas, and the American industry is lobbying for wide approvals. The current queue of permit requests—if approved and actually implemented by their sponsors—would allow the export of more than half the current annual U.S. gas production.

The drive for gas exporting has been opposed by an ad hoc alliance of heavy manufacturers—led by Nucor, Dow Chemical, and Alcoa—called America's Energy Advantage (AEA). They argue that the jobs and growth dividends from a gas-fueled manufacturing revival would far outweigh the returns from gas exports. They concede that limited amounts of exports would not be harmful, but that large-scale exporting at foreign prices would inevitably reset American prices to foreign, oil-indexed levels, imposing a heavy "rent extraction" premium on their customers.[2]

The economics profession has generally supported the arguments of the energy industry. Since several major gas-producing nations have even lower production costs than America, theory predicts that dynamic markets should react to American exports by squeezing out the rents component and forcing prices down to the American level or below. A corollary of that scenario is that the ultimate volume of American exports will be small irrespective of federal permit policies. The consensus of the major studies is that U.S. exports outside of North America will not exceed 10–15 percent of current output.[3]

Real world considerations, however, argue for greater caution in allowing exports. It is simply not true that economists can predict the future course of gas supply and demand, and prices cannot be forecasted with any certainty. Forecasts generally use equilibrium models that assume auction-type price setting and smooth price adjustments to keep supply and demand in approximate balance—assumptions that fit poorly with the realities of the global gas market.

Outside of North America, trading is dominated by oligopolies—either national companies or the oil majors. Contracts are generally long-term at indexed prices, and often negotiated by the respective governments. Gas is also the most difficult of the fossil fuels to transport, but outside of North America, the most important energy-consuming nations are gas-short, and at long distances from exporters. Gas pipelines require compression and large-diameter pipes. Ocean shipping requires specialized tankers and multi-billion-dollar liquefaction and regasification plants at the sending and receiving ports. Putting substantial new pipeline or liquefaction/tanker supply into place takes at least half a decade, and often much longer.

Many important suppliers—in Africa, the Middle East, and Central Asia—are politically unstable, while Russia, the world's largest gas exporter, has several times proved itself an unreliable partner. The prospect of China becoming a major gas importer is yet another source of instability. The country's voracious appetite for resources since the turn of the millennium has destabilized one commodity market after the other, and it is easy to construct similar scenarios for gas.

In short, global gas markets have a history of lurching from gluts to shortages with extreme price volatility; and the larger the American role in export markets, the more likely the volatility will be reflected in our domestic prices. Such risks cannot be quantified in a meaningful way, but their effects could be quite severe. Conventional economic models are not helpful in assessing such risks, since their assumptions usually preclude them.

The drive for exporting has been in part fueled by a glut of natural gas. Shale gas entrepreneurs, often to comply with site leasing terms, produced gas far in excess of pipeline capacity or the ability of their customers to absorb it. But since a low point in mid-2012, prices have recovered to just under the $4–6 per thousand cubic feet (Mcf) unit price at which the industry is generally considered to be profitable. Profitability has also benefited from improved segmentation of production. "Dry," or almost pure, gas output has been rising strongly at the Northeast's 100,000-square-mile Marcellus shale to feed regional utilities, while producers in liquid-rich shales have shifted to tight oil and higher-margin shale liquids. Judging by recent company presentations, it appears that, although the industry had a rough 2011 and 2012, it is now in much better financial shape. [4]

Superficially, there appears to be a wide swathe of agreement on the most important issues. Studies sponsored by the industry and independent researchers generally agree on the modest scale of the export opportunity. Opponents of unrestricted exporting, like the AEA, concur that exporting in the predicted range would not disrupt American pricing. The DOE has actually given the green light to that amount of exporting, and appears likely to approve even more. The industry, however, is lobbying hard for automatic approval of all environmentally compliant projects, ostensibly to allow "market forces" to sort out the optimum outcomes.

The disconnect between the fierceness of the industry lobbying campaign and the presumed modesty of the export opportunity suggests that gas companies think there may really be an opportunity for a profitable arbitrage—exploiting inherent market rigidities to achieve high levels of exports with a substantial rents component. Beyond a tipping point of export volumes, domestic gas prices would inevitably be dragged up to match the international "netback," or the revenue after transport costs.

The purpose of this issue brief is not to prove that such an outcome will ensue, but merely to show that there is a real risk that it could. While that "risk" would be a boon for the global energy companies, it would impose heavy costs on Americans and dash promising opportunities in manufacturing, costing perhaps millions of blue-collar jobs. Because gas exportation would require a faster ramp-up of production, it could invigorate the anti-fracking movement, and quite possibly drain away some of our most economically attractive reserves. Those are not risks worth taking.

THE INSTABILITY OF INTERNATIONAL GAS MARKETS

Since gas is difficult to transport, industry trading flows have traditionally been intra-regional. As with oil, international gas transport is by pipeline or tanker, but because of the low energy-density of gas at atmospheric pressures, special provisions are required to make it cost-effective. International gas pipeline arteries are very large and require high compression, but depending on geography can still be cost-effective at distances of thousands of miles. Efficient ocean transport requires that the gas be cryogenically liquefied to about the same energy-density as crude oil and shipped in specialized tankers. Liquefied Natural Gas (LNG) plants cost tens of billions of dollars and the importing locations must be equipped with regasification plants that are only somewhat less expensive. In general, LNG shipping becomes relatively more cost-effective than pipelines as distances increase. Most important, unlike pipelines, LNG tankers can be redirected almost anywhere to keep pace with market demand.

Major pipelines and liquefaction/regasification infrastructures take years to plan and construct and require large upfront investments, but operating costs are low. Projects are therefore typically financed with syndicated long-term debt (twenty years or longer), financed by comparable-maturity price-indexed customer contracts. Such contract structures can introduce difficult pricing rigidities during periods of volatile markets.

While gas market areas have become progressively larger, they still break along regional lines. Except for North America, there are substantial mismatches between gas-producing and gas-consuming markets.[5]

Table 1. Gas Production and Consumption, by Region

Region/ Country TCF/Y*	2012 Production	2012 Consumption	Prod. minus Cons.
North America	30.9	31.0	-0.1
United States	23.9	25.6	-1.7
OECD Europe	10.0	19.6	-9.6
OECD Asia**	2.5	7.5	-5.0
Australia	2.3	1.3	1.0
FSU*** and Eurasia	26.7	20.8	5.9
Other Asia****	14.8	14.2	0.6
China	3.8	4.4	-0.6
Middle East	18.6	14.3	4.3
Africa	7.0	3.6	3.4

*Trillion cubic feet per year
**Primarily Japan and Korea
*** Former Soviet Union
****Major producers are Indonesia and Malaysia
Source: U.S. Energy Information Administration, *International Energy Outlook 2013*, July 2013, World Natural Gas Consumption/Production Reference Cases, http://www.eia.gov/forecasts/ieo/index.cfm.

As Table 1 shows, North America is in approximate balance. The United States, Canada, and Mexico are linked together by extensive pipeline connections and function as a more or less single integrated market. The United States imports modest amounts of gas from Canada, and exports roughly similar amounts to Mexico.

Industrialized Europe is the largest natural gas importer, importing more than half its supply. Declining native resources and rising gas usage portend continued reliance on imports. Imports are primarily by pipeline, with approximately 50 percent coming from Russia, 40 percent from Norway, and 10 percent from Africa. It has also been expanding its LNG imports, primarily from Africa and Qatar.

Russia is the world's largest gas exporter; in 2011 it sent 7.8 trillion cubic feet (Tcf) of pipeline gas primarily to Europe, but also to Turkey and Central Asia. But it has a record of being an unreliable partner, using its market power for political purposes—shutting off major pipelines to Europe in 2009, for example, to pressure Ukraine during a pricing dispute. Because of its position on the littoral of the Caspian Sea, a highly productive oil and gas region, Russia has dominated exports from Central Asia. To diversify from Russia, Europe has been developing new Caspian pipeline supplies from Khazakstan, Turkmenistan, and Azerbaijan that will circumvent Russia.

The OECD Asia region consists of Japan, Korea, and Australia/New Zealand. Japan and Korea produce almost no gas, and between them take about half of the world's LNG exports, with Japan's dependency spiking in the wake of the Fukushima disaster. Australia, on the other hand, has been investing heavily in additional LNG capacity and will export about 90 percent of its new gas production.

Although the Other Asia region looks deceptively balanced, it encompasses large international gas flows. Indonesia and Malaysia are major producers, exporting a net of about 2.4 Tcf in 2012, although their capacity is diminishing. China, India, and a host of smaller Asian industrial countries have traditionally relied on coal, but the dangerous state of Asian air pollution is forcing a greater emphasis on gas, which generally must be imported. China is simultaneously adding to its LNG import capacity, bargaining with both Russia and Central Asian gas exporters for major new pipelines, and letting contracts to exploit its own large shale gas deposits. The U.S. government's official forecasting agency, the Energy Information Administration (EIA), expects that by 2035, coal's share of China's energy budget will have shrunk from 70 percent to 59 percent, but that China's consumption of coal will still have doubled.

The Middle East remains the second largest exporter of gas, behind only the states of the former Soviet Union (FSU), but its exports should flatten for the foreseeable future, due to hyperdevelopment on the Arabian Peninsula and the region's wasteful consumption of subsidized fuel. Qatar is the world's largest LNG exporter, having developed massive new exporting capacity for the much-anticipated but illusory boom in American gas imports, and has no current plans to add capacity. Oman and the United Arab Emirates are also major gas exporters, but their reserves have been falling. Saudi Arabia is planning aggressive development of its gas reserves, but primarily for in-country use in order to free up more oil for export. Modest internal pipelines connect Lebanon, Syria, and Israel to Egyptian gas, but constant unrest in the region makes supply very unreliable. Iran could become a major supplier, if it can succeed in lifting western sanctions, but its infrastructure has been poorly maintained, and could take a number of years to reboot.

Africa is the third largest gas exporter. Besides the traditional North African fields (in Egypt, Algeria, and Libya) there are major fields in sub-Saharan Africa and its coasts. Nigeria is estimated to have the ninth-largest gas reserves in the world, although they are poorly developed. In 2011, the country produced about 1 Tcf of gas, and exported 80 percent of it, most of it as LNG, and most of it to Europe. Orderly development of the country's hydrocarbon reserves has been limited by civil unrest and political instability. Gas production is managed by Shell and Total, and directed primarily to exports rather than internal development. (Only half of the country is electrified.) Angola has the second-largest continental oil and gas reserves after Nigeria, and its first LNG plant achieved operational status last spring. It has the capacity to export about 350 billion cubic feet (Bcf) annually, most of which will be directed to Asia. Stated intentions of African leaders to direct more of their hydrocarbons to internal development could undercut current export expectations.

In short, much of the world's exportable gas supplies are in unstable states, vulnerable to a range of disruptions caused variously by technical backwardness, political interference, corruption, or revolution and war. Gas demand and supply move in large-scale discontinuous jerks, rather than in smooth curves. All projections and timetables are suspect, and it takes years to make major upward adjustments in supply. The post-Fukushima price disruptions would have been much more violent, for example, if Qatar had not made its offsetting miscalculation of American demand. In a world in which large-scale singularities are the norm, extreme price volatility should be expected.

THE AMERICAN NATURAL GAS INDUSTRY

The late George P. Mitchell of Mitchell Energy brought in the first commercial shale gas well only fifteen years ago, but shale gas now accounts for a third of American gas production, a share that will steadily rise as conventional gas resources dwindle. American gas markets are the deepest and most liquid in the world. Prices are based on spot and futures trading at the Henry Hub, a major pipeline collection and processing point on the Gulf Coast of Louisiana. By volume, the Henry Hub is the third-largest physical commodity market in the world.

In the late 1990s, American gas was extremely cheap, with spot prices averaging about $2.50 per Mcf.[a] As gas shortages began to bite, prices rose to the $10 level and beyond, actually sparking fevered interest in LNG importing, until the dimensions of the shale gas opportunity began to be understood in the mid-2000s. The first enterpeneurial rush into the gas fields quickly generated a gas glut. (Many shale leases mandated minimum production levels, so well development often outran distribution pipeline capacity.) By the spring of 2012, spot gas dropped to only $1.83. The economic recovery, weak as it is, coupled with major pipeline investments drove prices to more than $4 last spring, and they hovered just below that level into the fall. Most experts agree that the industry is profitable when Henry Hub prices are in the $4–6 range.

Regulating Exports

LNG terminals require environmental permits from the Department of Energy's Office of Fossil Energy (DOE/FE) and the Federal Energy Regulatory Commission (FERC), an independent regulatory body within the DOE. Projects that that pass the environmental hurdles must receive a timely permit if they are exporting only to countries that have Free Trade Agreements (FTA) with the United States. Plants planning to export to non-FTA nations must also be approved, unless there is a finding that the exports are not "consistent with the public interest." (Canada, Mexico, and Korea are the only important gas-using states currently covered by FTA agreements.) Among the "public interest" criteria, the DOE has listed adequacy of domestic supplies, economic impact, trade balances, international relations, deference to market judgments, and anything else raised during public hearings.

While the DOE/FE concentrates on generating broad public testimony on the merits of a project, the FERC conducts an exhaustive nuts-and-bolts examination of the plant and its proposed operation. The round-number price estimate for a full-blown FERC review is $100 million. To expedite the review process, the DOE and FERC have established a FERC pre-filing procedure that will flush out basic designs and operational issues during the DOE/FE hearings cycle. If the FERC certifies the successful completion of the pre-filing inquiries, and if the DOE/FE hearings have not raised any show-stopping environmental issues, and, usually, if the facility has contracted for most of its product, DOE/FE will conditionally certify the project. FERC then completes its final review, which will entail settling all key environmental, engineering, and operational questions. When FERC is satisfied, construction can begin.

As of this writing, twenty-one[b] projects for non-FTA LNG exporting have been proposed to the DOE, encompassing 12.45 Tcf per year, or slightly more than half of total 2012 U.S. gas consumption. One project has received all approvals and is in construction. Three others have been approved by the DOE, conditionally on the completion of the final FERC certification. Assuming all four plants go into operation, they will export 2.3 Tcf per year, which is already within the range of economists' consensus on the likely exporting opportunity. The rate of approvals has also been accelerating. After approving the first project in May 2011, the DOE placed a moratorium on approvals to conduct further policy analyses. The second project was then approved on May 22, 2013, the third on July 22, and the fourth on September 11.[6]

At the moment, the DOE seems to following the logic of a much-criticized study contracted in 2012 to the consulting group NERA Inc., which seems to hew closely to the industry position.[7] In apparent response to criticisms of the study, the DOE has taken pains to defend it in each of its recent export approval statements. But the DOE has also expressly refused to accept the industry desire that export volumes should be determined entirely by the market, implicitly reserving its right to impose volumetric limits if it is adjudged to be in the public interest.

[a] Henry Hub prices units are in millions of British thermal units (MMBtus), while the DOE tracks export capacity in thousands of cubic feet (Mcf). To a second decimal place, one cubic foot of gas equals 1,000 Btus, so $2.50 per Mcf is essentially identical to $2.50 per MMbtu at the Henry Hub. The EIA also uses both cf per day and cf per year in its reporting. Other metrics commonly used are tons, cubic meters, megawatt hours, and barrels of oil equivalent. For consistency, I use the metric of cf per year throughout this essay.

[b] This count omits several micro-exporting projects that will not involve a coastal LNG terminal, and consolidates several related projects.

THE PITFALLS OF LNG EXPORTS

The decision whether to export should turn on at least five questions:

- How much recoverable gas does America have?
- How does that supply measure up to American demand for gas?
- What is the trajectory of foreign demand for LNG?
- Who will be competing for the LNG opportunity? and
- How will an exporting drive affect American gas prices?

U.S. Gas Supply

There is a wide range of estimates of America's recoverable gas reserves, with the export lobby consistently on the most optimistic side. For example, the EIA has recently estimated U.S. recoverable reserves at 1,582 Tcf. The American Petroleum Institute (API), an industry trade group, however, released a roughly contemporaneous study with a forecast more than twice as large, at 3,500 Tcf. [8]

A common feature of the optimistic forecasts is that they make no allowance for the public's attitude toward shale drilling. Shale gas is widely and thinly distributed, so shale drilling strays far away from traditional oil and gas country. The Barnett shale in the Fort Worth region is the world's most intensively developed shale formation, and wells are often cheek-by-jowl with suburban developments and shopping malls. Texas has a history of privileging the energy industry, but other regions are not so welcoming. A single major accident with civilian casualties (methane is quite flammable) could seriously disrupt supply flows.

The calculation of reserves is complex. Although the journalistic emphasis is on shale gas, there are six components to the American supply picture—Alaskan conventional gas, coal bed methane (CBM),[c] lower 48 offshore gas wells, lower 48 conventional gas wells, "tight" gas,[d] and shale gas. (See Table 2.) Under the EIA's most recent forecast, Alaskan gas output more than triples, but from a very small base, while CBM, lower 48 offshore, and tight gas all show only modest growth. The real action is between the precipitate decline of onshore conventional gas fields and the rapid growth of shale gas. Since the resulting estimate is the residual of a number of other estimates changing at different rates, the potential for error is high.

Two data points suggest how unstable such estimates are. The Marcellus may be the most important gas shale formation in the world, but last year the EIA reduced its estimate of the Marcellus's reserves from 400 Tcf to 141 Tcf, a 65 percent reduction.[9] The second is the current DOE estimate of "proved reserves" of gas, a tighter definition than "technically recoverable reserves." Proved reserves are essentially currently recoverable reserves with all the projections and guesswork removed. DOE's current estimate of U.S. proved gas reserves is 305 Tcf, or just 9 percent of the API's projection. The shale gas component of that is just 94 Tcf. [10]

Table 2. Components of the Energy Information Administration 2040 Gas Forecast

	VOLUME TCF		PERCENT TOTAL	
Source	*2012*	*2040*	*2012*	*2040*
Alaska Conventional	0.32	1.18	1.3%	3.5%
Coalbed Methane	1.67	2.11	7.0%	6.4%
Lower 48 Offshore	2.19	2.85	9.2%	8.6%
Lower 48 Onshore Conventional	5.83	2.96	24.4%	8.9%
Tight Gas	5.76	7.34	24.1%	22.2%
Shale Gas	8.13	16.70	34.0%	50.4%
TOTAL	**23.91**	**33.14**	**100.0%**	**100.0%**

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2013*, April 2013, http://www.eia.gov/oiaf/aeo/tablebrowser/.

A final confounder is that all supply estimates are critically dependent on the elasticity assumption—how easy is it to increase supply in response to more demand? Optimists project high elasticity, or flat supply curves—that ramping up production a lot will have little effect on the price of gas. Total U.S. shale gas production to date is about 30 Tcf. The API study assumes we could produce another 750 Tcf of shale gas easily enough without having to resort to more costly extraction methods, all the while keeping Henry Hub prices below $5. That is more than twice the total shale gas production forecast by the EIA from now until 2040, and would support a far higher level of gas exploitation than almost anyone contemplates. Skeptics, of course, assume steeper supply curves. While few doubt the great extent of U.S. gas reserves, many still worry about the difficulties of getting it out.[11]

In truth, all such estimates are merely informed guesses. While the geology of most U.S. shales is reasonably well known, only a relatively small portion has been intensively exploited, so real-world drilling histories are still sparse. The Marcellus gives up its gas treasures easily, but Rocky Mountain shales may not. There was great excitement a few years ago about the high quality of Eastern European shales, especially in Poland. The majors rushed in, and after several years of disappointment, all but Chevron seem to have given up.[12] California's Monterey shale, a tight oil play, was heralded as even bigger than the fabulous North Dakota/Montana Bakken, but closer examination has geologists puzzling how, or whether, they can possibly get product out. [13]

[c] Coal mines trap large amounts of methane that can be accessed by techniques similar to those used for shale wells. CBM makes up a large share of Australia's gas supplies, but has a minor role in the United States.

[d] Tight gas is trapped in sandstone or similarly porous media; harvesting methods are similar to those for shale.

U.S. Gas Demand

Demand is easier to evaluate than supply, since the critical data are not buried miles below the earth's surface. The key indigenous drivers of gas demand are growth in power usage and/or changes in gas's share of power generation, plus changes in gas's use as a feedstock. Absent regulation, shifts in the international energy demand/supply curves determine net exports.

In its current reference case, the EIA assumes slow growth in industrial energy consumption, and continued decline in energy consumption per capita, due to higher efficiency vehicles and residential lighting. The EIA also assumes that as coal prices continue to fall, coal will claw back some of its recent share losses to natural gas in power generation. On the export side, the EIA projects a modest 1.6 Tcf of LNG exports in 2025, and minimal net pipeline exports. (The United States now imports natural gas from Canada and exports it to Mexico; Canadian imports are falling while Mexican imports will continue to grow. On net the agency forecasts a net pipeline outflow of 1.1 Tcf by 2035.)[14]

It is easy to make a more bullish case. Analysts at Bernstein Research built up a ten-year (2012–2022) projection of natural gas consumption that grows more than twice as fast as forecast by the EIA.[15] Bernstein analysts assume, probably correctly, that the Obama administration will be tougher on emission regulation in his second term, which will favor gas. (Coal-fired and gas-fired power plants now generate about the same amounts of electricity, but the coal-fired plants produce four times the emissions.) They also assume a continuation of recent increases in industrial gas consumption, which is also likely correct. And, finally they assume 2.3 Tcf of LNG exports. That almost quintuples the EIA forecast, but the four LNG projects already approved take us almost to that volume, and there will almost certainly be more approvals.

The cumulative result is a Bernstein forecast of 2022 gas consumption that is more than a quarter, or 7 Tcf, higher than that of the EIA. Most of the increment will come from new shale gas production, since none of the other components of the U.S. gas pool has the required growth potential. That will require more than doubling the 2012 production of shale gas. It is certainly feasible, for the industry has ramped up very rapidly in the past. The real question is whether it can do so without major price effects or a more intense environmentalist reaction.

Over the longer term, the wild card in American gas usage is transportation. Gasoline is the most efficient transportable form of energy, so it is an ideal transportation fuel. Current compressed natural gas (CNG) transportation solutions provide about one-third less energy per weight unit, but if American gas prices stay de-linked from oil, a switch to CNG-based transportation would be worth it, and would bring a big emissions bonus. For the medium-term future, there is likely to be a fairly rapid increase in CNG truck fleet and railroad conversions, but the prospect of CNG or LNG private automobiles is still quite speculative.[16]

Foreign LNG Demand

The LNG consumption story for the next several decades will be centered in Asia and dominated by China. The United States may also have opportunities in Europe, but they are likely to be quite constrained. The unexpected surpluses of Qatari gas have forced Russia to reduce its rent extractions, while Russian and Central Asian production and delivery costs should continue to be lower than U.S.-sourced LNG.

But China, as always, is a different case. The EIA projects that, by the late 2030s, China will be consuming more than double the gas consumed by the next three biggest Asian consuming nations combined.[17] (See Figure 1.)

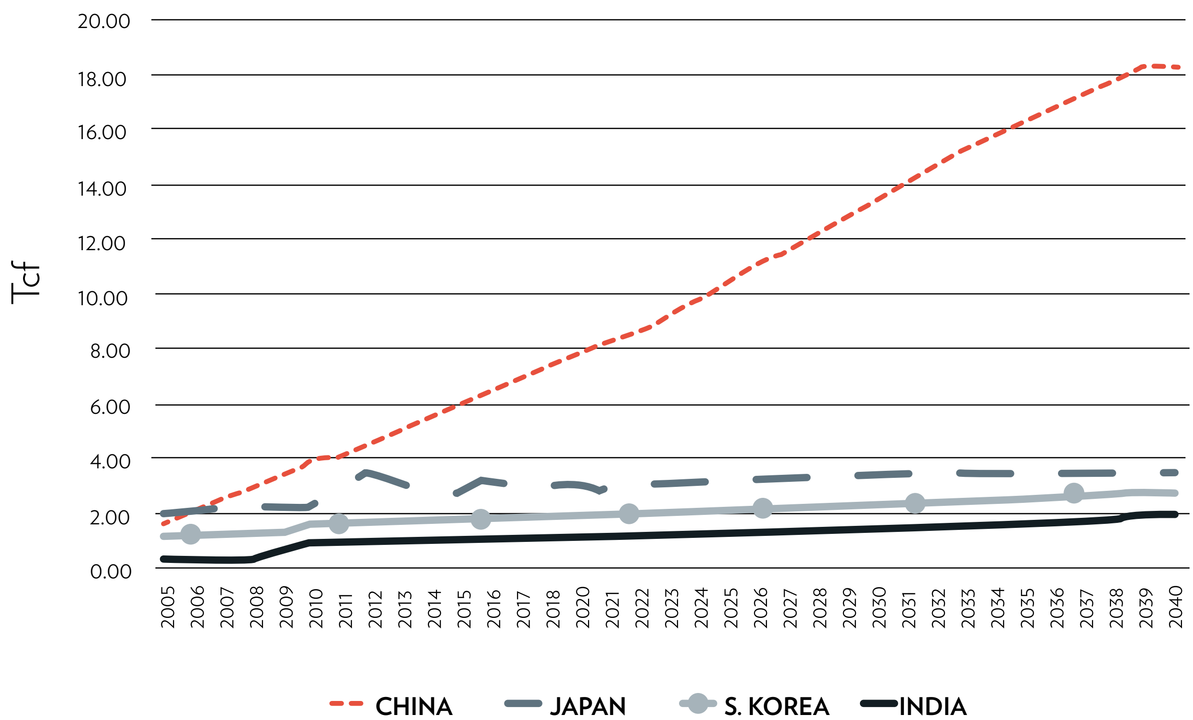
On its face, this forecast is not unduly alarming. The IEA forecasts a slightly higher figure of 19.2 Tcf for 2035, but it assumes that 11.1 Tcf will be from indigenous production. Of the remaining 8.1 Tcf, 4.6 are assumed to come from Russian and Central Asian sources, mostly by pipeline but with some LNG. That leaves only 3.5 Tcf for the global LNG market, which seems quite digestible. But recent history demonstrates what a disruptive force China can be. Its great manufacturing export drive moved into high gear about 2000. Between 2001 and 2007, China's metals exports increased sixfold, and its share of global steel manufacture soared from 15 percent to 45 percent, while steel production in the rest of the world was nearly stagnant. To feed its steel-making machinery, China's iron ore imports soared. By 2009, China accounted for 54 percent of global iron ore demand, 73 percent of which was imported. Figure 2 shows the resultant tenfold jump in iron ore prices. Chinese pressures on nickel and copper prices were only somewhat less extreme, as both rose about fivefold.[18]

In the light of that experience, the strong official Chinese commitment to gas is disquieting. The current Chinese Five Year Plan, to 2016, calls for gas consumption growth twice as fast as the EIA forecasts. (The EIA expects a growth of 1.8 Tcf in gas consumption between 2012 and 2016, against the Five Year Plan's target of 3.5 Tcf growth.) The Chinese government has trumpeted the importance of the shift to gas, and is pumping floods of money into the provinces, which, if skeptics are to be believed, may be producing mostly Potemkin-like gas pipelines to nowhere.

Projections by China's leadership treat shale gas and coal bed methane as the most important source of growth in indigenous production. China's National Energy Administration sets a median shale gas target of 2.8 Tcf/Y by 2020, which the EIA describes as "ambitious." A BP executive is less diplomatic: "It will be a long time before China could commercialize its shale resources in a large way." Current shale gas production is still at an exploratory stage.[19]

China does in fact have immense shale gas resources, and there are areas with Marcellus- and Barnett-like characteristics. But large areas of the Chinese shale are problematic. Much of it is lacustrine (formed in lakes), with high clay content that is difficult to fracture, while the marine shale areas are frequently

Figure 1. Anticipated Gas Consumption in Four Asian Countries



Source: U.S. Energy Information Administration, *International Energy Outlook 2013*, July 2013, http://www.eia.gov/oiaf/aeo/tablebrowser/.

tectonically unstable, very deep, or with low organic content. Coal bed methane may also disappoint; after twenty years of development, annual production is only about 180 Bcf, far too small to make a meaningful contribution to the country's energy supply. Given sufficient resources, time, and ingenuity, all those problems may be soluble, but it could take much longer than the leadership is hoping.[20]

The energy transition in China is usually presented as part of the country's rebalancing from an investment- and export-led growth strategy to a greater focus on consumers. That rhetoric is belied, however, by the government's pharaonic, energy-gobbling infrastructure projects, including creating new cities for 250 million people from scratch, with all the roads, train connections, airports, electrical utilities, continent-scale aqueducts, and urban water and waste disposal systems that they will require. The China risk, in short, is that its standard top-heavy, energy-intensive, State-Owned-Enterprises-driven strategy of mega-investment will continue to be the path of least resistance in order to maintain growth. Coal usage will continue to grow with predictable consequences, while internal gas production will lag far behind plan.

That is clearly a worst case, but not at all beyond the realm of possibility. The odds are fairly high that the Chinese government's assumptions of indigenous gas production will turn out to be optimistic, even wildly off the mark. [21] The estimates for volumes and timing of Russian and Central Asian pipeline imports are far from guaranteed, if only because of the long history of fractious relations between the principals.

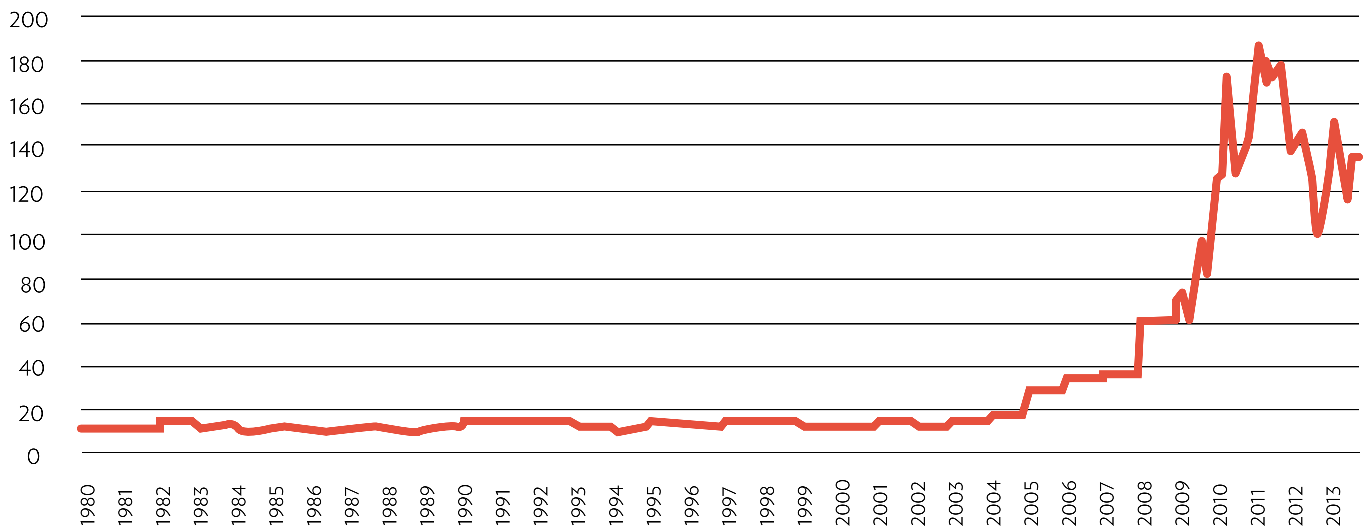
Finally there is the question of how much longer the Chinese can increase their coal consumption. There is plenty of coal, but its use may be self-limiting. The Beijing government recently announced a series of shut-down triggers based on the city's air pollution index. At the third level ("orange"), factories are shut down—and there would still be another alert level to go. A week after the Beijing announcements, when the city of Harbin, with ten million citizens, turned on its coal-fired municipal heating system, the pollution output was so great that visibility dropped to ten meters, traffic was paralyzed, schools were canceled, and older citizens were urged to stay home.[22] There is a point at which even citizens as docile as the Chinese start to rebel. The EIA forecasts that China will double its coal consumption over the next twenty years, but that may well be intolerable.

Since LNG is the only flexible method of long-distance gas supply, it will necessarily be the shock absorber for excess Chinese gas demand. For the right price, LNG vendors will break contracts and re-direct deliveries, so if a desperate Chinese government begins hoovering up the world's LNG supplies, we could easily see a repeat of the experience in the global metals trade.
Outside of China, most gas markets will grow, but only gradually. The most important variable may be how quickly Middle Eastern countries shift energy production to service their own development, which could squeeze supplies in the rest of the world.

Global LNG Supply

Recall that supporters of unlimited LNG exporting insist that the export opportunity is a small one (so it would be unlikely to affect American prices much). The underlying premises are that

Figure 2. Price of Iron Ore, in dollars per metric ton



Source: International Monetary Fund, Primary Commodities, Monthly Data, http://www.imf.org/external/np/res/commod/index.aspx.

there will be ample LNG supplies, so the current rent extractions would not be feasible, and that the United States, in a rent-free market, would not be a low-cost provider. (See Table 3 for relevant amounts.)

Table 3. Global LNG Current and Forecast, Tcf per year

2012 Global LNG Exports	11.0
New Foreign LNG in Construction	10.9
New U.S. LNG in Construction	1.5
New U.S. Approved*	0.8
On Advanced U.S. Application List**	7.6
API Estimate of Global LNG (In Construction + Planned)	18.0
API Estimate of Global LNG Requirements 2035 Low & Middle Case	16-19
API Estimate U.S. 2035 Low & Middle LNG Export Case	1.5-3
EIA Estimate of U.S. LNG 2035 Exports	1.5
Bernstein Research Estimate of U.S. 2022 LNG Exports	2.3

*Pending final FERC Certification
** Prefiled with FERC and have customers
Source: Associated Press International, Department of Energy, Energy Information Administration, Bernstein Research.

Table 3 shows that total global LNG exports last year were about 11 Tcf, which is about the same amount as the new foreign LNG capacity under construction, and close to the capacity of the U.S. plants already approved and in the current DOE approval queue. The API has also compiled a list of global planned LNG projects, which brings the putative total future global LNG capacity to 18 Tcf, which is pretty close to the estimated demand for their "Low" and "Middle Export" 2035 cases. If they are right, the United States will have to fight for share, and can expect only modest export sales over the period of the forecast.[23]

Charles River Associates, which was retained by the AEA alliance of heavy manufacturers, suggest that the API has seriously overestimated future global LNG capacity. Of the 7.3 Tcf of capacity that the API lists as in the planning stage, about a quarter of it has already been shelved, and another quarter is so far in the future as to be quite speculative.[24] But in fact, if LNG growth follows the consensus models' predictions, building that much export capacity would be foolish. On the other hand, if there were a desperate spike in China's LNG demand or some other demand shock, it would not be nearly enough.

For the time being, the Asian LNG supply story is about Australia. The country has centered its growth strategy on exporting natural resources—oil, coal, iron ore, and gas—into the Asian manufacturing juggernaut. Of the twelve LNG-exporting terminals under construction outside of the United States, eight of them are in Australia, comprising three-quarters of the new capacity. [25]

The NERA report assumed that the Australians enjoyed sizeable cost advantages over American gas. But that is no longer clear. The proposed U.S. LNG export terminals are nearly all to be built on the sites of idle import terminals, so tanker-ready docks and much of the required pipelines and product handling equipment are already in place. Retrofitting a U.S. import terminal for LNG exporting is still very expensive—usually in the $5 billion to $7 billion range. But Australian plants are all "greenfield" sites, and mostly in hard-to-supply remote areas; so total costs are about three times that of the American retrofits. The biggest Australian project of all, the mammoth Gorgon LNG development, is being built on an island that is also a wildlife conservancy site—at a cost in excess of $50 billion.[26] Browse, a 600 Bcf per year LNG plant, expandable to twice that output, owned by a consortium comprising major Australian, Japanese, Chinese, and European companies, is much delayed. Its Final Investment Decision (FID) was first scheduled for mid-2012, eyeing a probable operational startup in 2016. Rising costs pushed the FID to mid-2013, and again just recently to 2015, in order to execute a complete redesign in the hope of bringing costs under control. A startup before 2020, if at all, is increasingly unlikely.[27]

A recent blog post from an Australian academic with long industry experience recalls the "euphoria" that characterized the country's initial foray into LNG, then recounts a litany of canceled or postponed projects, "massive cost increases," project sponsors trying to dump their stakes, growing community opposition, and global partners "sounding increasingly cautious." He also suggests that coal bed methane reserves, Australia's mainstay, "are proving harder to add than original expectations with increasingly complex and expensive wells likely to be required." And a recent editorial in the Australian Financial Review, which is in favor of the exporting program, lamented Australian and European companies defecting to the United States in search of cheap energy, and the growing power of the environmental opposition. The editors worried that "this could all degenerate, with unnecessary constraints on gas supply colliding with the demand shock from our new LNG export industry."[28]

Australia is quite different from the United States. For one thing, it intends to export almost all of its gas, since its industrial sector's needs are small relative to its gas supplies. With respect to a potential competition with America, it now looks more likely that Americans could undersell the Australians rather than the other way around. Further, from a market standpoint, continued delays in Australian product coming online will also add to market tightness.

LNG Pricing

Oil-Linking. One of the promised benefits of a strong American entry into international gas markets is that it would squeeze out the sizeable rent extraction premium inherent in the oil-linked pricing that is especially egregious in Asia. Oil-linking originated as the international gas trade expanded in the 1990s and early 2000s. Financing the heavy capital costs of pipelines and LNG plants requires long-term contracts, and some form of price indexing. At the time, crude was trading at about $25 a barrel, and there was only limited international gas trading, so indexing to oil made perfect sense. The indexing was typically to a discounted oil spot price, and usually included caps and collars to dampen temporary price swings, as well as sliding scales so even permanent pricing changes were incorporated gradually. The export markets were dominated by a few players—Russia with its pipelines into Europe, and Qatar, Indonesia, and Malaysia shipping LNG into Asia.

When oil prices began to escalate, gas suppliers, in a sellers' market, generally refused to modify their contracts. The sudden bonanza of Qatari gas intended for America, however, forced concessions from Russia, and some contracts have been shifted to European gas hub-based pricing. (But Europe's most liquid gas hub, the Dutch Title Transfer Facility [TTF], a virtual trading site, has recently traded at the equivalent of a $10 Henry Hub contract price.) Asian gas consuming companies, with the strong encouragement of the Geneva-based International Energy Association (IEA), are attempting to organize a buyer's club to force Henry Hub-based indexing, and eventually to create a liquid Asian trading hub to replace oil-linking. It seems unlikely that they will succeed. Post-Fukushima Japan will buy at whatever price they can get for the foreseeable future, and by all reports, gas exporters to Asia have been stiffening their terms. Australia's newest LNG plant opened last year, and its prices to Asia are determinedly oil-linked; indeed, as a veteran industry consultant suggested, oil-linking may come pretty close to their real costs.[29]

Henry Hub Indexing. LNG pricing has several components: the cost of the gas, pipeline transport, liquefaction, shipping, and regasification at the importer's terminal. Assuming a Gulf Coast point of origin, and shipping through the expanded Panama Canal to Japan, the total liquefaction, shipping, and regasification cost would be about $6 per Mcf. The gas and associated pipeline charges would be about $4.50, at most.[30] Recent Asian spot prices (Platt's Japan Korea Marker) have been bouncing around $16. No wonder the industry is goggle-eyed.

The Brookings Institution, however, in a wide-ranging 2012 report extolling the virtues of LNG exporting, assumes that American exports will put an end to the arbitrage.

> By adding supply volumes to the global LNG market, the U.S. will help Japan, Korea, India, and other import-dependent countries in South and East Asia to meet their energy needs. . . . U.S. LNG exports linked to a floating Henry Hub benchmark, have the potential to weaken the market power of incumbent LNG providers to Asia. . . . [T]he ability of the U.S. to provide a degree of increased energy security and pricing relief to LNG importers in the region will be an important economic and strategic asset.[31]

Those are noble sentiments, but are they at all realistic? A clue to the likely behavior of American LNG exporters can be gleaned by looking at who they are, and what interests they have. I have examined the filings of all the projects in the DOE queue, including the four already approved as of mid-October, for indications of their business strategies, and the strategies of their intended customers, insofar as they have been identified.[32] Customers can be identified as either consumers or portfolio players.[33] For example, the first signed customers for the first approved plant, the Sabine Pass Liquefaction LLC, fit the consumer model.[e] They are Japanese and Korean utilities that have purchased specific liquefaction volumes for twenty years on a stated fee schedule. They will buy their own gas at Henry

Hub prices, deliver it to the LNG plant, repossess it in its liquid form, and arrange their own shipping and regasification.

A second group of customers are major international gas traders, including BP Energy, Great Britain's BG, Shell, GDP Suez, Total, Centrica (a British trading company), and Statoil, Norway's state oil company. BG, for example, sells gas to almost all Asian gas importers, all of it presumably oil-linked, and is a major player in Australia's newest LNG projects. They are not likely to compete against themselves by selling American-sourced gas at one price and Australian-sourced gas at another.

Finally, there are several projects that will be owned by portfolio players and clearly intended to service their own trading. Golden Pass, on the Texas Gulf, is a joint venture between ExxonMobil and Qatar. Exxon has recently stressed that its current strategy is focused on "oil-based and oil-linked gas" projects.[34] The company has previously partnered with Qatar in several of their Qatar-based LNG projects and is also a partner in the biggest LNG projects in both Australia and Papua New Guinea. It strains credulity that it will sell gas to its global customers at any other than the prevailing local price.

Taken together, the projects would offer a total annual processing capacity of 12.4 Tcf, or just over half of current U.S. production. Of that amount, 39.4 percent has not yet been allocated, 13.4 percent has been allocated to consumer-type customers, and 47 percent to portfolio players.

In short, even if all of these projects were approved and built, the amount of gas actually sold at Henry Hub-based prices is likely to be far too small to have any impact on international prices. For the meaningful future, the Bernstein Research analysis of likely LNG plant openings over the decade suggests a short period of oversupply in about 2016 as new Australian capacity comes on line, bracketed by periods of tight markets, so sellers should hold their advantage. (And, since that report, major doubts have risen about the Australian production schedules.)

Estimates of a decade or so from now are necessarily speculative. But one can be fairly sure that if LNG becomes the dominant gas resource for China, international prices will be very high; but if the Chinese have a bonanza of cheap gas of their own, and the big pipeline projects come in more or less as scheduled, global prices could gradually trend toward the marginal cost of production. Choosing between one or the other outcome is simply guesswork.

The Role of Market Principles. Several of the economists' studies recommending unlimited or highly unconstrained LNG exporting ground their argument on an American quasi-moral obligation to embrace market-based free-trading principles. Most nations are now committed to some form of market economics, but few as fully as the United States (even admitting the many political lapses from the true faith).

But for a number of decades, emerging nations have used their great resources of inexpensive labor to wrest away American market share in one critical industry after the other, playing by market rules only when it suited their national strategy. Japan ostentatiously cut tariffs during its economic rise, while cloaking its import processes with a veil of rules and standards designed to reserve the Japanese market for Japanese companies. China has erected even more blatant and effective customs, patent, and other non-tariff barriers while mounting the greatest-ever campaign of business espionage. Recent research also suggests that the Chinese first concentrated their exporting assault on the United States, because U.S. officials had made clear that they were committed to "normal" trade relations, and so could be readily exploited.[35]

By law, the DOE cannot withhold approval of gas exports to nations with a Free Trade Agreement with the United States. South Korea has recently signed such an agreement, and nearly all applicants for LNG export licenses have already received DOE approval to export to FTA countries. We do not have FTAs with Japan, China, or India, or with any European countries, and are not likely to have them in the foreseeable future because of the difficult protectionist issues on both sides.

In the days of the Marshall Plan and the postwar recovery, the United States could well afford to be generous with its bounties, and to provide examples of principled behavior without regard to reciprocation. But we have made ample donations at the church of market economics, and are no longer the "hyperpower" that can readily subordinate its interests to a theoretical greater global good. Now that the United States has discovered a new extremely valuable natural resource, it is simply foolish to give it away cheaply to all comers for the dubious objective of bringing "energy security and pricing relief" to the world.

CONCLUSION

It is very much in the interest of the United States to limit its exports of natural gas, in order to preserve a valuable industrial commodity that could play a major role in reinvigorating its much-battered manufacturing sectors. There is also a great deal of evidence that the gains in jobs and economic activity from gas-enabled domestic manufacturing will be far higher than those from increasing gas exports.

There are at least two other important common sense reasons to limit exporting, at least for the time being. Although the American supply of inexpensive natural gas does appear to be large, there is still a great deal of uncertainty surrounding such estimates. The percentage of the shale reserves that have been intensively exploited is still quite low. There have been disappointments already—the rapid rate of depletion of many

[e] In doubtful cases, I have classified customers as consumers. So Mitsui and Mitsubishi are big trading houses, but I have assumed that the *keiretsu* ethos still applies, and that they will sell all of their gas to Japanese firms at a Henry Hub-based price. The big Spanish conglomerate, Gas Natural Fenosa, is both a utility and power provider and a major trader, but I have assumed that all of its gas will be used in its operations businesses.

wells, for instance. None has yet been a show-stopper, but our experience still hardly amounts to a decade's worth, so it is too early to start spreading our gas around the world.

And secondly, the anti-fracking movement is very strong. While many of their claims are unfounded, many are not. Well management performance—issues of leakage, spillage of noxious fluids, overflows of uncovered waste tanks, poor disposal practices, and so on—often leave much to be desired. The industry is clearly improving its game, especially as it consolidates into bigger firms, but it still has a long way to go. All estimates of exporting assume that it will mostly come from increased production. Ratcheting up production another 10–15 percent should not make waves, but much above those levels could generate a strong reaction. In the worst case, a frenzied rush to meet a spike in high-value export demand could provoke a very damaging political response.

The counter to such arguments is typically an appeal to "market principles." According to the economic models, an American entry would kick-start the world toward globally efficient pricing, and would be a signal markets-advancing demonstration to the whole world. As the economists at Brookings put it, limitations on exporting American gas "would come at the opportunity cost of forgoing the benefits of a free market," which as "a principle advocate and beneficiary of a global trading system" would always be against our interest.

The argument is hubristic. Economics itself teaches the Theory of Second Best: When reality differs from modelers' assumptions, they can be a poor guide to policy. The global financial crash demonstrates the point. Virtually all mainstream models suggested that financial deregulation would be market-stabilizing. In the financial services industry, in fact, reality does track closely to the economic ideal. Performance standards are unambiguous, rewards are often immediate, payoffs are in real money. But the models missed crucial nuances—for example, they assumed that the objectives of traders and financial executives were aligned with the long-term interests of their firms. They were not, and trillions of dollars were lost as a consequence.

In the case of international gas trading, the gap between the real world and that of the models is yawning. It is an industry dominated by energy cartels, oligopolies, and twenty-year contracts. Much of the supply is based in politically unstable states or regions, and prolonged market disruptions are almost the norm. Engineering a major supply response takes years and puts immense amounts of capital at risk. Plugging current prices and other parameters into an equilibrium model may produce interesting hypotheses, but little of predictive value.

In the real second-best (or third- or fourth-best) world of gas trading, we really do have to fall back on a common sense approach. That does not exclude exporting, but it would seem to counsel against empowering a large export capacity. Even if the plants are not immediately built, we would have foolishly put the country at risk of some remote catastrophe creating a stampede for American gas. It does make sense to approve a limited amount of exports—and we are about there—and then wait. Granted it will take several years to see how the market develops, and we may miss some export opportunities. But we would avoid the risk of losing control of our own energy future. It should be an easy choice.

POSTSCRIPT

Two recent developments warrant comment. First, two of the authors of the Brookings report cited above have issued a policy memorandum proposing a "balanced" approach to approving LNG plant applications as a compromise between the two "extreme" proposals of a volumetric cap of 10–15 percent of production, as proposed by Senator Ron Wyden (D, OR) who chairs the Senate Energy and Natural Resource Committee, and the "approve them all" position of the energy industry. They propose that any applicant who successfully passed the FERC pre-filing process and signed up a substantial block of customers would automatically be approved. In effect, they call for a process much like the current one, but without the necessity of a "public interest" finding.[36]

It is not clear why volumetric limits are an "extreme" measure. First-past-the-post rules are common in a number of areas as a reasonable, if imperfect, ordering principle when qualitative distinctions may be difficult. Worse, as a practical matter, this supposedly balanced approach would be equivalent to the industry "approve them all" position. In effect, whenever exporting profitability was sufficient to merit the rigors of the FERC process, companies would be approved for export, in whatever quantity, and regardless of the consequences. If China was willing to absorb half of our gas at the right price, the industry could export half of our gas.

The second is a rulemaking request filed with the DOE by the AEA, the manufacturing alliance, to clarify the approval standards. They note that the governing policy standards on gas trading were designed to regulate imports, at a time when looming gas shortages were viewed as a serious problem. There is no reason to assume that standards designed to encourage imports of a scarce resource are automatically suitable for regulating the export of a national treasure. The petition requests an explicit rulemaking to create policy specifically for exporting, addressing besides decisional criteria, the role of volumetric standards and policies regarding rescindment of permits.[37]

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NOTES

[1] Keith Johnson, "Foreign Firms Tap U.S. Gas Bonanza," *Wall Street Journal*, October 1, 2013; Ben Lefebvre, "Valero Plans $700 Million Petrochemical Plant," *Wall Street Journal*, July 11, 2013. Harold Sirkin, Michael Zinser, and Douglas Hohner, "Made In America, Again," The Boston Consulting Group, August 2011; Kevin Swift et al., "Shale Gas, Competitiveness and New U.S. Investment: A Case Study of Eight Manufacturing Industries," American Chemistry Council, May 2012; Edward L. Morse et al., "Energy 2020: North America, the New Middle East?" Citi GPS: Global Perspectives and Solutions, March 20, 2012, 10.
[2] See website for America's Energy Advantage, www.americasenergyadvantage.org.
[3] See, for example, Charles Ebinger, Kevin Massy, Govinda Avasarala, "Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas," Brookings Institution: Energy Security Initiative, Policy Brief 12-01, May 2012; and Kenneth P. Medlock III, "U.S. LNG Exports: Truth and Consequence," James A. Baker Institute for Public Policy, Rice University, August 10, 2012.
[4] U.S. Energy Information Administration, "Markets Expect Marcellus Growth to Drive Appalachian Natural Gas Prices below Henry Hub," *Today in Energy,* October 9, 2013. (Marcellus natural gas production has risen 30 percent over last year.) For profitability material see e.g analyst presentations by Range Resources, Inc., a company with a strong Marcellus position (both wet and dry), http://phx.corporate-ir.net/phoenix.zhtml?c=101196&p=irol-presentations. Shale-heavy ETFs have been rising strongly for about a year from a 2012 low point.
[5] The data in the table are from U.S. Energy Information Administration, *International Energy Outlook 2013*, July 2013, World Natural Gas Consumption/Production Reference Cases, http://www.eia.gov/forecasts/ieo/index.cfm. The discussion that follows is drawn primarily from the country analyses supporting that document. For the reference case summary and detailed tables, see "Highlights," http://www.eia.gov/forecasts/ieo/more_highlights.cfm.
[6]A current summary of all applications is available from the U.S. Department of Energy Office of Fossil Energy website, http://energy.gov/fe/downloads/summary-lng-export-applications. The file contains links to all the publicly available supporting documents for each application.
[7] NERA Economic Consulting, "Macroeconomic Impacts of LNG Exports from the United States," December 2012, http://energy.gov/fe/services/natural-gas-regulation/lng-export-study. The study seems to parrot the energy industry's position. It dismisses almost out of hand the prospect of lost industrial opportunities due to rising gas prices; it assumes that all exports will be indexed to the Henry Hub; and that all gains will accrue to Americans, although many of both the exporters from the United States and the proposed export facilities are wholly or partly foreign-owned. While it concedes that rising gas prices would disadvantage all sectors of the economy outside of the energy industry, it concludes that the losses in the broader economy would be offset by the increased income "of consumers who own LNG export facilities."
[8] ICF International, "U.S. LNG Exports: Impacts on Energy Markets and the Economy," study prepared for the American Petroleum Institute, May 15, 2013, 44. The breakdown of the EIA estimate is from the Oil and Gas Module of the agency's National Energy Modeling System (NEMS) Table 9.2.
[9] The backstory to the reassessment is at U.S. Energy Information Administration, *Annual Energy Outlook 2012*, 63–64.
[10] Ibid., Oil and Gas Module, Table 9.2.
[11] Art Berman may be the best known of the skeptics. See "Arthur Berman Talks about Shale Gas," The Oil Drum, July 28, 2010, http://www.theoildrum.com/node/6785.
[12] Ben Winkley, "Energy Journal: Chevron Still on the Shale Trail in Poland, Wall Street Journal, July 25, 2013; Oleg Yuknanova and Agnieszka Barteczko, "Poland's Energy Security Comes at a High Cost," Reuters, September 9, 2013.
[13] Jim Carlton, "Oil Firms Seek to Unlock Big California Field," *Wall Street Journal,* September 22, 2013.
[14] U.S. Energy Information Administration, *Annual Energy Outlook 2013*, tables.
[15] Bernstein Energy Team, "The Long View: Will Rising North American Energy Demand Drive a Third Investment Surge," Bernstein Research, September 2013.
[16] For a bullish case, see Charles River Associates, "Evaluation of the May 2013 APIU Report: U.S. LNG Exports, Impacts on Energy Markets and the Economy," prepared for America's Energy Advantage, July 19, 2013, 25; Mike Ramsey, "Truckers Tap Into Gas Boom," *Wall Street Journal*, October 30, 2013.
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[20] Ibid., The entire chapter makes a strong case for the unlikelihood of large Chinese shale gas harvesting for the foreseeable future.
[21] Herman K. Trabish, "China Backs Off Shale Gas Targets," *GreenTechMedia*, June 28, 2013, http://www.greentechmedia.com/articles/read/china-backs-off-shale-gas-targets; Svetlana Izrailova, "Shale Development in China," e-International Relations, January 9, 2013; Lu Xin, "China Risks Severe Shortfalls with Gas Expansion," *Natural Gas Daily*, October 17, 2013.
[22] Didi Kristen Tatlow, "Amid Heavy Pollution, Beijing Issues Emergency Rules to Protect Citizens," *New York Times*, October 17, 2013. Mai Li, "'Airpocalypse' Hits Harbin, Closing Schools," *New York Times*, October 21, 2013.
[23] ICF International, "U.S. LNG Exports," 59–64.
[24] Charles River Associates, "Evaluation of the May 2013 APIU Report," 15–17.
[25]The data here follow the catalog in ICF International, "U.S. LNG Exports."
[26] For a detailed description of the challenges, see "Gorgon Project: CO2 Seismic Baseline Survey," Chevron Australia Pty Ltd., July 7, 2010, http://www.chevronaustralia.com/Libraries/Publications/CHEVRON_CO2_Brochure_07_07_10.pdf.sflb.ashx. Chevron and ExxonMobil are joint venture partners in the project's construction.
[27] Summary from multiple articles in *Offshore Energy Today*, http://www.offshoreenergytoday.com/tag/browse/.
[28] Vivek Chandra, "Can Australian LNG Projects Stay Competitive?" Deakin Speaking blog, July 21, 2013, http://communities.deakin.edu.au/deakin-speaking/node/512; "Fix the NSW Gas Supply Crunch," Editorial, Australian Financial Review, September 28, 2013.
[29] "Asia Brainstorms on LNG Price," *World Gas Intelligence* 23, no. 47 (November 21, 2012). James Jensen, private conversation.
[30] Several studies converge on the $6 "transport" estimate: *The Future of Natural Gas: An Interdisciplinary MIT Study*, (Cambridge, Mass.: MIT Energy Initiative, 2011), 25, estimates $3–5, with Asia at the high end; Charles Ebinger et al., "Liquid Markets," citing Jensen; and NERA Economic Consulting, "Macroeconomic Impacts of LNG Exports from the United States," estimates $7.14 for Korea/Japan, but they include pipeline transport to liquefaction and from regasification, which the others do not.
[31] Charles Ebinger et al., "Liquid Markets," 43.
[32] The details of the customers are from the application material on file with DOE and FERC, plus recent updates reported in the press.
[33] A useful taxonomy of LNG players is set out in James Henderson, "The Potential Impacts of North American LNG Exports," The Oxford Institute of Energy Studies, NG 68, October 2012. I have simplified the schema by whether they are predominately interested in trading or consuming. Mixed cases such as Natural Gas Fenosa of Spain and Great Britain's Centrica, I have classified by their dominant interest as indicated by company materials. So I treat Fenosa as a utility even though it has an important trading operation, and Centrica as a portfolio player, even though it owns some utilities. Cheniere's recent reservation of a portion of its capacity for its own use, I assume is for arbitrage purposes; and although companies such as Freeport McMoRan and ExxonMobil/Qatar reserve the right to lease some of their capacity to third parties, their overall business strategy implies that they will use it for trading in their own products.
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