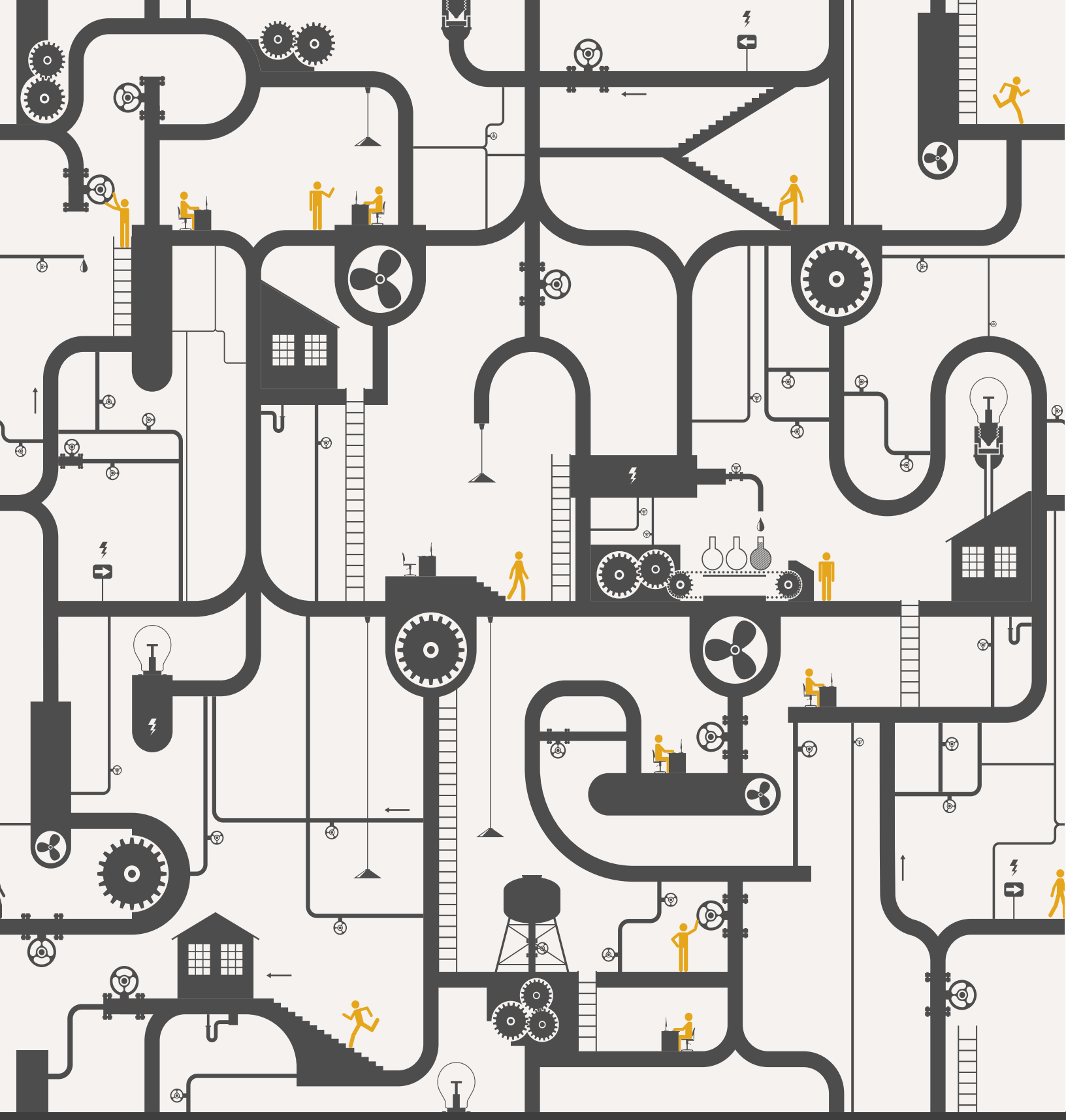

# SHALE GAS: A GAME-CHANGER FOR U.S. MANUFACTURING

PREPARED BY THE UNIVERSITY OF MICHIGAN

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# SHALE GAS: A GAME-CHANGER FOR AMERICAN MANUFACTURING

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# SHALE GAS: A GAME-CHANGER FOR AMERICAN MANUFACTURING

## Executive Summary

A country is only as strong as its capacity to build. Managed properly, the availability of low-cost shale gas could catalyze a renaissance in U.S. manufacturing, revitalizing the chemical industry and enhancing the global competitiveness of energy-intensive manufacturing sectors such as aluminum, steel, paper, glass, and food. This report summarizes and expands upon the University of Michigan-sponsored daylong Symposium "Shale Gas: A Game-Changer for American Manufacturing," held on March 28, 2014 at the National Press Club in Washington, D.C. The Symposium's purpose: to explore how the shale gas boom can be used to the best advantage of U.S. manufacturing.

Symposium attendees, including representatives from U.S. manufacturers, environmental groups, the Department of Energy, and the University of Michigan, explored how manufacturers could benefit from the shale gas boom while taking into account important environmental, market, infrastructure, and workforce realities. Symposium participants were energized by the manufacturing revitalization promised by the shale gas boom, eager to discuss environmental pitfalls and solutions, and interested in the intersection of policy, prosperity, and responsibility.

An interdisciplinary team of U-M researchers and policy experts analyzed the information from the symposium and from numerous publicly available sources. These are our recommendations aimed at fueling the growth of U.S. manufacturing through responsible and sustainable production and utilization of shale gas:

**Ensure societal license to operate through greater transparency and dissemination of best practices.** Establish a federally administered, information-rich website designed as an impartial source of public data on gas drilling sites, best practices, safety incidents, and rates of reported emissions. Use this site to educate the public about the processes involved in shale gas production, the chemicals and water used, industry impact on the local economy and infrastructure, and to explain the responsibilities and regulations of state and federal agencies, as well as the policy and regulatory options being implemented by state and local governments.

**Incentivize infrastructure investment.** Create incentives for investment in improved natural gas transmission, storage, and distribution infrastructure in order to realize the potential benefits of shale gas across the economy and across our nation.

**Apply remote sensing technologies to methane emissions.** Meeting the methane measurement challenge will require support from federal agencies and the effort of researchers and entrepreneurs. The portfolio of remote sensing technologies developed and deployed by agencies such as DOE, NOAA, NASA, EPA and DOD should be reviewed for possible adaptation to address methane emissions monitoring and quantification.

**Train a next-generation energy workforce.**
The Department of Energy and the Department of Labor – in collaboration with groups impacted by the shale gas boom, including unions, utilities, and manufacturing and trade organizations – should assess workforce requirements and develop skills training certificate and degree programs in partnership with community colleges.

**Build the bridge to a cleaner energy future**
With proper incentives, the construction and operation of power plants combining natural gas and renewables may lead to faster growth of renewables than could occur in the absence of or in competition with gas. Energy intensive manufacturing industries such as chemicals and paper that generate significant fractions of their own power requirements may also be good candidates for such strategies. Invest a portion of the economic benefits realized from shale gas to fund research, development and deployment of clean energy technologies for the future energy and manufacturing economy.

# SHALE GAS: A GAME-CHANGER FOR AMERICAN MANUFACTURING
## A Report by the University of Michigan

The U.S. shale gas boom of recent years has enabled domestic job creation and economic growth, and has recast the U.S. role in the global energy landscape. This rapid shift in energy supply and resource development has exposed an important weakness: the U.S. lacks a strategic plan and a suite of economically, socially, and environmentally viable policies to responsibly leverage the new abundance of low-cost natural gas, both as fuel and as feedstock for a variety of industries. With this policy void in mind, the University of Michigan's March 28 public-private stakeholders' symposium, "Shale Gas: A Game-Changer for American Manufacturing," brought together top decision-makers from the private and public sectors to develop a set of options aimed at strengthening U.S. manufacturing through sustainable shale gas use.

A country is only as strong as its capacity to build. Managed properly, the availability of low-cost shale gas could catalyze a renaissance in U.S. manufacturing, revitalizing the chemical industry and enhancing the global competitiveness of energy-intensive manufacturing sectors such as aluminum, steel, paper, glass, and food. Lower feedstock and energy costs could help U.S. manufacturers reduce natural gas expenses by as much as $12 billion annually through 2025, creating one million new manufacturing jobs.[1] In February 2014, the American Chemistry Council (ACC) reported 148 chemical and plastics projects totaling $100 billion in potential new investment in the U.S. But this window of opportunity may be limited; nations such as China also possess potentially vast natural gas reserves, much of them yet untapped.

The symposium focused on economic impacts of increased manufacturing competitiveness, and also included the perspective of recent studies on price, supply, investment needs, competition from other uses, environmental and health impacts, technology, and public acceptance. Symposium participants included high-level representatives from key government agencies, the White House, industry stakeholders, and thought leaders from civil society and academia. (See Appendix 1 for an agenda and a full list of attendees.)

These industry and government leaders touched on almost every dimension of the shale gas boom. Thomas Kalil of the White House Office of Science and Technology Policy and the National Economic Council raised the prospect that shale gas could not only enhance the competitiveness of traditional manufacturing industries but usher in new industries that use gas as a feedstock. Former Lockheed Martin CEO Norman Augustine noted the national security

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[1] Bret Shulte, *National Geographic*, "Can Natural Gas Bring Back U.S. Factory Jobs?," 2014: http://news.nationalgeographic.com/news/energy/2014/01/140131-natural-gas-manufacturing-jobs/

benefits of bringing manufacturing "home". Former U.S. Treasury Secretary Paul O'Neill advanced the case for shale gas as a bridge fuel, advocating for using the resource responsibly while concurrently pushing ahead with research and development of renewable energy sources.

During a moderated forum, participants explored these and other opportunities, barriers, and potential paths forward. The result is this report: a set of publicly accessible, actionable policy considerations that maximize the benefits of U.S. shale gas.

Manufacturers at the symposium recognized the enormous potential of shale gas to contribute to the U.S. manufacturing economy in many different ways, but held several important concerns in common: the operational and environmental threats of aging or insufficient support infrastructure; the ongoing need to create paths to renewable energy, even as we take advantage of the development of shale gas resources; the risks to societal license to operate; and a workforce that may be inadequately prepared to meet the human capital needs of a full-scale manufacturing renaissance.

In order for the promise of shale gas to be fully realized in all its dimensions, the federal government must partner with state governments and stakeholder industries. Key policy recommendations of this report encourage decision-makers to:

1. Ensure societal license to operate through greater transparency and dissemination of best practices.
2. Incentivize infrastructure investment.
3. Apply remote sensing technologies to methane emissions.
4. Train a next-generation energy workforce.
5. Build the bridge to a cleaner energy future.

## SHALE GAS: AN OVERVIEW

In recent years, technological advances have enabled the rapid growth of domestic energy production. In particular, the development of horizontal drilling and high-volume hydraulic fracturing technologies has set the stage for what many consider to be a boom in shale gas. Shale formations are porous sedimentary rocks that can be rich sources of trapped fossil fuels.[2] Shale gas refers specifically to natural gas found within these shale formations. With the U.S. now appearing to be on-track to become one of the world's largest producers of this fossil fuel, it is important to understand the current outlook for shale gas.

[2] U.S. Energy Information Administration, "What is Shale Gas and Why is it Important," 2012: http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm

In 2011, approximately 95% of the natural gas that was consumed in the United States was produced domestically.[3] This is significant, as it means the supply of natural gas is not as dependent on foreign producers as is the supply of other fossil fuels, such as crude oil.[4] Furthermore, the availability of large quantities of shale gas (see the figure below for the U.S. proved reserves for shale gas) could enable the U.S. to not only consume primarily domestic natural gas, but also to produce more gas than it consumes, and thus become an exporter.[5]

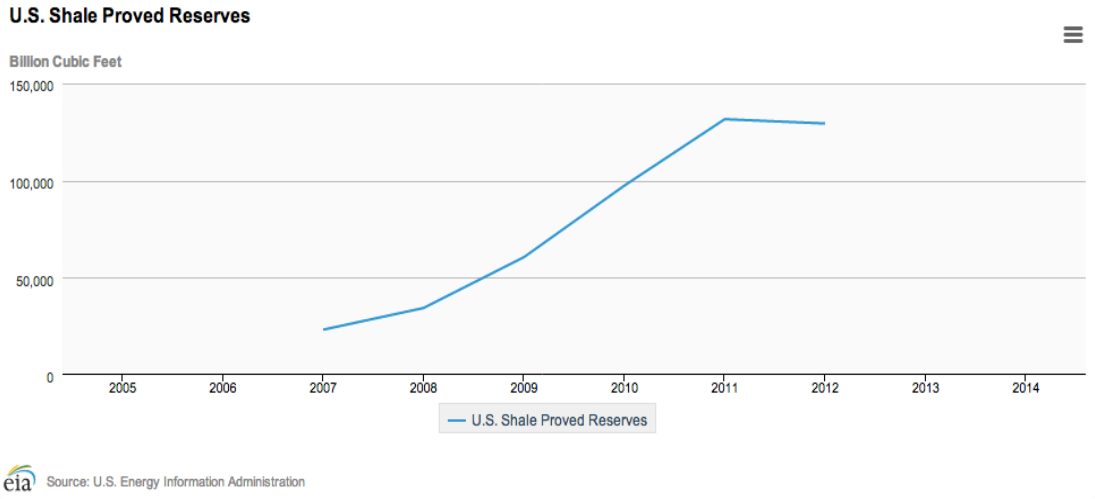


Figure source: EIA[6]

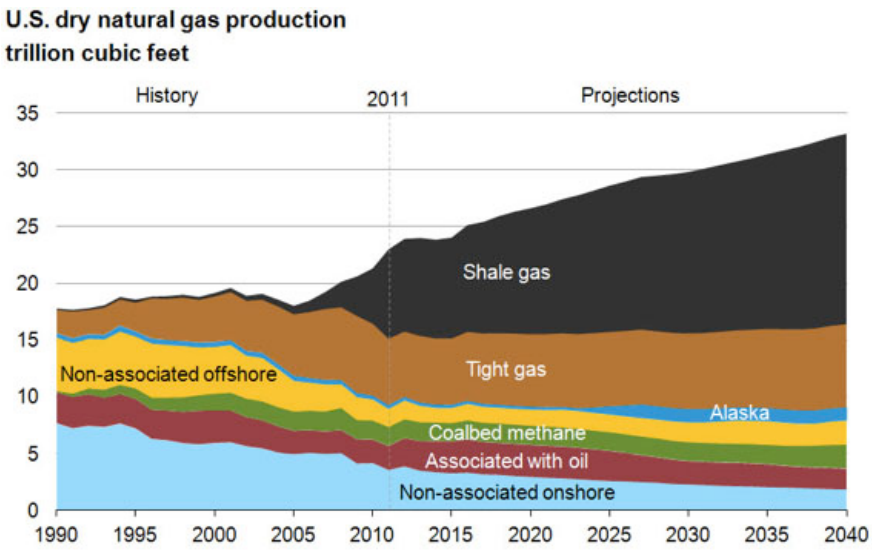


Figure Source: EIA[7]

[3] ibid.
[4] ibid.
[5] ibid.
[6] ibid.
[7] Energy Information Administration, "AEO2013 Early Release Overview," 2013: http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2013).pdf

Owing in large part to the abundant supply of gas, the domestic price of natural gas dropped to $3.35/thousand cu. ft. at the end of 2012.[8] Low prices such as this make it an attractive fuel and feedstock for many, especially in industry. However, there remains considerable uncertainty about where the price of natural gas might go in the future, as this depends on both supply and demand factors, such as resource availability, regulations, the domestic market, and the global market. Uncertainty, whether about supply, price, policy or regulation, inhibits investment, not only in manufacturing, but in other capital-intensive enterprises.

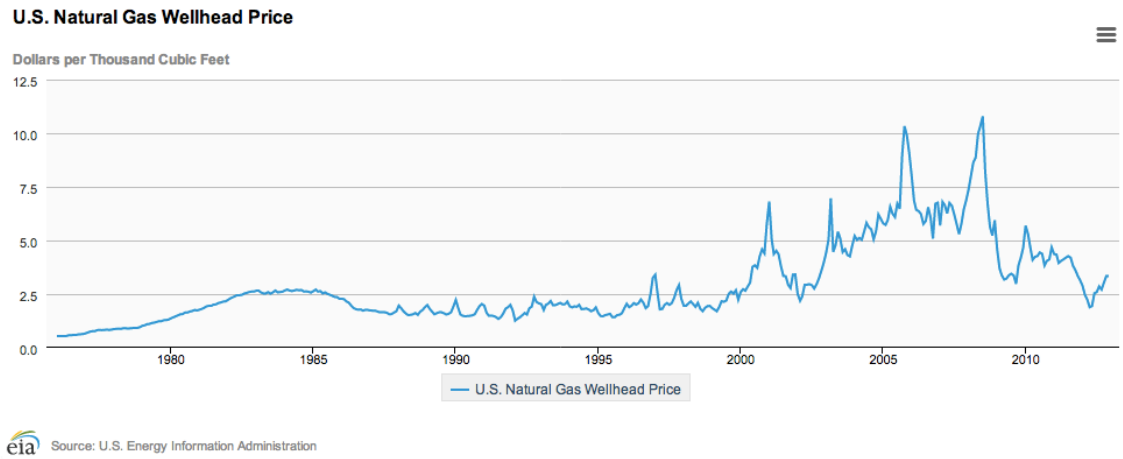


Figure Source: EIA[9]

## Industry Consumers

Numerous analysts expect the petrochemical, long haul transportation, and metals industries to benefit significantly from an increased availability of affordable natural gas.[10,11,12,13] With natural gas prices falling by 75% between 2005-2013, U.S. chemical manufacturers who use it as an energy source or as a feedstock stand to benefit significantly, as the U.S. has become one of the lowest-cost chemical producers outside of the Middle East.[14,15] Resources for the Future analysts also note that an expansion in petrochemical production - particularly

[8] U.S. Energy Information Administration, http://www.eia.gov/dnav/ng/hist/n9190us3M.htm
[9] ibid.
[10] Dan Radomsky, NextEnergy, "Natural Gas: Midwest Supply Chain opportunities," 2013: http://www.chicagofed.org/digital_assets/others/events/2013/detroit_energy/radomski_830am_040913.pdf
[11] IHS, "America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy," 2013: http://www.ihs.com/images/Americas-New-Energy-Future-Mfg-Renaissance-Exec-Sum-Sept13.pdf
[12] Benjamin Schlesinger & Associates, "Energy Market Upheaval: The Shale Revolution," 2013: http://www.chicagofed.org/digital_assets/others/events/2013/detroit_energy/schlesinger_315pm_040813.pdf
[13] Center for Business and Economic Research, "Value-Added Opportunities from Natural Gas," 2013: http://www.wvonga.com/Portals/1/Docs/Value%20Added%20Opportunities%20from%20Natural%20Gas.pdf
[14] Jack Kaskey of *Bloomberg Businessweek*, "Chemical Companies Rush to U.S. Thanks to Cheap Natural Gas," 2013: http://www.businessweek.com/articles/2013-07-25/chemical-companies-rush-to-the-u-dot-s-dot-thanks-to-cheap-natural-gas
[15] Andre Walberer, Pittsburgh Chemical Day (event), 2012: http://www.pittchemday.com/pdfs/presentations/Kearney_Presentation.pdf

ethylene - could likely boost production and have positive impacts on the entire manufacturing industry.[16]

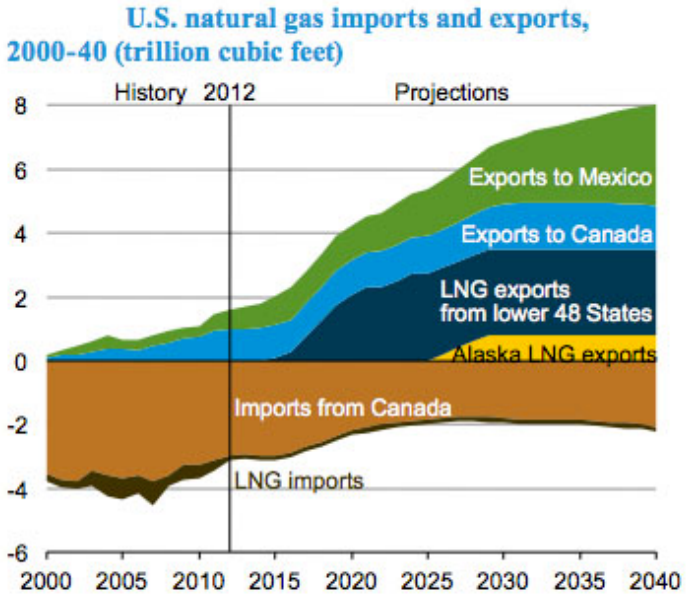


Figure Source: EIA[17]

Metal – especially steel – manufacturing is projected to benefit from shale gas through an increase in demand and a decrease in energy costs. Some U.S. manufacturers, such as Nucor and U.S. Steel[18, 19] are currently building or considering building facilities that make use of gas instead of coal to process iron ore – an opportunity that takes advantage of the relative price difference between coal or oil vs. gas.[20] Growth is also coming from an increase in demand for steel products used in drilling and production of shale gas.[21] Although there are those within the steel industry who are optimistic that growth could lead to around one million additional jobs,[22] others point out that the cost reduction from switching to natural gas from coal is in the range of $8-10/ton, compared to overall steel production costs of around $600/ton.[23] While those numbers reflect savings only

[16] Resources for the Future, "Sector Effects of the Shale Gas Revolution in the United States," 2013: http://www.rff.org/RFF/Documents/RFF-DP-13-21.pdf
[17] Energy Information Administration, AEO2014 Early Release Overview, 2014: http://www.eia.gov/forecasts/aeo/er/pdf/0383er%282014%29.pdf
[18] Justine Coyne, *Pittsburgh Business Times*, "Shale Development Big Boost for the Steel Industry," 2013: http://www.bizjournals.com/pittsburgh/blog/innovation/2013/10/shale-development-big-boost-for-steel.html
[19] Jason Hall, *The Motley Fool*, "Is Natural Gas Nucor's Secret Weapon?," 2013: http://www.fool.com/investing/general/2013/10/18/is-natural-gas-nucors-secret-weapon.aspx
[20] Center for Business and Economic Research, "Value-Added Opportunities from Natural Gas," 2013: http://www.wvonga.com/Portals/1/Docs/Value%20Added%20Opportunities%20from%20Natural%20Gas.pdf
[21] Congressional Research Service, "Natural Gas in the U.S. Economy: Opportunities for Growth," 2012: http://fas.org/sgp/crs/misc/R42814.pdf
[22] Center for Business and Economic Research, "Value-Added Opportunities from Natural Gas," 2013: http://www.wvonga.com/Portals/1/Docs/Value%20Added%20Opportunities%20from%20Natural%20Gas.pdf
[23] Congressional Research Service, "Natural Gas in the U.S. Economy: Opportunities for Growth," 2012: http://fas.org/sgp/crs/misc/R42814.pdf

from switching fuels, they highlight the fact that the primary cost in steel production comes from scrap steel, which is unaffected by the cost or availability of natural gas.[24] Aluminum is similarly poised; see the manufacturing outlook section of this report for further discussion of this and other industries.

The transportation sector also stands to benefit from shale gas, although higher up-front costs for new equipment have thus far been a significant limiting factor.[25,26,27,28] Relative to diesel, the cost of natural gas is, for the moment, drastically lower[29] - which could be part of the reason why orders for natural gas powered trucks have increased by nearly 150% recently.[30] However, one of the main reasons that natural gas remains cheap is that there are relatively limited options for how it can be used within the U.S.[31] As infrastructure and usage expand, prices are likely to increase somewhat, which will affect just how economical natural gas as a transportation fuel source will be.[32] For now however, the main obstacles facing natural gas powered vehicles are a limited nationwide fueling infrastructure, on-board fuel storage challenges, relatively high costs for purchasing and maintenance, and some safety concerns.

## International Exports

Less than a decade ago, it seemed the United States was poised to become one of the largest importers of natural gas in the world,[33] but with the boom in shale gas production in recent years, the national conversation has reversed course entirely, and now many are discussing the possibility of exporting domestically produced natural gas overseas.[34] While the U.S. currently only exports natural gas within

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[24] ibid.
[25] Resources for the Future, "Sector Effects of the Shale Gas Revolution in the United States," 2013: http://www.rff.org/RFF/Documents/RFF-DP-13-21.pdf
[26] Ernest Moniz, *et al.*, "The Future of Natural Gas: An Interdisciplinary MIT Study," 2011: URL: https://mitei.mit.edu/publications/reports-studies/future-natural-gas
[27] Sean Kilcarr, *FleetOwner*, "Debating the Potential of Natural Gas Trucking," 2013: http://fleetowner.com/blue-fleets/debating-potential-natural-gas-trucking
[28] Center for Climate & Energy Solutions, "Natural Gas Quick Facts," 2012: http://www.c2es.org/technology/factsheet/natural-gas
[29] Sean Kilcarr, *FleetOwner*, "Debating the Potential of Natural Gas Trucking," 2013: http://fleetowner.com/blue-fleets/debating-potential-natural-gas-trucking
[30] ibid.
[31] David Biello, *Scientific American*, "Cheap Fracked Gas Could Help Americans Keep on Truckin," 2012: http://www.scientificamerican.com/article/natural-gas-as-alternative-transportation-fuel/
[32] ibid.
[33] Simon Romero, *The New York Times*, "Demand for Natural Gas Brings Big Import Plans, and Objections," 2005: http://www.nytimes.com/2005/06/15/business/15gas.html?pagewanted=all&_r=2& . Clifford Krauss, *The New York Times*, "A Big Bet on Natural Gas," 2006: http://www.nytimes.com/2006/10/04/business/04gas.html?pagewanted=all . Carl Hulse, *The New York Times*, Natural Gas Outlook Worries Greenspan," 2003: http://www.nytimes.com/2003/06/11/business/natural-gas-outlook-worries-greenspan.html
[34] Wendy Koch, *USA Today*, "U.S. natural gas exports poised for takeoff despite debate," 2014: http://www.usatoday.com/story/news/nation/2014/04/07/us-natural-gas-exports-to-begin/7204925/

North America,[35] a number of proposals to export liquefied natural gas around the world have emerged in recent years.[36]

Proponents of allowing widespread exports argue that it has numerous potential benefits, including netting U.S. producers, exporters, and their suppliers in excess of $10 billion a year, along with narrowing the U.S. trade deficit, giving the U.S. new leverage in trade negotiations, and influencing geopolitics.[37] Allowing LNG exports could lead to indirect benefits in international trade diplomacy, ensuring U.S. access to exports from other markets (for instance, Chinese rare earth metals – currently essential to many segments of the U.S. clean energy industry).[38] A paper published by The Brookings Institute analyzing the value of LNG exports along six dimensions (macroeconomic, distributional, oil security, climate change, foreign and trade policy, and local environment) found that the expected benefits from permitting exports outweigh the costs of restricting them, provided that environmental safeguards are employed.[39]

According to EIA's Annual Energy Outlook 2014,[40] the total domestic consumption of natural gas by 2040, including electricity generation, industrial, residential, and transportation, is projected to reach 32.2 trillion cubic feet (TcF) and the total exports are expected to grow to 5.7 TcF. By the same time, AEO2014 estimates the U.S. natural gas production to reach 37.6 TcF – nearly enough to meet domestic demands and export opportunities. These projections are based on the assumption that the current laws and regulations remain generally unchanged throughout the projection period.

A 2012 Brookings Institute analysis concluded that the "U.S. natural gas resource base is large enough to accommodate the potential increased demand for natural gas from the electricity sector, the industrial sector, the residential and commercial sectors, the transportation sector, and exporters of LNG."[41]

One central question in the export debate is what effect exporting natural gas will have on domestic prices.[42] Although a significant increase in exports would likely raise domestic prices, the magnitude of any increase is uncertain.[43] Participants at the symposium from the manufacturing sector expressed relatively little

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[35] ibid.
[36] Michael Levi, The Brookings Institute, "A Strategy for U.S. Natural Gas Exports," 2012: http://www.brookings.edu/~/media/research/files/papers/2012/6/13%20exports%20levi/06_exports_levi.pdf
[37] ibid.
[38] ibid.
[39] ibid.
[40] Energy Information Administration, Early Release Overview, 2014: http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf
[41] Charles Ebinger, Kevin Massy, Govinda Avasaral, Brookings Institute, "Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas," 2012: http://www.brookings.edu/~/media/research/files/papers/2012/1/natural%20gas%20ebinger/natural_gas_ebinger.pdf
[42] Congressional Research Service, "U.S. Natural Gas Exports: New Opportunities, Uncertain Outcomes," 2013: http://www.fas.org/sgp/crs/misc/R42074.pdf
[43] ibid.

concern about exports or the impact of exports on prices. Producers generally contend that increasing exports would not significantly increase prices, due to the ample supply to meet domestic demand, but many consumers are concerned that the prices would rise and negatively impact them.[44] Furthermore, research indicates that increases in domestic natural gas prices would potentially have disproportionate consequences for low-income consumers.[45]

Other concerns regarding exports include the possibility that exporting gas would diminish the potential for domestic benefits such as boosting manufacturing, replacing coal-fired power plants, and replacing oil as the source of automotive fuels.[46] Others are opposed to expanded exports that could result in greater U.S. shale gas production, potentially generating environmental and social challenges.[47] Furthermore, many of the economic benefits that proponents cite could actually be less substantial. For instance, terminal construction could employ up to 8,000 at various points in the next few years, but these would be temporary positions.[48] Additionally, while expanded production could create up to 40,000 new jobs along the natural gas supply chain, many of these jobs would take years to materialize, and could largely be offset by lower employment in other areas.[49]

Despite the various challenges detailed above and the capital outlay required to build an export LNG terminal, corporate interest in liquid natural gas exports is rising quickly and dramatically, though even the most ardent investors are limited by slow permitting. Of the seven LNG export terminal permit applications approved by the DOE as of March 2014, only two are fully permitted, and just one project is already under construction. Cheniere Energy, which began applying for permits in 2010, is constructing a multi-billion dollar natural gas terminal in Louisiana, slated to make its first exports in 2015.[50] Other interest appears more speculative. The American Petroleum Institute has created a map of pending Department of Energy LNG terminal construction applications; since March, the number has ballooned from seven to 24.[51] The DOE is at present considering a plan to streamline and reorganize the permitting process.[52]

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[44] ibid.
[45] Michael Levi, The Brookings Institute, "A Strategy for U.S. Natural Gas Exports," 2012: http://www.brookings.edu/~/media/research/files/papers/2012/6/13%20exports%20levi/06_exports_levi.pdf
[46] ibid.
[47] ibid., Congressional Research Service, "U.S. Natural Gas Exports: New Opportunities, Uncertain Outcomes," 2013: http://www.fas.org/sgp/crs/misc/R42074.pdf
[48] Michael Levi, The Brookings Institute, "A Strategy for U.S. Natural Gas Exports," 2012: http://www.brookings.edu/~/media/research/files/papers/2012/6/13%20exports%20levi/06_exports_levi.pdf
[49] ibid.
[50] Jennifer Dlouhy, *Fuelfix*, "Houston Company wins federal approval for gas export project," 2014: http://fuelfix.com/blog/2014/06/19/houston-company-wins-federal-approval-for-gas-export-project/
[51] American Petroleum Institute, "LNG Export Facilities, Compiled by the American Petroleum Institute," 2014: https://api.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=aa7b306e4769400fbc69989d9cbcbea4
[52] Department of Energy, "Proposed Procedures for Liquefied Natural Gas Export Decisions," http://energy.gov/fe/proposed-procedures-liquefied-natural-gas-export-decisions

## SHALE GAS AND MANUFACTURING OUTLOOK

The need for regulatory certainty has not dissuaded U.S. manufacturers from making investments motivated by the shale gas boom; its impact can be felt across U.S. manufacturing in its direct and indirect contribution to onshoring, and the use of shale gas as a feedstock and a fuel.

More than 200 mostly U.S.-based companies have participated in onshoring during the past four years, a trend in part motivated by the availability of less expensive natural gas.[53] One Fall 2013 survey of $1B-plus company executives stated that over half of those are either already planning for or actively considering moving production back to the U.S. from China- a figure double that from the same survey given the previous year.[54] While not the only factor, the affordability of natural gas as both an energy source and a feedstock is a powerful motivator: natural gas and electricity account for just 2% of total manufacturing costs in U.S. manufacturing processes compared to 5-8% in Japan and 6% in China.[55]

Why have chemical companies been the first to invest in manufacturing supported by natural gas? Supported by both anecdote and numbers, the importance of low-cost natural gas to the chemical industry is difficult to overstate. During the symposium, American Chemistry Council president Cal Dooley heralded the shale gas boom as a period of "rational exuberance" for the chemical industry. In May 2013, the American Chemistry Council reported that nearly 100 chemical companies had announced new projects related to opportunities created by the availability and price of U.S. shale gas.[56] The appeal of low cost feedstock, in total, had yielded just shy of $100 billion in promised facility construction.[57]

The shale gas boom has already reversed the U.S. trade balance for the chemical industry from a $9.4 billion deficit in 2005 to a $3.4 billion surplus in 2013. The trade surplus in basic chemicals excluding pharmaceuticals was $41.3 billion in 2013.[58]

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[53] Chevron Phillips Chemical Company LCC, "Chevron Phillips Chemical Celebrates USGC Petrochemicals Project Groundbreaking at its Cedar Bayou Plant in Baytown, Texas," 2014: http://www.cpchem.com/en-us/news/Pages/Chevron-Phillips-Chemical-Celebrates-USGC-Petrochemicals-Project-Groundbreaking-at-its-Cedar-Bayou-Plant-in-Baytown,-Texas.aspx

[54] David Fondiller, Boston Consulting Group, "Majority of Large Manufacturers Are Now Planning or Considering 'Reshoring' from China to the U.S.," 2014: http://www.bcg.com/media/pressreleasedetails.aspx?id=tcm:12-144944

[55] Boston Consulting Group, "Study: Manufacturers Will Benefit From Low-Cost U.S. Natural Gas," 2014: http://www.manufacturing.net/news/2014/02/study-manufacturers-will-benefit-from-low-cost-us-natural-gas

[56] American Chemistry Council, Shale Gas, Competitiveness, and New U.S. Chemical Industry Investment: An Analysis Based on Announced Projects, 2013: http://chemistrytoenergy.com/sites/chemistrytoenergy.com/files/shale-gas-full-study.pdf

[57] Reuters U.S. Edition, "Shale Gas Lures Global Manufacturers to U.S. Industrial Revival," 2013: http://www.reuters.com/article/2013/03/26/manufacturing-shale-idUSL6N0CE57M20130326

[58] Scott Jenkins, *Chemical Engineering*, U.S. Trade Surplus in Chemicals Expanded in 2013: http://www.che.com/only_on_che/latest_news/U-S-trade-surplus-in-chemicals-expanded-in-2013-ACC-says_11488.html

Much of the U.S. chemical industry is based on ethylene, a feedstock produced by cracking ethane and higher hydrocarbon components of natural gas liquids. Because the supply of natural gas in other countries is limited, many European and Asian companies use naphtha as a feedstock, a more expensive product derived from crude oil. When a consistent supply of feedstock is assured, the U.S. advantage is clear. "Ethane cracker" plants produce the raw material needed for plastics and chemicals manufacturing. Proximity to shale gas deposits lowers the production costs for cracker plants. The shale gas boom is already producing huge results for these manufacturers: the ethane supply in the United States has increased fourfold.[59]

In 2012, Dow Chemical announced plans to locate a major new plastics facility in Texas, a project Dow CEO Andrew Liveris credited directly to the regional availability of abundant, low-cost natural gas.[60] The move is similar to that of Odebrecht Brazil; the company is planning a $4-6 billion dollar ethane cracker facility in Parkersburg, West Virginia, near Pennsylvania's Marcellus shale deposits.[61] Royal Dutch Shell has been holding a land option and considering a large-scale ethane processing facility in Pennsylvania, also near Marcellus, for over two years; as of April 2014, the company had scheduled several public meetings to gauge regional support for the project.[62] Chevron Phillips Chemical Company broke ground on a 3-plant ethane cracker and polyethylene project in Baytown, Texas earlier this spring.[63]

The ammonia production industry also stands to benefit dramatically from the shale gas boom. Between 70-90% of the cost of producing ammonia, a key component of fertilizers and other agricultural products, is the cost of natural gas – as both feedstock and fuel. Just three years ago, more than half of U.S. nitrogen fertilizer was imported.[64] Until a recently announced spate of new projects, no new ammonia plants had been constructed on U.S. soil in the past 30 years. In 2013, Incitec Pivot Ltd. announced an $850 million ammonia plant construction project in Waggaman, Louisiana, and began construction almost immediately. The plant is slated to begin operation in 2016.[65] A $1.7 billion CF Industries fertilizer plant in Port Neal, Iowa, which broke ground in 2013 and is slated to begin

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[59] Calvin Dooley, "$100 Billion and Counting: Shale Gas and New U.S. Chemical Industry Investment," 2014: http://chemistrytoenergy.com/sites/chemistrytoenergy.com/files/Dooley-U-Mich-slides.pdf

[60] Daniel Gilbert, *Wall Street Journal*, "Chemical Makers Ride Gas Boom," 2012: http://online.wsj.com/news/articles/SB10001424052702304331204577352161288275978

[61] Dan Shingler, *Crain's Cleveland Business*, "Ethane Cracker Planned for Parkersburg, W. Va.," 2014: http://www.crainscleveland.com/article/20140326/FREE/140329825

[62] Marie Cusick, *State Impact (NPR)*, "Shell Holds Public Meetings on Proposed Cracker Plant," 2014: http://stateimpact.npr.org/pennsylvania/2014/04/16/shell-holds-public-meetings-on-proposed-cracker-plant/

[63] Chevron Phillips Chemical Company, "Chevron Phillips Chemical Celebrates USGC Petrochemicals Project Groundbreaking at its Cedar Bayou Plant in Baytown, Texas," 2014: http://www.cpchem.com/en-us/news/Pages/Chevron-Phillips-Chemical-Celebrates-USGC-Petrochemicals-Project-Groundbreaking-at-its-Cedar-Bayou-Plant-in-Baytown,-Texas.aspx

[64] U.S. Department of Agriculture, "2012 Saw Near Record Imports of Nitrogen, Moderate Declines in Phosphate Exports, and Large Declines in Potash Imports," 2013: http://www.ers.usda.gov/data-products/fertilizer-importsexports/summary-of-the-data-findings.aspx#.U3zCuFhdWbE

[65] Incitec Pivot Limited, "Major Projects: New Ammonia Plant, USA," 2014: http://www.incitecpivot.com.au/about-us/major-projects/ammonia-plant-usa

operation in 2016, represents the single largest capital investment in the state's history.[66] Capable of producing two million tons of ammonia and 2 million tons of urea ammonium nitrate each year, the plant is expected to save Iowa farmers $740 million a year by enabling local fertilizer purchases. As of May 2014, multinational chemical company BASF had announced plans to construct a Texas ammonia plant with an annual capacity of 750,000 tons with Norwegian company Yara. At the same time, BASF is considering building its largest-ever facility, designed to convert methane to propylene, on the Gulf Coast. BASF chairman and CEO Hans Engel said the plant would "allow BASF to take advantage of very competitive gas prices in the U.S. due to shale gas production."[67]

Natural gas from shale has brought new life to a once dominant industry still recovering from the 2008 recession: steel. Shale gas has both lowered the cost of production and increased demand for the product; the estimated 50,000 miles of new or improved pipeline needed to support the shale gas boom could require steel purchases of $100 billion.[68]

In March, Nucor dedicated the first of five planned projects – a $750 million reduced iron plant located in Louisiana. (Reduced iron is needed for the manufacture of steel.) The plant uses raw material from several other countries, processing them with U.S. natural gas; it is the largest such facility on the planet.[69] In Arkansas, Big River Steel is constructing a $1.3 billion steel plant employing 545 full-time workers; they are beginning construction this summer.[70] The plant sits near Arkansas's rich Fayetteville Shale deposit. In January 2014, to address rising demand, ArcelorMittal announced the reopening of a Tennessee steel finishing plant that had just closed in 2011.[71]

Aluminum manufacturing is a similarly energy-intensive industry. In 2008, Alcoa announced an operations reduction, and then closure, at its Port Comfort, TX plant – one of nine alumina facilities the company operates around the globe. The plant, which closed due to high power costs, employed 650 people.[72] Eric Roegner, COO of Alcoa, noted during the March symposium that natural gas prices have enabled Port Comfort to operate at full capacity again.

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[66] Matt Breen, KTIV, "CF Plant Manager 'looking forward' to Expanding Port Neal Plant," 2013: http://www.ktiv.com/story/23984383/2013/11/15/cf-plant-manager-looking-forward-to-expanding-port-neal-plant

[67] Renita Young, *The Times Picayune*, "BASF, Yara to build ammonia plant in Texas," 2014: http://www.nola.com/business/baton-rouge/index.ssf/2014/05/basf_considering_new_expansion.html

[68] Steve Mehltretter, Herve Wilczynski and Peter Findlay, *Industryweek*, "The Shale Gas Boom: Boon or Bust for U.S. Steelmakers?," 2013: http://www.industryweek.com/competitiveness/shale-gas-boom-boon-or-bust-us-steelmakers

[69] Area Development, "Nucor Corp's Direct Reduced Iron Plant First Phase Of $3.4 Billion Project In St. James Parish, Louisiana," 2014: http://www.areadevelopment.com/newsitems/3-4-2014/ucor-st-james-parish-louisiana238902.shtml

[70] "Financing Closed for Big River Steel Mill," Arkansas News, 2014: http://arkansasnews.com/news/arkansas/financing-closed-big-river-steel-mill

[71] Joseph S. Pete, *Northwest Indiana Times*, "ArcelorMittal reopens mothballed Tennessee finishing plant," 2014: http://www.nwitimes.com/business/local/arcelormittal-reopens-mothballed-tennessee-finishing-plant/article_d67e10ae-050d-563a-90d6-c58505d9242e.html

[72] *Ceramic Industry News*, "Alcoa to Reduce Alumina Production at Port Comfort by 25%," 2008: http://www.ceramicindustry.com/articles/alcoa-to-reduce-alumina-production-at-port-comfort-by-25-posted-10-31-08

Commodity producers of products like paper and glass have also experienced an uptick related to the increased availability and lower price of natural gas. In Vermont last year, reversing a series of plant closures, International Paper invested $70 million in a pipeline project aimed at supplying their 600-employee factory with natural gas.[73] The company will invest an additional $10 million to convert the plant's power source. During the symposium, International Paper Director of Global Technology Chris Read explained that his company makes $1 billion in investment decisions each year. Because the price of natural gas is so low, more of the company's U.S. projects are being greenlighted. Natural gas is also important to glass manufacturers, who use it to heat their furnaces. Three-quarters of energy used during the process of creating glass comes from natural gas.[74]

Can manufacturing growth on this scale last? At the symposium, the American Chemistry Council's Cal Dooley noted the current gas and oil prices a bit wryly, remarking "We've never had it so good and probably never will again." But a November 2013 IHS report predicted that natural gas prices would remain at $4-5 per 1,000 cubic feet (in 2012 dollars) through the year 2035.[75]

Even with many manufacturers still working through capital investment phases, the price advantage afforded by U.S. natural gas is making an impact. Factory output grew 2.1% in April 2014 compared to the previous year, and is comparable with pre-recession production levels. Industrial production enjoyed a 3.5% growth percentage during that same period.[76,77] Boosting an overall trend of a slowly narrowing U.S. trade deficit, between March 2013 and March 2014 exports rose five percent– the second highest increase on record. The increase was supported by rising exports in gas, oil, farm goods, aircraft, and cars.[78]

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[73] Kathyrn Flagg, *Seven Days Vermont,* "For a North Country Paper Mill, Natural Gas Could Be a Lifesaver," 2013: http://www.sevendaysvt.com/vermont/for-a-north-country-paper-mill-natural-gas-could-be-a-lifesaver/Content?oid=2243120

[74] U.S. Energy Information Administration, "Glass manufacturing is an energy-intensive industry mainly fueled by natural gas," 2013: http://www.eia.gov/todayinenergy/detail.cfm?id=12631

[75] Rita Beale *et al.*, IHS Cera, "Fueling the Future with Natural Gas: Bringing it Home," 2014: http://www.fuelingthefuture.org/assets/content/AGF-Fueling-the-Future-Study.pdf

[76] Steve Minter, *Industryweek*, "Manufacturing Output Takes a Tumble in April," 2014: http://www.industryweek.com/global-economy/manufacturing-output-takes-tumble-april

[77] Federal Reserve, "Industrial Production and Capacity Utilization," 2014: http://www.federalreserve.gov/RELEASES/G17/current/default.htm

[78] *Trading Economics*, "U.S. Trade Deficit Narrows in March," 2014: http://www.tradingeconomics.com/united-states/balance-of-trade

## ENVIRONMENTAL CONCERNS

Through impacts to water, air, soil, flora, and fauna, ecological systems can be adversely affected in a variety of ways from shale gas development, as with other resource extraction processes. In fact, many of the ecosystem impacts ascribed to shale gas are characteristic of oil and gas drilling and production, and are not unique to the horizontal drilling or hydraulic fracturing techniques that have enabled shale gas development. Nevertheless, the risks of shale gas development concern stakeholders across the board, from the public, to operators, to policy-makers.

Resources for the Future, a non-profit organization, conducted a survey and statistical analysis of experts from government agencies, industry, academia, and non-governmental organizations to identify the risks that relevant experts perceive from shale gas development.[79] From this survey, 12 risks (out of 264) were established as 'consensus' risks, or those that were chosen most frequently as a priority by each expert group. Of those 12 consensus risks, nine were related to water, highlighting that the greatest perceived environmental risks among experts are related to water, as well as suggesting that water could very well be vulnerable as a result of shale gas development.

Water concerns focus primarily around the potential contamination of water as well as the volume of water withdrawals. The contamination of surface water and groundwater could arise from three main sources: "1) spills and releases of produced water, chemicals, and drill cuttings, 2) erosion from ground disturbances, or 3) underground migration of gases and chemicals".[80] Additives in fracturing fluid could pose risks to water quality if they come into contact with surface or groundwater, since some are known to be toxic.[81]

Understanding the impact of water withdrawal is particularly important in arid or drought-prone regions. In Pennsylvania for instance, hydraulic fracturing operations have used between 3-5 million gallons of water over the course of two to five days.[82] While some of this water might be recycled, much of it frequently comes from regional surface waters.[83] Although relative to overall consumption, shale gas development is generally not a major consumer of water,[84] it is important to consider the implications of large water withdrawals on a local

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[79] Resources for the Future, "Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development," 2013: http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale-Gas-Expert-Survey.aspx
[80] University of Michigan, "Hydraulic Fracturing in the State of Michigan Integrated Assessment," 2013: http://graham.umich.edu/media/files/HF-04-Environment-Ecology.pdf
[81] ibid.
[82] New York State Water Resources Institute, "Water Withdrawal Volumes Required for Hydrofracking," 2012: http://wri.eas.cornell.edu/gas_wells_water_use.html
[83] ibid.
[84] Felicity Barringer, *The New York Times*, "Spread of Hydrofracking Could Strain Water Resources in West, Study Finds," 2013: http://www.nytimes.com/2013/05/02/science/earth/hydrofracking-could-strain-western-water-resources-study-finds.html?_r=1&

context, where the withdrawal needs for production are usually extreme for a short period of time, and then largely insignificant afterwards.[85] In areas where water is already scarce, this could potentially be problematic.

In addition to water withdrawal concerns, there are also serious concerns regarding the disposal of water used in the hydraulic fracturing process. "Produced water," which is simply all of the wastewater that emerges from the well after production begins,[86] can contain pollutants that are potentially harmful both to humans and to ecosystems, through toxicity, radioactivity, corrosiveness, oxygen depletion causing algal blooms, or even interacting with disinfectants at water treatment facilities to form carcinogens.[87] The most common ways to manage this wastewater involve reusing the water, treating and discharging it, underground injection, storage in special containers, and applying it on land areas (usually roads). Federal and/or state governments regulate all of these activities, as they present some level of risk to health or to the environment.[88]

While disposal methods will continue to depend to a large degree on economics and regulations, there is a growing body of evidence suggesting that current practices and regulations do not provide adequate human or ecosystem protection.[89,90] Recent studies exploring the impact of underground injection of wastewater on seismic activity have yielded new concerns about the practice's safety. During 2010-2011, Oklahoma recorded 850 seismic events — up from only 7 during 2000-2008.[91] Originally thought to stem from fracking itself, the seismic events were only recently definitively tied to wastewater injection.[92]

Air quality and climate concerns, stemming in particular from the release of methane, represent two of the 12 consensus risk pathways identified in the RFF report.[93] Methane, the primary gas in shale gas, is a potent greenhouse gas. Fugitive methane emissions during production and distribution of natural gas have the potential to offset the carbon benefit of increased combustion efficiency of natural gas.[94] Recent studies in the U.S. have indicated methane emissions

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[85] ibid.
[86] Rebecca Hammer, Natural Resources Defense Council, "In Fracking's Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater," 2012: http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf
[87] ibid.
[88] ibid.
[89] ibid.
[90] Nathaniel R. Warner *et al.*, *Environmental Science and Technology,* Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania, 2013: http://pubs.acs.org/doi/abs/10.1021/es402165b?journalCode=esthag
[91] Dominic Basulto, *The Washington Post*, "Oklahoma Earthquakes Highlight an Inconvenient Truth About Innovation," 2014: http://www.washingtonpost.com/blogs/innovations/wp/2014/07/15/oklahoma-earthquakes-highlight-an-inconvenient-truth-about-innovation/
[92] K.M. Keranen, *et al.*, *Science*, "Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection," 2014: http://www.sciencemag.org/content/early/2014/07/02/science.1255802
[93] Resources for the Future, "Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development," 2013: http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale-Gas-Expert-Survey.aspx
[94] Ramon A. Alvarez, *et al.*, *Proceedings of the National Academy of Sciences*, "Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure," 2014: http://www.pnas.org/content/109/17/6435.full?sid=17397862-0670-459c-a71f-ab50a16fbb4e

are substantially higher than currently estimated by inventories,[95] but this review notes the under-estimates appear across the oil and gas industry. This highlights the need for identifying and reducing fugitive emissions across the broader natural gas infrastructure, particularly as newly accessible shale reserves increase the volume of gas in the system.

Other air-related impacts from shale gas development include emissions from other sources, particularly machinery and traffic. Many operators use diesel-fueled combustion engines to power their equipment, and the development process itself typically involves a sharp increase in traffic. These engines produce exhaust, which contains pollutants such as nitrogen oxides (that create ground-level ozone) as well as particulate matter that can adversely affect human and ecological health.[96]

The final risk pathway identified in the RFF report is habitat disruption, resulting primarily from land clearing and the construction of infrastructure.[97] While this impact category is not typically a prominent part of many discussions on the environmental impacts of shale gas development, impacts here have the potential to be significant.[98]

Other impacts are possible as equipment and water are brought in from distant locations. In particular, invasive species, which can disrupt normal ecosystem functioning, are of concern.[99] Finally, increased levels of light and noise from operations can cause disturbances to "feeding, breeding, and rest patterns in micro- and mega- flora and fauna, providing a potential for ecosystem degradation".[100]

In order to ensure sustainable development and to prevent supply constraints resulting from loss of license to operate, environmental issues related to shale gas must be a primary concern of all parties across the supply and manufacturing chain working toward its expanded utilization.

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[95] A.R. Brandt, *et al.*, *Science*, "Methane Leaks from North American Natural Gas Systems," 2014: http://www.sciencemag.org/content/343/6172/733.full
[96] University of Michigan, "Hydraulic Fracturing in the State of Michigan Integrated Assessment," 2013: http://graham.umich.edu/media/files/HF-04-Environment-Ecology.pdf
[97] Resources for the Future, "Pathways to Dialogue: What the Experts Say about the Environmental Risks of Shale Gas Development," 2013: http://www.rff.org/centers/energy_economics_and_policy/Pages/Shale-Gas-Expert-Survey.aspx
[98] Daniel J. Soeder, The Marcellus Shale: Resources and Reservations, 2010: http://onlinelibrary.wiley.com/doi/10.1029/2010EO320001/abstract
[99] ibid.
[100] University of Michigan, "Hydraulic Fracturing in the State of Michigan Integrated Assessment," 2013: http://graham.umich.edu/media/files/HF-04-Environment-Ecology.pdf

## SHALE GAS AND MANUFACTURING: POTENTIAL BENEFITS

Shale gas has the potential to bring significant benefits to the U.S. economy as a result of its growing use as a fuel and feedstock, and its increasing role in the domestic energy mix. In terms of the U.S. economy, analysts project that the use of shale gas in the manufacturing sector will lead to increases in employment, household income, government tax revenue, and GDP value-added. IHS predicts that by 2025, shale gas and other unconventional fuels could contribute one to nearly four million additional jobs and increase household disposable income by an average of $3,500. In 2012, they report, the average family enjoyed a disposable income increase of $1,200.[101] The U.S. EIA likewise projects the most significant industrial growth to take place before 2025, at which point output growth will likely slow as a result of rising energy prices and growing international competition.[102]

There is limited room for growth through the residential energy market, according to the EIA, which projects a 4% decline in average household electricity demand by 2040.[103] On the other hand, the industrial energy market is projected to increase by 28% by 2040, largely from increasing natural gas use.[104] Nonetheless, the EIA points to the mix of industrial energy sources remaining relatively constant, which they see as reflective of "limited remaining capability for switching from other fuels to natural gas in most industries".[105] While this is a significant challenge, it could also be seen as an opportunity for the development of new technologies or new infrastructure.

In fact, there are opportunities to innovate around natural gas development and usage at many levels. The development of next generation sensors and monitoring hardware/software could find widespread demand as both regulators and operators attempt to address public concerns about emissions and improve profitability. Storage capacity is another challenge that has become clearer with recent winters that have produced prolonged periods of deep cold for large parts of the country. Innovation in storage technologies and infrastructure could provide value for both consumers and producers.

Finally, the possibility of growth in U.S. exports of natural gas and natural gas liquids represents a significant opportunity. Through careful planning, domestic exports could give the U.S. increased leverage in global trade and geopolitics, justify expanded domestic production and infrastructure developments, and

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[101] IHS, "U.S. Unconventional Oil and Gas Revolution to Increase Disposable Income by More than $2,700 per Household and Boost U.S. Trade Position by More than $164 billion in 2020," 2013: http://press.ihs.com/press-release/economics/us-unconventional-oil-and-gas-revolution-increase-disposable-income-more-270

[102] U.S. Energy Information Administration, EIA Annual Energy Outlook 2014, "For Energy-Intensive Industries, Output Growth is Strong Early, Then Slows After 2025," 2014: http://www.eia.gov/forecasts/AEO/MT_intl.cfm

[103] ibid.

[104] ibid.

[105] ibid.

provide additional revenue streams for governments. Of course, there are risks, but thorough and careful planning could reduce the environmental and social risks associated with shale gas development and export.

## SHALE GAS AND MANUFACTURING: CHALLENGES TO CONSIDER

In order for all the promised contributions of shale gas to the economy to be realized, challenges related to infrastructure, price, supply, and workforce need to be addressed.

### Infrastructure

The shale gas industry has grown explosively over the past half-decade, and pipeline construction has raced along with it. A report authored by the House Natural Resources Committee Democratic staff suggests that American consumers paid $20 billion between 2000-2011 to cover the cost of natural gas escapes from pipelines operated by 3,000 separate companies, in 46 states.[106] That cost is, of course, also being passed along to manufacturers – not only in real dollars, but also in the opportunity cost of industry reluctance to make the heavy capital and permitting investments needed to reach a distribution network.

Unaccounted-for Gas, Emissions, and Significant Incidents on Natural Gas Systems[107]

| | |
|---|---|
| **Total U.S. Unaccounted for Gas from Natural Gas Systems from 2000-2011**[a] | 2.6 trillion cubic feet of natural gas |
| **Total U.S. Reported Emissions from Natural Gas Distribution Systems from 2010 - 2011**[b] | Equivalent to releasing 56.2 million metric tons of $CO_2$ |
| **Significant Incidents on U.S. Natural Gas Distribution Systems from 2002-2012**[c] | 796 incidents / 116 fatalities / 465 injuries / $810,677,757 in property damage |

[a] Source: EIA, Form 176. Includes unaccounted for gas from transmission companies and distribution companies.
[b] Source: EPA, U.S. Greenhouse Gas Inventory of Sources and Sinks, 1990-2011, available at: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf
[c] Source: PHMSA, available at: http://primis.phmsa.dot.gov/comm/reports/safety/SigPSI.html?nocache=1229

With existing pipelines in far heavier use than they were during 2000-2011, addressing aging infrastructure is ever more imperative. In this urgent

[106] The House Natural Resources Committee Democratic Staff, "America Pays for Gas Leaks: Natural Gas Pipeline Leaks Cost Consumers Billions," 2013: http://www.markey.senate.gov/documents/markey_lost_gas_report.pdf
[107] The House Natural Resources Committee Democratic Staff, "America Pays for Gas Leaks: Natural Gas Pipeline Leaks Cost Consumers Billions," 2013: http://www.markey.senate.gov/documents/markey_lost_gas_report.pdf

environment the U.S. Pipeline and Hazardous Materials Safety Administration announced a 9% staff cut in April 2014, puzzling industry experts.[108]

North America built and planned more pipeline in 2013 – 41,810 miles – than any other region on earth,[109] but even at that rate of construction, the distribution network remains insufficient. New pipelines often hook up to older ones of dubious maintenance status, and because pipelines are often built to service individual ventures or utility needs, they lack the logic of a highway-system-style network. The limitation of the current infrastructure can be viewed in stark terms through the lens of winter wholesale natural gas prices in New England. In winter 2013-2014, the wholesale price in Pennsylvania, on top of the Marcellus shale deposit, was $3.37 per million BTUs. In Boston, it was $24.09.[110]

During the symposium, Alcoa COO Eric Roegner cited infrastructure improvement, along with "thoughtful regulation," as the two most needed steps to ensure maximum utilization of shale gas by manufacturers. Christopher Guith of the U.S. Chamber of Commerce described sluggish infrastructure improvement as one of the "dominoes that needs to fall" before manufacturers can take full advantage of the shale gas boom.

Price

"To what extent does America want to accrue benefits for our own firms by retaining shale gas on our shores, or balance trade by exporting liquid natural gas? What combination is most beneficial to us as a nation?"

-Norman Augustine, "Manufracking," Shale Gas: A Game Changer for American Manufacturing, March 28, 2014

In May 2014, Russia and China signed a $400 billion, 30-year natural gas deal, tipping the global gas market in an ever-more-regional direction.[111] The signing of a single agreement, even one so massive, will not slake foreign demand for natural gas. The Department of Energy, representatives from industry, and lawmakers have all been debating the appropriate trade balance for this resource. Contributors to the symposium were unopposed to exports, maintaining that the U.S. is capable of achieving a natural gas trade balance similar to that of Middle Eastern countries' approach to oil trade, and that market forces would keep the price competitive.

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[108] Elizabeth Douglass, *Inside Climate News*, "Federal Pipeline and Oil-by-Rail Regulator Making 9% Staff Cut, Confounding Experts," 2014: http://insideclimatenews.org/news/20140424/federal-pipeline-and-oil-rail-regulator-making-9-staff-cut-confounding-experts

[109] Rita Tubb, *Pipeline and Gas Journal*, "2013 Worldwide Construction Report," 2013: http://pipelineandgasjournal.com/pipeline-gas-journal%E2%80%99s-2013-worldwide-construction-report?page=show

[110] Alison Sider, *The Wall Street Journal*, "Why Marcellus Shale Gas Doesn't Get to New England," 2014: http://online.wsj.com/news/articles/SB10001424052702304788404579519461682943726

[111] Jane Perlez, *The New York Times*, "China and Russia Reach 30-Year Gas Deal," 2014: http://www.nytimes.com/2014/05/22/world/asia/china-russia-gas-deal.html?hpw&rref=business&_r=0

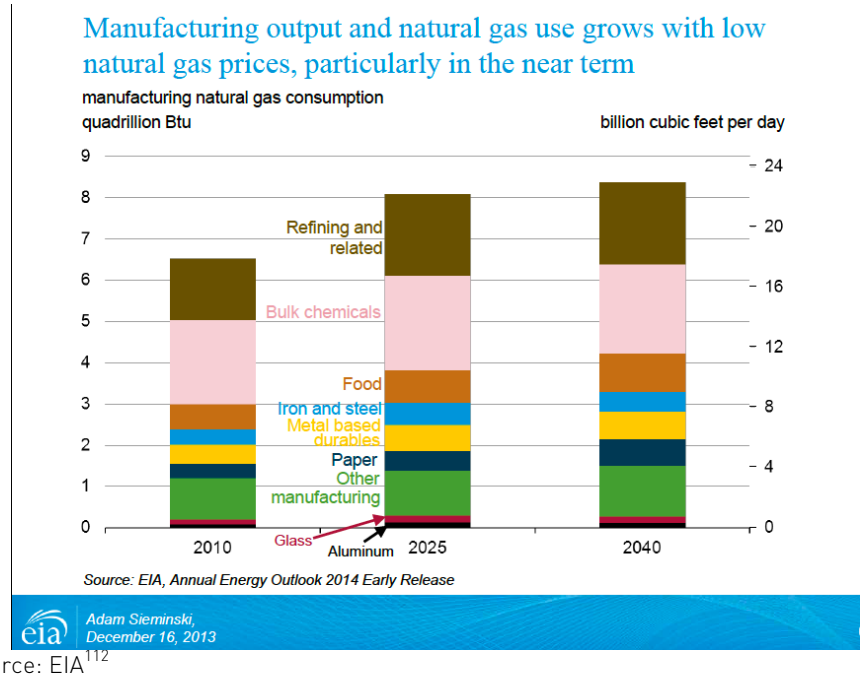


Figure source: EIA[112]

"We don't need to go back to being an island economy in order to prosper," said 72nd Secretary of the Treasury Paul O'Neill during the symposium, adding that exports on a case-by-case basis, to encourage the development of economic allies, would be beneficial overall to the U.S. bottom line. May 2014 EIA forecasts do predict that the price of natural gas, particularly for industrial markets, will rise steadily over time, but not enough to cede the U.S. competitive advantage wrought by shale gas.

In addition to exports, manufacturers will face demand for natural gas driven by electricity generation; coal power plants, when retired, are most likely to be replaced with natural-gas-powered plants, at least in the current and foreseeable economic and regulatory climate. Use of natural gas for electric power generation is expected to eclipse industrial usage by 2040 when, the EIA predicts, industrial usage will slow in response to rising price.[113]

[112] U.S. Energy Information Administration, "AEO2014 Early Release Overview," 2014: http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf
[113] U.S. Energy Information Administration, "U.S. Natural Gas Wellhead Price," 2014: http://www.eia.gov/dnav/ng/hist/n9190us3M.htm

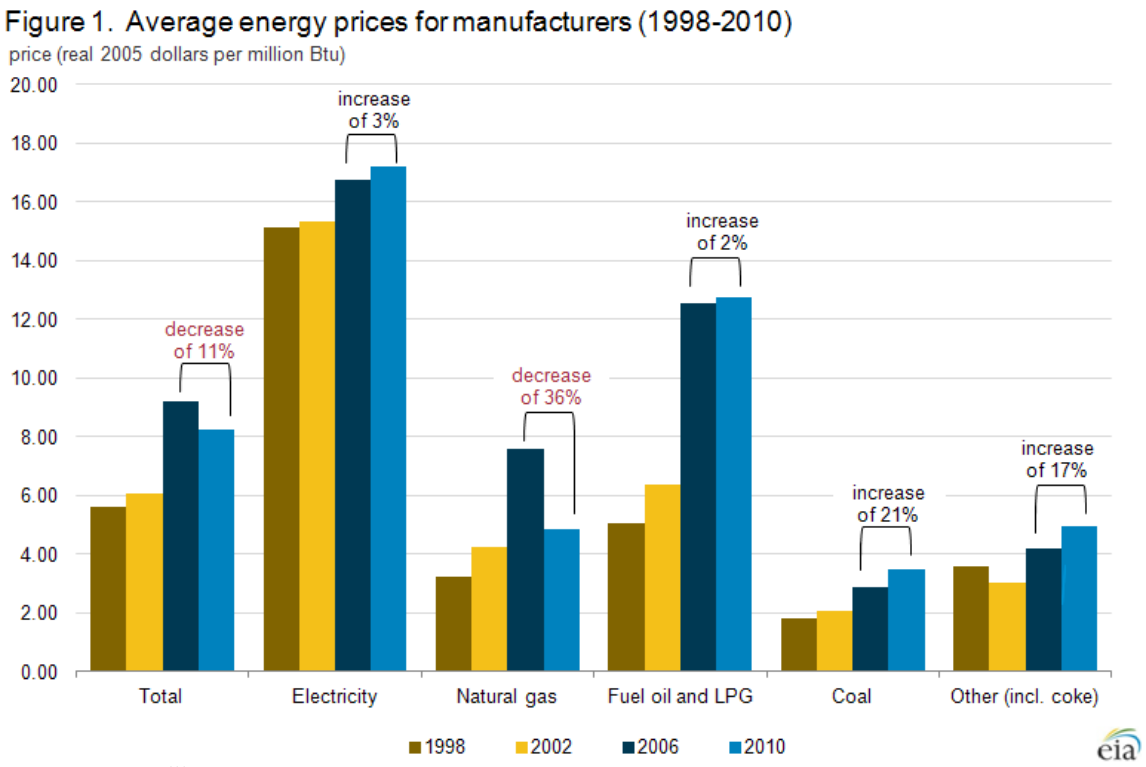


Figure source: EIA[114]

## Supply

Price considerations are inextricably linked to questions of supply. Estimates of the U.S. shale gas resources vary every bit as dramatically as oil estimates have done (most sit between 30 and 200 years supply), but the most commonly used number is the EIA's 2011 estimate of 92 years.[115]

Those estimates also presume that municipal or state fracking bans will not threaten license to operate – the threat, aside from lack of regulatory clarity, most frequently invoked by symposium participants. Moratoria and bans – real and symbolic – on hydraulic fracturing have been passed by municipalities in the following states: Arkansas, California, Colorado, Delaware, Hawaii, Iowa, New Jersey, New Mexico, New York, North Carolina, Pennsylvania, Texas, Vermont, Virginia and West Virginia. The overlap between states with a history of passing municipal bans and states with fracking activity is significant – especially important are Pennsylvania, West Virginia, and Texas. (Notably, Louisiana and

[114] U.S. Energy Information Administration, "Cost of Natural Gas Used in the Manufacturing Sector Has Fallen," 2013: http://www.eia.gov/consumption/manufacturing/reports/2010/ng_cost/?src=%E2%80%B9%20Consumption%20%20%20%20%20%20Manufacturing%20Energy%20Consumption%20Survey%20(MECS)-f1

[115] Chris Nelder, *Slate*, "What the Frack? Is there really 100 years' worth of natural gas beneath the United States?," 2011: http://www.slate.com/articles/health_and_science/future_tense/2011/12/is_there_really_100_years_worth_of_natural_gas_beneath_the_united_states_.html

South Dakota – both of which have benefited heavily from hydraulic fracturing-have no such municipal bans in place.)

Workforce

Manufacturing in the age of the shale gas boom faces another important challenge: many members of the skilled labor workforce are reaching retirement age over the coming decade, and workforce shortages loom in both skilled manufacturing and, up the supply chain, in the power generation industry.

Though skilled labor shortages have been covered extensively in the news, a comprehensive new MIT study[116] – surveying 900 manufacturers who utilize skilled labor positions – suggests that skilled labor shortages might not be as great as many 2012 and 2013 reports estimated.[117] Only 16% percent of manufacturers reported a labor shortage equal or greater than five percent of their total employee population. 75% reported zero long-term vacancies.[118]

The aging of the American workforce is a broader issue than manufacturing. In 1950, there were 7.1 Americans of working age for every retiree. In 2050, that number will shrink to 2.7.[119] Workers in manufacturing, utility and supply chain fields skew older than the general working population – the average American welder is 55 years old.[120] Almost half of U.S. utility workers are eligible for retirement in the next five years.[121]

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[116] Paul Osterman, *The National Journal*, "What Skills Gap?," 2014: http://www.nationaljournal.com/next-america/perspectives/what-skills-gap-20140502

[117] Joshua Wright, Forbes, "America's Skilled Trades Dilemma: Shortages Loom As Most-In-Demand Group Of Workers Ages," 2013: http://www.forbes.com/sites/emsi/2013/03/07/americas-skilled-trades-dilemma-shortages-loom-as-most-in-demand-group-of-workers-ages/

[118] Paul Osterman, *The National Journal*, "What Skills Gap?," 2014: http://www.nationaljournal.com/next-america/perspectives/what-skills-gap-20140502

[119] Technology Innovation Program, National Institute of Standards and Technology, "MANUFACTURING: Advanced Robotics and Intelligent Automation," 2011: http://www.nist.gov/tip/wp/upload/manufacturing_adv_robotics_intelligent_automation_wp_08_11.pdf

[120] Matthew Phillips, *Bloomberg Businessweek Global Economics,* "Welders: America Needs You," 2014: http://www.businessweek.com/printer/articles/191361-welders-america-needs-you

[121] Shannon Miller, *Pipeline and Gas Journal,* "Utility Workers Rapidly Reaching Retirement Age: Now What?," 2013: http://www.pipelineandgasjournal.com/utility-workers-fast-reaching-retirement-age-%E2%80%93-now-what

## POLICY RECOMMENDATIONS

While greater certainty – whether about supply, price or regulatory environment – is always desired by those who must make decisions about investments of the scale and term of those required for new manufacturing facilities, it is clear that significant investments are already being made in response to the U.S. shale gas bonanza. We focus therefore on policies needed to promote a sustained manufacturing renaissance powered by this resource, policies that will incentivize a broad spectrum of investments needed to promote manufacturing growth and reduce the associated vulnerabilities, if not the uncertainties.

Although much public discussion has focused on the potential of competing uses for natural gas to produce higher gas prices and thereby reduce the advantage currently enjoyed by energy-intensive U.S. manufacturing industries, the scale and lead times associated with these are not likely to cause abrupt changes to markets. Disruption of supply, rather than competition for supplies, represents a potentially greater limitation to manufacturing investment and operations. Coherent and complementary policies are needed to ensure stable, robust supplies to manufacturers. Both Federal and State governments have important roles to play, as do the industries that benefit from shale gas at many points in our economy.

Recommendation 1: Ensure societal license to operate through greater transparency and dissemination of best practices

Societal license to operate is of paramount importance, particularly as related to supply. While manufacturing facilities can be sited in areas chosen to minimize popular and environmental sensitivities, the siting of transmission and distribution networks is less flexible, and the location of resources of gas production sites is even less so. Therefore gas users, including manufacturers and electric utilities, have a significant interest in the societal license to operate of gas producers.

Given the primary regulation of oil and gas production at the state level and the myriad federal and state agencies with equities in this area, no single policy is likely to reduce the contentiousness of drilling or of technologies associated with the rise of shale gas production such as hydraulic fracturing. However all parties, public and private, have a direct interest in greater transparency and in the development, dissemination and broad implementation of best practices – not only in production, but in manufacturing and gas utilization, and in monitoring and regulation.

Establishment of a federally administered website, modeled after or as a section of data.gov, could keep the public apprised of shale gas

drilling sites, safety incidents, and reported emissions. Such a site could be used to educate the public about the processes involved in shale gas production, the chemicals & water used, and industry impact on the local economy and infrastructure. It could also explain the responsibilities and regulations of state and federal agencies, and illuminate the policy and regulatory options being implemented by state and local governments.

The need for a comprehensive shale gas production and utilization information resource can be illustrated by water-related issues alone. As noted above, a Resources for the Future study of experts identified 9 water-related risks of the 12 'consensus risks' related to shale gas development. Yet while public concern about these issues can run quite high, especially in areas that have seen or been proposed for shale gas development, public understanding can be quite limited, and distrust is further exacerbated by reliance on selective sources of information. For example, a recent public survey in the Marcellus Shale region of Pennsylvania in which shale gas development is most concentrated revealed that more than 40% of the respondents indicated that they were unfamiliar with the process of hydraulic fracturing.[122] The two perhaps most visible information sources, the natural gas industry and popular films, scored at the low end of trustworthiness with the public.[123] Clearly there is a void to be filled if decisions about responsible development of U.S. shale gas resources are to be made with the participation of an informed public. Information resources such as Fracfocus.org, the national hydraulic fracturing chemical registry, have met an important part of the need, but reliable information needed to assess other impacts of shale gas development, including air, seismicity and public health issues, is harder to come by. Because the public interest would be served by information and transparency across a very broad range of issues related to shale gas, we view this as an appropriate and important Federal role.

There is a similar need for reliable public dissemination of information about best practice technologies. Horizontal drilling and hydraulic fracturing technologies have evolved rapidly in the 21st century, and practices that might have been acceptable (or legally permitted) only a decade ago may no longer be so. Current and future consolidation within the industry may also result in losses of knowledge, particularly about historical practices. New improvements, including reductions of the concentration and toxicity of chemical additives, reduction in water demand, improvement in water reprocessing, and alternatives to water as a fracking fluid, are occurring in real time. While some of these may convey proprietary advantages to their developers, those entities also have an overriding interest in the preservation of their societal license to operate that incentivizes transparency and public information. However,

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[122] G. L. Theodori *et al., Energy Research and Social Science*, Hydraulic fracturing and the management, disposal, and reuse of frac flowback waters: Views from the public in the Marcellus Shale," 2014: http://www.shsu.edu/~org_crs/Publications/hydraulic%20fracturing%20wastewater%20treatment%20final%20report.pdf

[123] ibid.

given the distrust of industry sources of information noted above, and the legislative and regulatory interests of governments to incentivize best practices for the benefit of their citizens, this need can also best be met by public sector collection and dissemination of information as called for here.

Ensuring robust supplies of domestic natural gas, both by increasing public confidence via greater transparency, and through continuous improvement of technologies to reduce the environmental and public health footprints, is essential to industries and manufacturers that depend on a reliable gas supply. These industries have a direct interest in seeing that that supply is produced in a responsible fashion. Much as apparel companies and retailers have exerted substantial influence to ensure that their suppliers meet environmental, labor, and other standards, so too **energy-intensive industries must extend standards of responsible stewardship to their suppliers.**

Recommendation 2: Incentivize infrastructure investment

Ensuring the robust production of domestic gas is not sufficient to ensure sustained growth of U.S. manufacturing in the areas covered in this report. Transmission of natural gas, primarily via pipelines, and its distribution to users, including manufacturers and electric utilities, merits significant attention.

Investments are needed:

1. To upgrade and ensure the integrity and security of our existing transmission and distribution infrastructure,
2. To enhance the ability of owners, operators and regulators at all points in the supply chain to monitor system integrity and to detect leaks that have potential safety and environmental consequences, and
3. To expand natural gas transmission, storage, and distribution, and to alleviate bottlenecks, so that manufacturers, utilities and consumers nationwide can benefit directly from increased domestic gas supplies.

**Creation of incentives for investment in natural gas transmission, storage, and distribution infrastructure is essential if the potential benefits of shale gas are to be realized across the economy and across our nation.** This report does not presume to suggest the mix of typical tools – direct funding, tax credits, fee rebates, etc. – that might be employed. Rather we emphasize the need for investments in both new and existing infrastructure, and the importance of incentivizing both.

Recommendation 3: Apply remote sensing technologies for methane emissions

Beyond infrastructure investments, there are significant needs and opportunities for investment in research, development and deployment of new technologies for detection and monitoring of gas releases. Recent studies attempting to quantify methane releases from natural gas production have highlighted many of the uncertainties associated with this task. **Improvement of technologies for measuring methane emissions with high spatial resolution, and sustained support for deployment and emissions monitoring, is needed.** Technologies are needed that could provide the appropriate "field of view" to measure releases across the entire supply and manufacturing chain, from production sites to transmission systems to manufacturing facilities and power plants. Successful device development and deployment will likely require a suite of technologies, from new or improved sensors, to enhancement of detector mobility, e.g., by use of drones or other platforms with varying degrees of autonomy. The availability of real time information about methane leakage would reduce environmental impact, increase resource utilization efficiency, and improve public confidence in powering our economy with domestic shale gas.

Meeting the methane measurement challenge will require both support from federal agencies and the response of researchers and entrepreneurs to create solutions. The policy and programmatic tools to address such challenges have been tested in many other arenas, and we do not presume to prescribe specifics here. However, because of the nature of this challenge, there may be an opportunity for the federal government to accelerate development and deployment of solutions, as well as supporting monitoring on a continuing basis, as with other air quality measures. The challenge of remote sensing with high spatial resolution is not unique to energy; in fact it has been the subject of considerable federal investment by various mission agencies. Therefore, as part of the President's Methane Strategy, we recommend that the portfolio of remote sensing technologies developed and deployed by agencies such as DOE, NOAA, NASA, EPA and DOD be reviewed for possible adaptation to address methane emissions monitoring and quantification.

Recommendation 4: Train a next-generation energy workforce

While the "supply" that comes to mind first in discussing the impact of shale gas on U.S. manufacturing is indeed that of gas itself, this fuel is not the only resource with the potential to impact industrial growth. Supply of capital for investment – in production, transmission, and utilization – is a critical factor, and one, as we have noted above, that can be addressed in part through fiscal and industrial policies at the federal level. Human capital is also essential, both to build and sustain a domestic manufacturing base, and to ensure that its benefits are widely enjoyed by society.

There is a need for a skilled workforce, not just to support the growing manufacturing base of the industries considered in this report and those that utilize their products, but across the energy industry in general. The confluence of several drivers makes this a particularly opportune time for new training programs aimed at growing the skilled workforce in the energy and manufacturing sectors. First, the traditional energy industry is characterized by an aging workforce that will need to be replaced. It has been reported, for example, that more than 40% of workers in the utility sector will retire in the next decade.[124] Second, expanded production of domestic energy resources will require a skilled workforce across the entire supply chain. It has been noted that the nature of the jobs at the far upstream end of the supply chain, e.g., well drilling and completion, is migratory. However, the construction, safe operation, and maintenance of the expanded infrastructure at all points downstream will create a far less transient need for a skilled workforce. Third, the growth of U.S. manufacturing in energy-intensive industries, spurred by low-cost shale gas as a fuel and a feedstock, is creating new domestic jobs for which a trained workforce – in advanced manufacturing, fabrication, chemical operations, etc., is required. Onshoring, whether of businesses, specific manufacturing equipment, or jobs, creates domestic job growth because the jobs onshored do not come with incumbents. Further, to the extent that other industries expand that utilize the products of, for example, the chemical, steel, glass, and paper industries, their skilled workforce needs are also likely to increase.

The confluence of interests in workforce development creates a great opportunity for public-private partnerships to create new training programs. **The Department of Energy and the Department of Labor – in collaboration with groups impacted by the shale gas boom, including unions, manufacturing and chemical industry organizations, and utilities – should assess workforce requirements and develop skills training certificate and degree programs in partnership with community colleges.** Because specific industries are often regionally concentrated, e.g., petrochemicals along the Gulf Coast, paper in the Southeast, workforce training programs should be targeted at regional needs and opportunities, and community colleges are well suited to address needs at this scale. Direct participation by the industries that will benefit to contribute curriculum development, delivery, and programmatic support is also critical if workers are to be well prepared to meet the needs of the market.

Because of the need to tailor solutions to local and regional opportunities, these programs are well suited to a federal role which provides funds, including

[124] Shannon Miller, *Pipeline and Gas Journal,* "Utility Workers Rapidly Reaching Retirement Age: Now What?" 2013: http://www.pipelineandgasjournal.com/utility-workers-fast-reaching-retirement-age-%E2%80%93-now-what

incentive and matching funds, through competitive mechanisms and ensures accountability of state and local programs for results. One approach would be to establish programs that build on successful Race-to-the-Top strategies and mechanisms previously developed for K-12 education. Establishment of a national database of programs would also benefit both potential employees and employers.

Recommendation 5: Build the bridge to a cleaner energy future

Sustainable domestic manufacturing fueled by sustainable domestic energy resources is a cause with which a broad cross-section of the public, industry and government can identify. However, as with most statements where the word "sustainable" appears, opinions about what is sustainable may vary considerably. From the perspective of its utilization as a fuel, shale gas offers a cleaner burning and less $CO_2$-intensive energy source than other fossil fuels. It is an important domestic resource, sufficient to meet domestic demand for decades, even with exports to other parts of the world. However, it is still a fossil fuel, one whose use as an energy source results in $CO_2$ emissions, and whose leakage adds further to the atmospheric greenhouse gas burden.

Many, including the current Secretary of Energy, Ernest Moniz, have spoken of natural gas as a "bridge" to a cleaner energy future. As we incentivize investments that will enable the beneficial impacts of this resource on manufacturing and other sectors, **it is essential that we invest in the future energy and manufacturing economy to which shale gas is a bridge**. This is not an either/or proposition. For example, as intermittent renewable resources make ever-greater contributions to electric power generation, the needs for energy storage and back-up generation also increase. Natural gas fired facilities are well suited to the task of responding to demands that exceed the availability of such intermittent sources. **With proper incentives, the construction and operation of power plants combining natural gas and renewables may lead to faster growth of renewables than could occur in the absence of or in competition with gas.** Examples of such commercial facilities already exist in the U.S. and provide possible models for the future.[125] Energy intensive manufacturing industries such as chemicals and paper that generate significant fractions of their own power requirements may also be good candidates for such strategies, and should be included in any incentives aimed at leveraging renewables with natural gas.

The dramatic and sustainable impact of shale gas on our national economy provides an unprecedented opportunity to invest in a sustainable future. It is imperative that the "bridge" find a robust "pier" at the other end in a yet more sustainable future. While the benefits of the shale gas boom accrue to those in

[125] Florida Power & Light, "Solar Energy Centers," 2014: http://www.fpl.com/environment/solar/projects.shtml

the marketplace – producers, shippers, users, manufacturers, consumers – the market alone may not be sufficient to ensure necessary investments in what comes next, particularly in the absence of pricing externalities such as carbon emissions. Many would see investment in the future as a proper role of government.

One such mechanism would be the creation of an Energy Security Trust, as proposed in President Obama's 2013 State of the Union Address to fund the research, development, and deployment of clean energy technologies. While this particular mechanism is not without its critics, the basic principle – invest some fraction of income now for a differently resourced future – differs little from the retirement planning advice that we all hear routinely. Certainly the interests of different industries within the energy and manufacturing sectors will differ. For example, the chemical industry may see hydrocarbons as too valuable a feedstock to be used as a fuel. However, that is precisely why there is a need for the private sector to engage in creating and guiding investments, both public and private, in a more sustainable future.

# APPENDIX 1: AGENDA

The University of Michigan's Public Private Stakeholders Symposium on

## SHALE GAS: A GAME-CHANGER FOR AMERICAN MANUFACTURING

National Press Club, Washington, D.C.

March 28, 2014

AGENDA

| | |
|---|---|
| 7:15 AM | **Registration** |
| 8:00 AM | **Welcome**<br>David Munson, Dean, College of Engineering, University of Michigan<br>Symposium Overview<br>Sridhar Kota, University of Michigan |
| 8:20 AM | **Opening Remarks**<br>Thomas Kalil, Associate Director – Technology and Innovation White House Office of Science and Technology Policy; Senior Advisor, National Economic Council<br>John Engler, President, Business Roundtable (former Governor of Michigan) |
| 8:45 AM | **Keynote Address – Manufracking**<br>Norman Augustine, Former CEO, Lockheed Martin Corporation |
| 9:20 AM | **$100 Billion and Counting: Shale Gas & New U.S. Chemical Industry Investment**<br>Calvin Dooley, President & CEO, American Chemistry Council |
| 9:45 AM | **U.S. Competitiveness – Energy-–Intensive Manufacturing**<br>Moderator – Robert Atkinson, President, Information Technology and Innovation Foundation<br>Christopher Guith, Vice President, U.S. Chamber of Commerce<br>Douglas Matthews, Senior Vice President, U.S. Steel<br>Chris Read, Director Global Technology, International Paper<br>Eric Roegner, Chief Operating Officer, Alcoa |
| 10:45 AM | Break |
| 11:00 AM | **An Environmentalist's Standards for Shale Development**<br>Paul O'Neill, 72nd Secretary of U.S. Treasury |
| 11:25 AM | **Opportunities & Challenges in the Shale Gas Market**<br>Moderator – Teresa Fryberger, Director, Board on Chemical Sciences & Technology, National Academy of Sciences<br><br>Steven Hamburg, Chief Scientist, Environmental Defense Fund |

Dave McCurdy, President & CEO, American Gas Association
Brad True, General Manager, Nucor Corporation

12:15 PM **Lunch**

1:00 PM **Federal Perspective**
Melanie Kenderdine, Director, Energy Policy, U.S. Department of Energy

1:45 PM **Moderated Discussion of Key Issues**
Mark Barteau, Director, Energy Institute, University of Michigan

3:15 PM **Break**

3:30 PM **Workshop Summary**

4:00 PM **Conclusion & Next Steps**
Sridhar Kota, University of Michigan

# APPENDIX 2: ATTENDEES

## SHALE GAS: A GAME CHANGER FOR U.S. MANUFACTURING

National Press Club, Washington, D.C.
March 28, 2014

Robert D. Atkinson
President
The Information Technology & Innovation Foundation

Norman Augustine
Former CEO
Lockheed Martin Corporation

Mark Barteau
Director, Energy Institute
University of Michigan, Washington DC Office

Rhys Best
Director
Commercial Metals

Bharat Bhushan
ASME Science and Technology Policy Fellow
House Science Committee's Subcommittee on Energy

Dan Bicz
President
National Fuel and Power LLC

Mark Boling
President V+ Development Solutions
Southwest Energy Company

Christa Bowers
Manager, Media & Corp. Relations
Alcoa

Tamara Browne
Director, Government Affairs
The Committee on Pipe & Tube Imports (CPTI)

Thomas Cellucci
Chairman & CEO
Cellucci Associates Inc.
Chris Clarke
Assistant Professor; Science, Health, Environmental, & Risk (SHER) Communication
George Mason University

Kathryn Clay

American Gas Association

Calvin Dooley
President/CEO
American Chemistry Council

John Engler
President
Business Roundtable (former Governor of Michigan)

Teresa Fryberger
Director, Board on Chemical Sciences and Technology
National Academy of Sciences

Wilson (Lynn) Garner
Reporter
Bloomberg BNA

Greg Gershuny
Chief of Staff
US Department of Energy - Office of Energy Policy & Systems Analysis

Martha Gilchrist Moore
Senior Director – Policy Analysis and Economics
American Chemistry Council

Allyson Green
Environmental Health Sciences Master's Student
University of Michigan

Christopher Guith
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Christa Gunn
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Office of the Deputy Assistant Secretary of the Air Force (Energy)

Arlene Hamburg
AAAS Fellow
National Science Foundation

Steve Hamburg
Chief Scientist
Environmental Defense Fund

Booth Jameson
Senior Director of Federal Affairs
American Chemistry Council
Mark Johnson
Director
U.S. Department of Energy

Rachel Jones
Counsel, U.S. House of Representatives
Subcommittee on Energy, Subcommittee on Science, Space, & Technology

Thomas Kalil
Deputy Director - Technology and Innovation
White House OSTP & National Economic Council

Owen Kean
Senior Director, Energy Policy
American Chemistry Council

Melanie Kenderdine
Director of the Office of Energy Policy & Systems Analysis
U.S. Department of Energy

Chris King
Senior Advisor
US Department of Energy - Office of Energy Policy & Systems Analysis

Kristina Ko
Director of Federal Relations for Research
University of Michigan

Rob Kopf
General Manager - North American Flat-Rolled Marketing
US Steel

Eric Kort
Assistant Professor
U-M College of Engineering - Atmospheric, Oceanic & Space Sciences

Sridhar Kota
Herrick Professor of Engineering
University of Michigan - College of Engineering - Mechanical Engineering

Maria Laverdiere
Policy Aid
U.S. Congressional Joint Economic Committee

Iryna Lendel
Assistant Director, Center for Economic Development
Cleveland State University

Frank Maisano
Bracewell & Giuliani

Amy Mast
Director of Marketing and Communications
University of Michigan

Douglas Matthews
Senior Vice President - North American Flat-Rolled Operations

U.S. Steel

Andrew Maynard
Director, University of Michigan Risk Science Center
University of Michigan

Katie McCall
Director - Federal Governmental Affairs
US Steel

Richard McCormack
Editor & Publisher
Manufacturing and Technology News

David McCurdy
President
American Gas Association

Dan Mitler
Center for Sustainable Systems
University of Michigan

Lawrence Molnar
Associate Director
University of Michigan IRLEE

David Munson
Dean of Engineering
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Mark Muro
Senior Fellow and Policy Director, Metropolitan Policy Program
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Paul O'Neill
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Center for Sustainable Shale Development (CCSD)

Chris Read
Director, Manufacturing Global Center of Excellence
International Paper

Kim Reid
Administrative Assistant
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Eric Roegner
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Greg Rorrer
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Reporter
Breaking Energy

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Embassy of the Republic of Kazakhstan

Johannes Schwank
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Jennifer Scott
Media Contact
American Chemistry Council

Jake Serwer
Business Development Executive
The National Press Club

Debbie Shon
US Steel

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Jeff Smith
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White House Office of Science and Technology Policy

Sean Sullivan
Reporter
SNL Energy

Derek Theurer
Federal Government Relations Advisor
Exxon Mobil

Brad True
General Manager - Resource Development
Nucor Corporation

Antoine Van Agtmael
Trustee & Co-Chair, International Advisory Council
Brookings Inst.

Michael Waring
Director of the Washington, D.C. Office and Executive Director of Federal Relations

University of Michigan, Washington DC Office

Salaha Waring
National Press Club Member

Carmen Wells Quigg
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University of Michigan

Charles Wessner
Director, Technology, Innovation and Entrepreneurship
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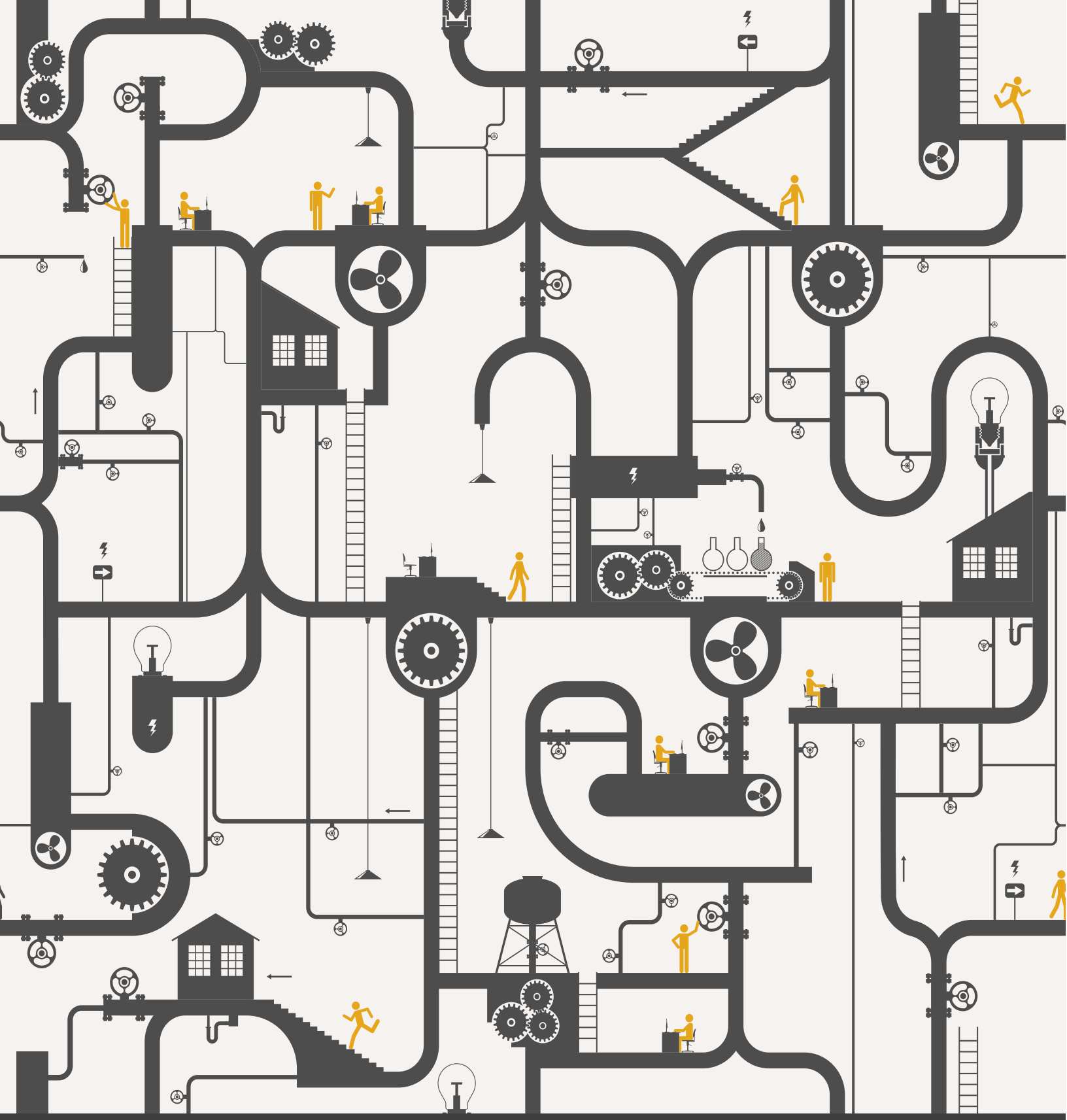
Aaron Weston
Counsel – U.S. House of Representatives
Subcommittee on Energy, Subcommittee on Science, Space, & Technology

Rodney White
Reporter
Gas Daily

Justin Zorn
Legislative Director
US House of Representatives - Representative Frederica Wilson



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