Paper #3-3

INDUSTRIAL NATURAL GAS AND ELECTRICITY DEMAND

Prepared by the Industrial Subgroup

of the

Demand Task Group

On September 15, 2011, The National Petroleum Council (NPC) in approving its report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Task Groups and/or Subgroups. These Topic and White Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic and White Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 57 such working documents used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix C of the final NPC report provides a complete list of the 57 Topic and White Papers and an abstract for each. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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I. SUMMARY OF FINDINGS

This section provides details on the use of natural gas and electricity in the industrial sector. It describes how these fuels have been used and then discusses the factors that might drive their use in the future. This analysis is a "study of studies" and does not include any new research. The 2010 Annual Energy Outlook (AEO) is used as a baseline. The analysis draws upon various 2010 AEO side cases including high/tight shale resources, high/low economic growth, and integrates high/low technology to determine their impact on industrial natural gas demand. In addition, the analysis incorporated data from the following studies to draw its recommendations and conclusions: 2009 Energy Market and Economic Impacts of H.R. 2454, The Future of Natural Gas (MIT), Implications for Greater Reliance on Natural Gas for Electric Generation (APPA), Sustainable Manufacturing and Growth Initiatives (IECA), and Natural Gas, A Bridge to a low Carbon Future (RFF). The 2011 AEO cases were generally not considered as they were published after most of the work of the Industrial Subgroup was completed.

Natural gas is a key raw material for chemicals and manufacturing. U.S. companies use natural gas as both a fuel source and a feedstock to create high-value, high-margin products that are used every day. Industry uses fossil fuels efficiently to create jobs. This is good for the economy and also good for the environment. When natural gas is used as a feedstock or is embodied in energy intensive products, the value is leveraged over and over, resulting in a tremendous value-added proposition for the economy and the environment. This is in contrast to the one time use created when natural gas is used as fuel in a power plant, truck, or automobile.

Industrial consumers will play an increasingly important role in encouraging increased gas supply by demanding more as prices go down and volatility eases. In 2009, industry used 32% of the natural gas consumed and 24% of the electrical power produced.[1] 23% of the power used was generated from natural gas increasing overall gas usage by industry (direct and indirect) to 38%.[2] History shows that when natural gas is plentiful, affordable, and reliable, industry grows stimulating local investment, creating jobs, and strengthening the U.S. industrial and economic base. Over the last decade, natural gas, petroleum, and electricity price increases contributed to plant shutdowns, decreased investment and a loss of over 5 million U.S. manufacturing jobs.[3]

In recent years, the development of hydraulic fracturing has allowed for the economic extraction of large quantities of natural gas from previously inaccessible shale gas reserves. Production has increased and prices have dropped. Industry has begun to respond in a positive way with increased production and investment.

Key drivers for future industrial energy demand include:

- economic growth
- natural gas pricing
- legislation and regulations
- carbon policy
- technology

AEO studies show that industrial growth is tied to GDP more than any other factor. As industry creates jobs, policy makers must consider the impact on manufacturing before enacting laws and regulations. They must look at how proposed policies impact global competitiveness and create legislation that promotes the most value-added uses of our limited fossil fuels. Carbon legislation, in the majority of cases, adds costs to natural gas and power prices and reduces industrial output. Therefore, serious consideration should be given to the impact of any carbon policy on manufacturing and industry. There is a continued need for breakthrough technologies that will significantly reduce the amount of energy consumed by the industrial sector. In addition, technology is needed to create a competitive environment for multiple energy feedstocks.

In September of 2010, Robert Baugh, Executive Director of the AFL-CIO Industrial Union Council, testified before the House Committee on Oversight and Reform Subcommittee on National Security and Foreign Affairs. His recommended actions that the US should take to protect its national security and economic viability included investing to maintain the U.S. global energy leadership in renewable, nuclear, and advanced coal technology, eliminating tax incentives for outsourcing and off shoring production and increasing tax incentives for making products in the U.S.

With appropriate policies, there is an opportunity for domestic natural gas to spur growth in the industrial sector helping the government to meet its objectives of economic growth, environmental protection, and national security. Manufacturing historically has contributed vital roles in economic growth, jobs creation, and national security interests and has participated in ongoing efforts to recover and sustain environmental quality. Balancing these roles going forward will require creative and innovative approaches to policy that do not compromise one objective over another.

The Industrial Task Group Concluded the following from the analysis:

- Energy intensive basic industries are important to long term economic growth because they are the base materials used to produce all other products consumed in the U.S.
- Industry has proven itself to be an efficient user of natural gas, responding to high prices by investing in new technology and shutting down assets which no longer compete.
- A robust supply of natural gas that is affordable and reliable would give the industrial sector, especially energy intensive industries, a global advantage creating investment and jobs in the United States.

- Action by federal and state policymakers will have a defining impact on whether the US industrial sector continues to lose jobs or whether it will thrive over the next century.
- The industrial sector use of energy creates significant value for the country.

II. INDUSTRIAL NATURAL GAS AND ELECTRICITY DEMAND

This section reviews industry's historical and current demand for natural gas and electricity.

A. Historical Industrial Energy Demand

Industrial natural gas demand between 1949 and 2009 showed four distinct phases: growth, curtailment, deregulation, and the pre-shale energy climate when natural gas supplies decreased and price fluctuated. (Figure 1) Beginning around 2000, large increases in fuel prices prompted industrial consumers to invest in energy-efficiency projects, and many energy-intensive manufacturers were compelled to move production overseas by high energy prices and other factors. This is underscored by the declining level of investment by industry in the U.S. during that period. (Figure 2)

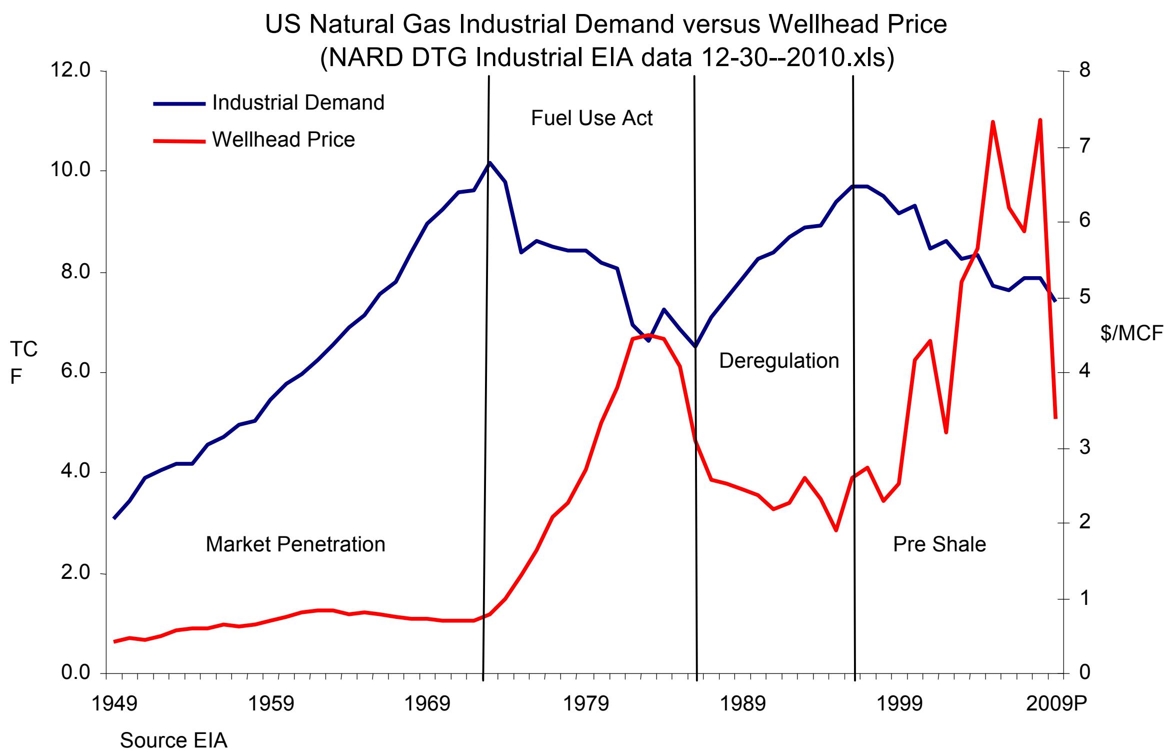


Figure 1. U.S. industrial consumption of natural gas, 1949-2009.

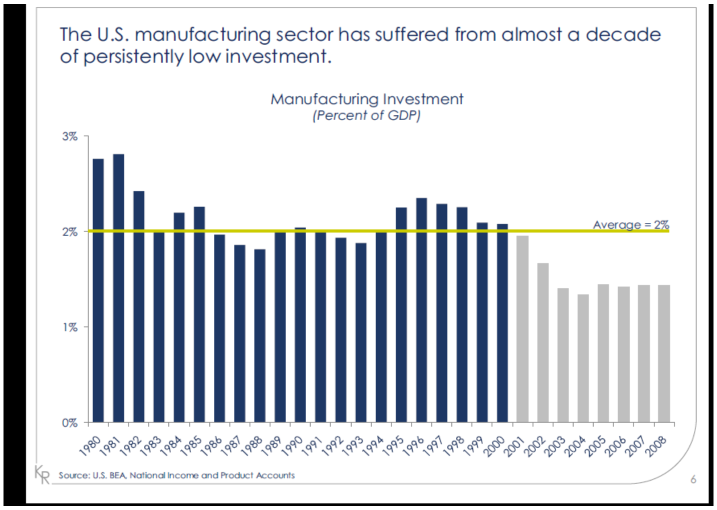
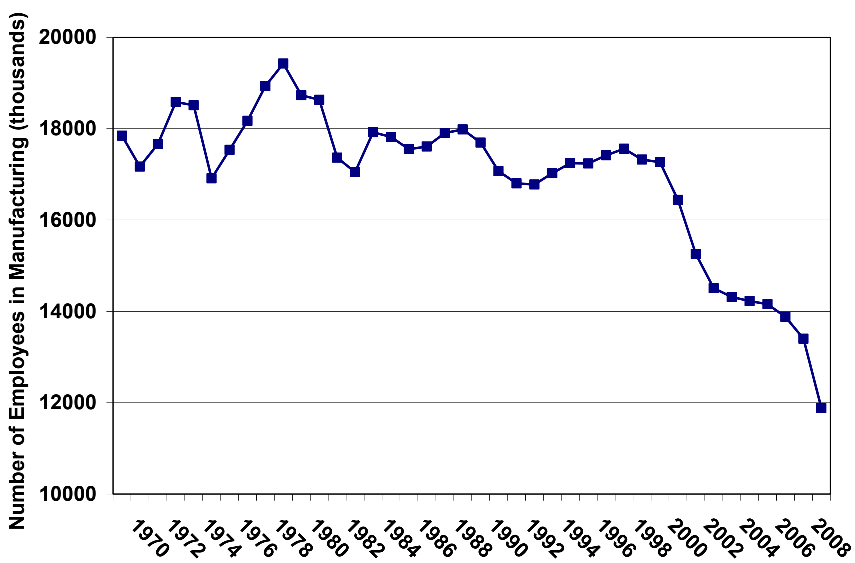


Figure 2. Investment by U.S. Manufacturing Sector 1980-2008.

As industrial investment declined, so did employment. Employment had been fairly constant in manufacturing from 1983 to 1996, a period of relatively low, stable natural gas prices. From 1996 to 2009 over 5 million US manufacturing jobs were lost (Figure 3). The situation was even worse than it appears when you consider that according to the National Association of Manufacturers, one job in manufacturing leads to six non-manufacturing jobs.



Source: U.S Department of Labor, Bureau of Labor Statistics.

Figure 3. US Employees in Manufacturing, 1970-2008

Another vivid example of the effect of natural gas pricing is the downturn in the fertilizer industry, with 26 ammonia plants closing over an 8-year period as natural gas prices rose from $1.90/MMBtu to over $8.50/MMBtu (Figure 4)[4],[5].

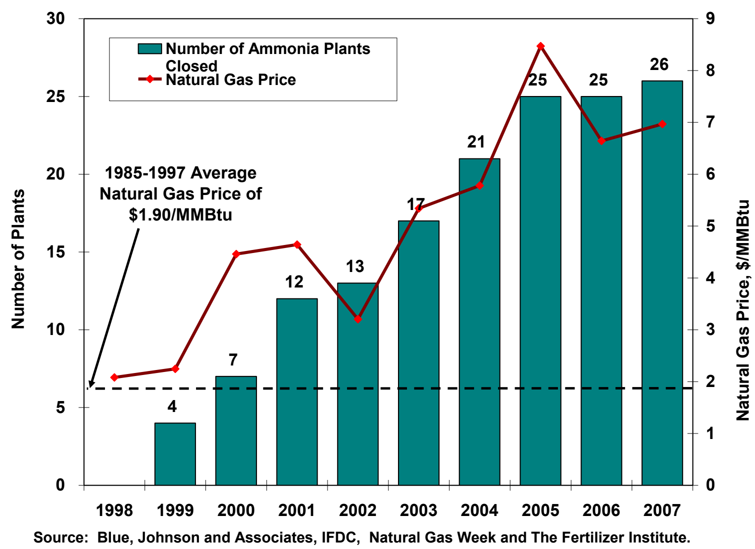


Figure 4. Ammonia Plant Closures Due to High Natural Gas Prices

In summary, history has shown that when the natural gas supply is plentiful, affordable, and reliable, industrial production and manufacturing jobs increase. Conversely, when natural gas prices are high and volatile, noncompetitive plants are closed and facilities moved offshore, taking jobs with them.

B. Current Status of Industrial Energy Demand

The U.S. industrial sector accounted for nearly 30% of all energy used in the economy in 2009 according to the EIA, second only to the electric power sector. This energy is used for fuel, raw material, feedstock, and to generate electricity for use onsite or to be sold to third parties. Natural gas accounts for the largest share of the industrial sector's use of fuel for energy, but petroleum liquids consumption is larger than natural gas because of petrochemical feedstock use (non-energy). In 2009, the EIA estimates that the industrial sector used about 999 billion kWh of electricity. Industry generated about 143 billion kWh, with 121 billion kWh used onsite and the remainder sold to third parties. Industry also purchased 879 billion kWh from utilities.

In 2010, the industrial sector used 7.9 TCF of natural gas according to EIA estimates (includes direct industrial plus Lease and Plant Fuel) accounting for 33% of all U.S. gas consumption. These statistics represent a decline from historical levels. The modern-day peak occurred in 1997 at a volume of nearly 9.7 TCF and a gas market share of 43%.

Details of natural gas use by specific manufacturing sectors are only available every four years from the Manufacturing Energy Consumption Survey or MECS. Comparing the 1998 and 2006 MECS reports show that the largest declines in natural gas use occurred in the chemicals, primary metals, petroleum and coal (mainly refining) and paper sectors. (Figure 5) Adding nonfuel declines to the Chemical sector would add in excess of 100 Bcf to the decline given that this sector consumes about 90% of nonfuel natural gas and that nonfuel natural gas use fell 133 Bcf between 1998 and 2006. Note that results from the 2010 MECS survey are unlikely to be available before 2012.

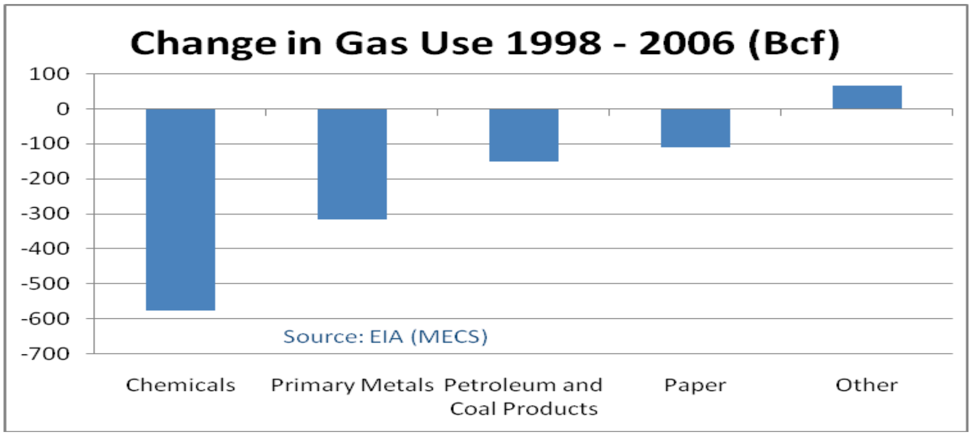


Figure 5. Industries with the Largest declines in Natural Gas Use

Figure 6 shows the relative amounts of natural gas consumed by each sector over the last four decades. Historically, industry has consumed greater than 40% of the natural gas, electricity production accounted for 17%, residential 25%, commercial 14%, and transportation 3%. Over the last two decades, the percentage of natural gas consumption for electricity has grown while the percentage consumed by industrial users has declined. In fact, in 2009, natural gas used by industry and the electricity sector were roughly equal at ~7 trillion cubic feet which equates to ~30% of the overall demand for natural gas.

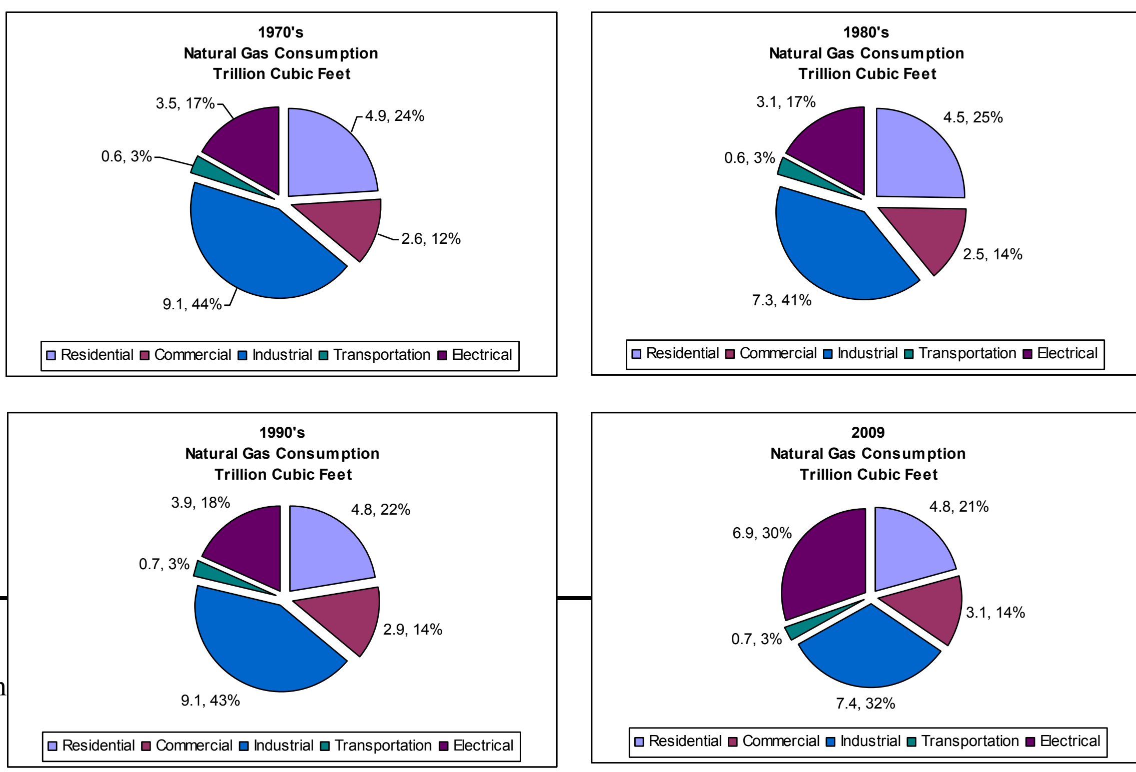


Figure 6. Natural Gas Consumption by Sector

Industrial use of natural gas is elastic. As prices increase, production is curtailed or moved to areas of the world with advantaged raw materials. At the same time, when natural gas prices are low, industrial users increase production. As a result, the manufacturing sector offers an excellent opportunity for increased natural gas use.

C. Recent Changes in the Natural Gas Market and Responses by Industry

The discovery of vast supplies of natural gas in shale rock and the ability to extract it economically through hydraulic fracturing significantly changes the picture of supply and demand.[6] Prices have gone down (Figure 7) and volatility has eased with increased onshore supply and storage.

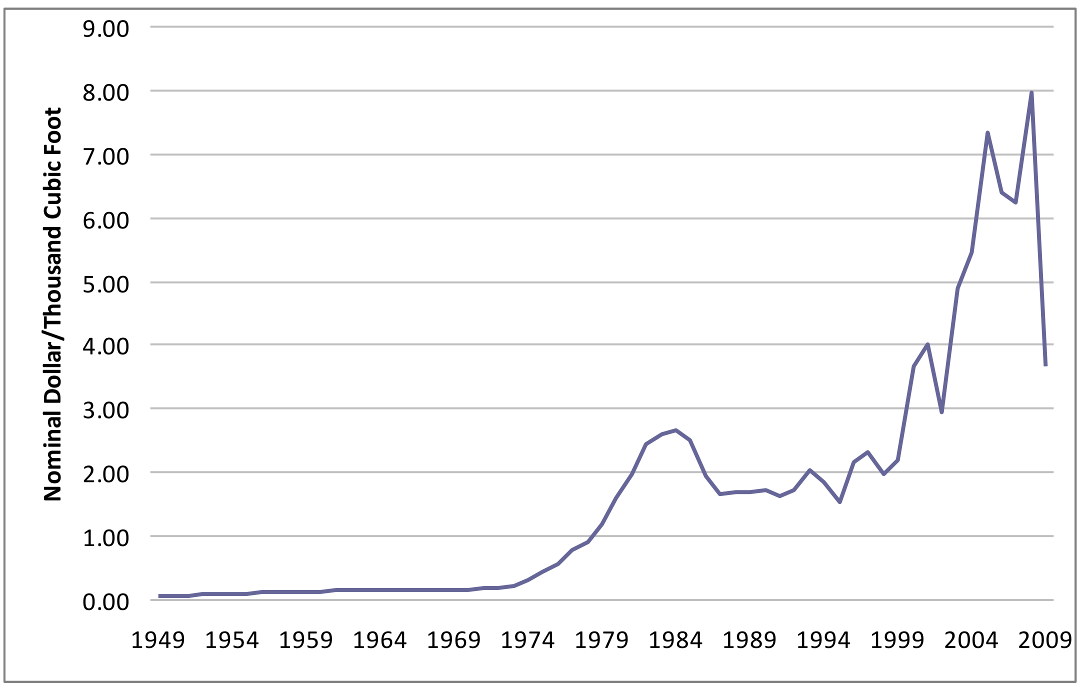


Figure 7.

The abundant supply of natural gas and natural gas liquids is already helping to improve the international competitiveness of the chemical industry. A relatively favorable price for natural gas has resulted in the restart of four ethylene plants representing more than 1,500,000 tons of ethylene capacity. At the same time, feedstock flexibility has been expanded and soon over 60 percent of ethylene in the United States could be manufactured from ethane resulting in a 25 percent or 200,000 barrel per day increase in ethane demand. In addition, large ethylene expansions and additions have been announced by Westlake, Ineos Olefins and Polymers, Formosa Plastics, and The Dow Chemical Company.

The American Chemistry Council recently estimated that a 25% increase in ethane supply could result in $16 billion in capital investment by the chemical industry. This would generate 17,000 new jobs in the U.S. chemical industry and 395,000 additional jobs outside the chemical industry and increase U.S. economic output by $132 billion.[7]

Outside of the chemical industry, other energy intensive manufacturers are also increasing production or expanding. Recently, several ammonia manufacturers have announced plans to restart idled units in the U.S. PCS announced that it will restart its ammonia plant in Geismar, Louisiana, and Pandora Methanol has begun the process of restarting its ammonia plant in Beaumont, Texas. Additionally, Nucor Corporation announced the construction of a $750 million iron and steel making facility in Louisiana.

When the industrial sector uses natural gas as a feedstock or to generate power to make energy intensive products, the value is leveraged over and over, resulting in a tremendous value-added proposition for the economy. U.S. firms rely on natural gas and oil-derived chemicals as building blocks for the production of electronics (including computers and cell phones), plastics, medicines (and medical equipment), cleaning products, fertilizers, building materials, adhesives, and clothing. Consequently, a strong industrial sector is critical to a healthy economy. In a global business environment where companies have the ability to move capital around the world, a dependable, competitive supply of natural gas is critical to creating investment and jobs. Therefore, attention must be paid to ensure there is adequate supply to meet the growth demands of the industrial sector.

III. KEY DRIVERS FOR FUTURE INDUSTRIAL ENERGY DEMAND

The key drivers for future industrial energy demand include:

- Economic growth
- Natural Gas Pricing
- Legislation and regulations
- Carbon policy
- Technology

A. Economic Growth

The 2010 Annual Energy Outlook (AEO) provides a baseline for an analysis of the factors that might drive energy use by industry in the future. Conclusions were drawn from cases published by the EIA and through analysis of other studies that looked at industrial gas and electricity use under various economic, regulatory, and foreign policy scenarios

The AEO forecast data were analyzed to demonstrate the relative impact of economic growth, natural gas supply and technology advances on industrial natural gas and electricity use. For each factor, a comparison of natural gas demand was done against the AEO 2010 reference case (Figure 8).

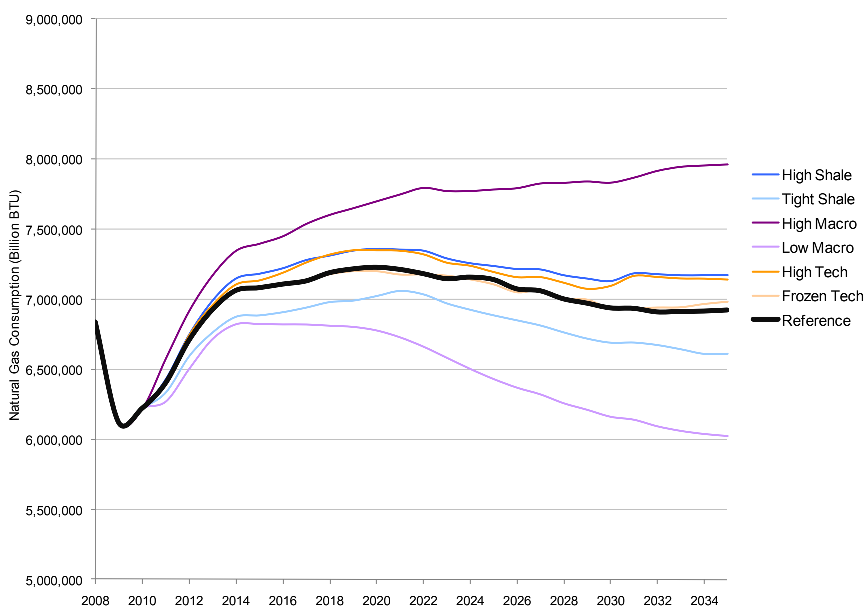


Figure 8. Natural Gas Demand Under Various AEO Scenarios

The greatest change from the reference case occurred in the high and low economic growth cases. The high and low shale supply cases impacted industry to a much lesser extent than the economy although the availability of shale changed both natural gas prices and power prices. Technology had the least apparent impact on industrial demand. Assumptions for the AEO advanced technology case bore out the move toward high value, and sometimes high energy intensity products. If the nation were to move towards an advanced technology future, industry would, in some cases, shift production processes for making advanced products that are more energy-intensive than the current stock. This does not imply that industrial operators would not strive to continue to improve efficiency in areas like lighting or motors, but if demand were to require new large processes that use more energy, those requirements could outweigh gains in other areas.

As the overall economy grows, consumer demand will also grow, driving industry to produce raw materials and ultimately consumer goods. In many industries, energy use can be viewed as a proxy for industrial output. The EIA's 2010 Annual Energy Outlook shows that outside of petroleum refineries, for energy-intensive industries, significant growth will only occur if there is high economic growth. In fact, in all cases, iron and steel are expected to decline in the face of international competition. With high energy costs, aging capacity, and subsidies in other countries, the U.S. iron and steel industry is projected to be at a competitive disadvantage. Also presented in the data is the close relationship between the bulk chemicals industry and the overall economy. This industry, which is responsible for the base ingredients to most consumer goods, has the greatest response to the economy as a whole. It is important to note that the bulk chemical industry is also the largest user of natural gas in the industrial sector. Consequently, the industrial consumption of natural gas has a strong tie to the economy as a whole via the bulk chemical industry.

B. Legislation and Regulations

Industrial consumers of energy are impacted by regulatory and public policy options in two ways:

- Directly through the imposition of regulations imposed upon the industrial sector facility, or
- Indirectly, through higher energy costs due to regulations imposed upon suppliers of energy or through mandates or financial incentives that would drive increased demand for natural gas or electricity.

A July 23, 2010 independent economic analysis conducted by the University of Maryland's Department of Economics and sanctioned by over 40 manufacturing companies shows that policies which favor more industrial growth can create over 3.2 MM job man years by 2020. The report, entitled "Economic Impact of Industrial Energy Consumers of America's Sustainable Manufacturing & Growth Initiative" illustrates the enormous economic benefits of a vibrant manufacturing sector. Therefore, it is clear that legislation and regulation have a profound impact on the economic well being of the country. When energy costs go up, the price-sensitive industrial sector consumes less energy or passes on the added costs directly to consumers, which slows economic growth. It is, therefore, important for policymakers to understand that high-cost natural gas and electricity is completely inconsistent with a globally competitive, expanding, profitable, job-creating, export-driven manufacturing sector.

The following paragraphs describe some of the important issues that policy makers need to be aware of when enacting legislation:

1. The Global Mobility of the Industrial Sector

As policymakers ponder legislation that may impact manufacturing companies or their energy suppliers, they must consider the global mobility of the U.S. industrial sector and how a proposed policy will impact global competitiveness. No other sector of the U.S. economy offers this complication. If U.S. costs are low, businesses can invest with confidence and thrive. If U.S. costs are high relative to other countries, companies will have little choice but to either move their facilities or go out of business and yield production to a foreign source. The fluidity of movement by the industrial sector to remain in the U.S. or move offshore can be a blessing or a curse to the economy. Industrial company CEOs are charged with the responsibility of creating value for their shareholders. Consequently, they are obligated to spend their finite capital where the best investment opportunities reside globally.

2. Industrial Energy Use has an Enormous Leveraging Value-added Effect

Industry uses fossil fuels efficiently to create real jobs. This is good for the economy and also good for the environment. When the industrial sector uses natural gas, the value is leveraged over and over, resulting in a tremendous value-added proposition for the economy and the environment. For example, natural gas (ethane) is used to produce ethylene; ethylene is used to produce plastics; plastics are used in an enormous array of products which include auto bumpers, food packaging, medical devices and electronics. Economic value is added in each step of the process. This is in contrast to the one time use created when natural gas is used as fuel in a power plant, truck, or automobile.

3. Incentives for Natural Gas Could Further Erode the U.S. Manufacturing Base

Of significant concern to the industrial sector are the numerous regulations under consideration that will directly or indirectly increase demand for natural gas in the short term before equipment and infrastructure is available to accommodate the increased demand. These proposals include:

- Financial or mandatory incentives for greater use of natural gas
    - Incentives for greater natural gas use in the power sector
    - Subsidies for natural gas vehicles and fueling stations
- Clean Air Act regulations and Renewable Electricity Standards
    - EPA GHG regulation
        - EPA CAA regulations that are so costly that they threaten to shut down existing coal-fired power plants and make it too costly to build new coal-fired power units
    - New federal or state renewable electricity standards that will result in the greater use of natural gas fired power generation for back up due to the intermittent nature of renewable energy.

When evaluating policies for the use of fossil fuels, policymakers should make every effort to give priority in pursuit of policies that add the most value to these precious resources. With appropriate pro-shale gas and offshore drilling policies and a market-driven gas supply, a robust supply of natural gas could give the industrial sector a global advantage much like that which existed in the 1980s and 1990s, a period of relatively low stable pricing.

C. Carbon Policy

Potentially one of the most significant influences on the use of natural gas in the industrial sector is carbon emissions policy. While natural gas has the lowest carbon content of all fossil fuels, it would still be subject to legislation and/or regulations that limit the output of carbon from fuel and feedstock uses. The lower carbon content of natural gas does create a preference over other fossil fuels in manufacturing where feasible, but the potential for carbon policies to penalize or stifle overall industrial activity looms as the greater force affecting natural gas industrial use.

The European Union (EU) is the only region where governments have put in place GHG reductions through the imposition of an Emissions Trading System (ETS). All other nations have pursued GHG reductions through a combination of voluntary programs, incentives, and sector mandates. As the European Union looks to expand its Emissions Trading System, energy intensive industries have expressed concerns that this should be done as part of a global framework to avoid carbon leakage. [8]

In the U.S., the federal government began to address GHG reductions by passing legislation in 2005 and 2007 that has put in place nearly 100 regulations intended to reduce GHG emissions. These include new appliance energy efficiency standards, banning the incandescent light bulb, renewable fuels, renewable energy, and setting new CAFE (Corporate Average Fuel Economy) standards. Tax and financial incentives are also used, such as the PTC (Production Tax Credit) for renewable energy and small combined heat and power units.

In addition, the Supreme Court decision on the endangerment finding has resulted in regulation of green house gases (GHG) under the Clean Air Act. The EPA has also proposed the GHG Tailoring rule that will start by regulating large sources using best available technology standards in 2011. Individual states have also taken various forms of action, from emissions trading regimes like RGGI (Regional Greenhouse Gas Initiative) to renewable electricity standards that require electric utilities to steadily increase the use of renewable energy.

The impact of any carbon policy is highly dependent upon its structure, making it impossible to predict with certainty the future effects of a generic carbon policy on natural gas use. Currently no national carbon legislation has been enacted, but the bill showing the most progress has been H.R. 2454, The American Clean Energy and Security Act of 2009. The EIA conducted extensive modeling of H.R. 2454 to assess its impact on the economy and environment, using its 2009 Annual Energy Outlook as a "Reference Case" to compare results.

Uncertainty exists even with highly detailed legislative proposals, necessitating the use of scenarios to surmise possible outcomes of policy. The EIA crafted a "Basic Case" to test the impacts of H.R. 2454 against the Reference Case, which includes the addition of cement industry process emissions not included in the Reference Case. However, the EIA recognized that a range of possibilities exists:

- Availability and cost of low carbon fuel options (nuclear, renewable, CCS)
- Availability and cost of international offsets specified in H.R. 2454 as a carbon mitigation option
- Degree of banking of carbon credits in the initial phases of implementation (EIA modeled H.R. 2454 to the year 2030 while the legislation targets 2050 emissions goals)

All of these independent factors could influence the impacts of H.R. 2454 on the economy and energy-related industries in particular.

Despite these uncertainties of market responses to H.R. 2454, the outcome of the legislation on industrial gas use is unambiguous: industrial natural gas use will be lower than what it would have been without carbon legislation as the increased use of natural gas in the power sector raises prices and reduces industrial output. The increase in natural gas prices could also cause a loss of market share for U.S. companies that rely on natural gas as a feedstock because they will face rising costs that their competitors overseas that do not restrict carbon emissions are protected from. This loss in market share could then cause a shift of production from the United States to these other countries, resulting in "carbon leakage" that will have serious economic implications for the United States, with no net environmental gains globally as emissions simply shift to unregulated markets.

Figure 9 illustrates industrial gas demand under the no-carbon policy Reference Case and the major EIA scenarios of H.R. 2454.

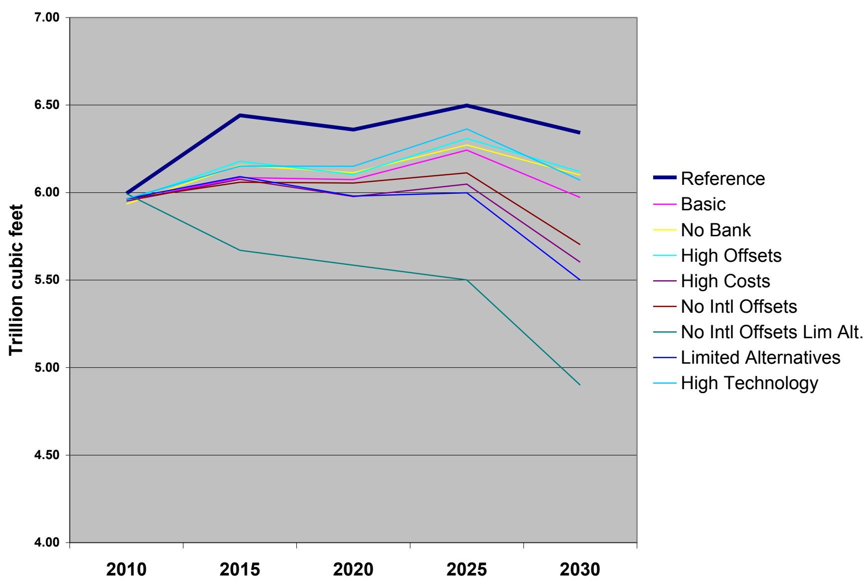


Figure 9. U.S. industrial gas demand under the no-carbon policy and major EIA scenarios

Industrial gas use in the Reference Case grows modestly from about 6.0 trillion cubic feet (tcf) in 2010 (excludes Lease and Plant Fuel) to 6.5 tcf in 2025 before declining slightly thereafter. The H.R. 2454 Basic Case shows more limited growth to just 6.25 tcf in 2025 and a decline to under 6.0 tcf in 2030—about 6% under the 2030 Reference Case demand. Every scenario tested by the EIA, including those both more optimistic and less optimistic than the Basic Case, resulted in industrial gas demand lower than the Reference Case. In 2030, the range of demand declines from the Reference Case was from 4% to over 20% (Figure 10)Figure .

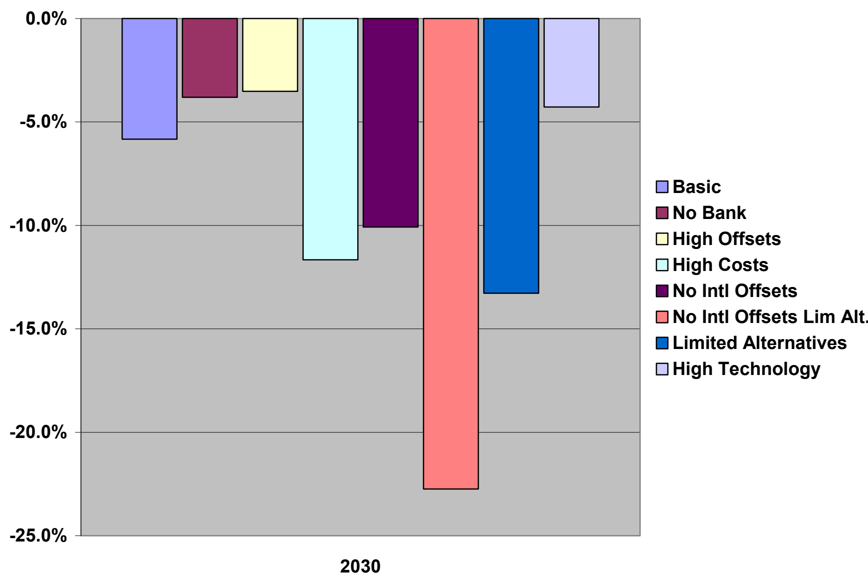


Figure 10. Carbon variances from reference (2030).

Emission allowance prices were another output of the EIA scenario modeling. In 2007 constant dollars, the range of allowance prices in 2030 ranged from a low of $40 per metric ton to as much as $190 per metric ton. In nominal dollars the price range for CO2 was $65/mt to $328/mt. When comparing the industrial gas demand reductions in the EIA scenarios against the projected carbon price it becomes apparent that the cost of carbon allowances will be a significant influence on the level of industrial gas demand (Figure 11).

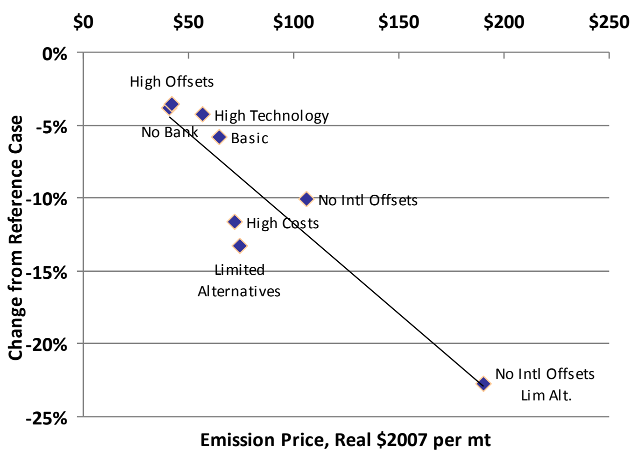


Figure 11. Effect of carbon price on 2030 U.S. industrial gas demand.

D. Technology

The availability of advanced technologies to either lower operating costs or produce advanced products will play a key role in enabling the U.S. industrial sector to lead the world into the manufacturing future. Some of the more promising technologies include combined heat and power (CHP), low temperature heat recovery, use of oxygen to supplement or replace combustion air, biomass integrated gasifier combined cycle, and municipal solid waste.

1. Combined Heat and Power and Waste Heat Recovery.

Some manufacturing facilities may choose to make their own power by burning natural gas, or a similar gas, in either a turbine or reciprocal engine, and recovering the off-gas sensible heat in the form of hot water or some other process fluid. This configuration is commonly referred to as combined heat and power (CHP). In addition to recovering the waste heat, CHP has the advantage of generating power when needed and is independent of electrical grid operation or pricing. Waste heat recovery such as hot stack gas from steel, aluminum, or glass manufacturing processes can also provide a source of power. The widespread local use of CHP and waste heat recovery may shift the balance between electrical grid supply and demand and influence how power generators choose to make power. Overall, the use of local CHP and waste heat recovery units will minimize electrical transmission line losses, which will ultimately decrease the demand on large power generators.

Greater use of combined heat and power (CHP) and waste heat recovery (WHR) provide a significant opportunity to improve the competitiveness of manufacturing while improving the environment, increasing reliability of the grid and reducing transmission losses. CHP/WHR technology allows a manufacturer to recycle waste heat to produce steam and/or power that potentially lowers steam and/or electricity costs and reduces indirect emissions of GHGs and criteria pollutants. The power produced can be used internally or sold to the electricity grid. For perspective, CHP can operate at upwards to 70 percent energy efficiency rates versus about 32 percent for base load power plants. Today almost 9 percent of electricity is produced this way. The Oak Ridge National Laboratory report of December 1, 2008 indicates that if the United States adopted high-deployment policies to achieve 20 percent of generation capacity from CHP, by 2030, it could save an estimated 5.3 quadrillion Btus (Quads) of fuel annually, the equivalent of nearly half the total energy consumed by US households. Such policies could also generate $234 billion in new investments and create nearly 1 million new highly –skilled technical jobs. CO2 emissions could be reduced by more than 800 million metric tons (MMT) per year, the equivalent of taking more than half of the current passenger vehicles in the US off the road. In this 20 percent scenario, over 60 percent of the projected increase in CO2 emission between now and 2030 could be avoided.

2. Low Temperature Heat Recovery.

Industries emit large quantities of low-temperature energy in off-gases. This energy could be captured and recycled back into the process to reduce fuel consumption or produce power. A common industrial practice is to recover the sensible heat of high-temperature furnace off-gases by passing them through a recuperator or heat exchanger. The recovered energy is usually put back into the process by preheating gaseous fuel, combustion air, or feed materials. A challenge in recovering low-temperature energy is the small temperature difference between the warm fluid and the ambient temperature. The "Organic Rankine Cycle" is an example of a technology being developed for recovery of low-temperature energy. The "organic" working fluid of the system has the characteristic of vaporizing at about 300°F and may be pressurized so that it can turn a turbine to produce power. After the turbine, the fluid is condensed and cycled back to the vaporizer in the waste gas stream.

A potential breakthrough technology for waste heat recovery would be the development of an economical, corrosion-resistant material that has favorable heat-transfer characteristics. Such a material would allow more energy to be recovered from combustion waste gas streams.

3. Use of Oxygen to Supplement or Replace Combustion Air.

Most furnaces or heat-generating processes use air to provide oxygen to support combustion. Systems that use oxygen rather than air to support combustion have significantly lower NOx concentration in the off-gas, consume less fuel, and require less energy to process and control the lower exhaust gas volume. The fuel savings associated with oxygen combustion are significant and may be as high as 50% depending upon the system. Since less fuel is consumed, emission of CO_2 and other greenhouse gases is lower. However, the reduction in GHGs from using oxygen should be compared to the amount released in the production of the oxygen to determine if the overall process results in a net reduction of GHG emissions.

The use of oxygen to support combustion is not widespread primarily because of the cost of producing oxygen. Large separation plants are the most economical means of generating oxygen from air for larger industrial users. For relatively small users, liquid oxygen can be delivered to facilities by truck, stored as a liquid, and vaporized to feed a process. A potential breakthrough technology would be to develop a low-cost oxygen generation process.

4. Biomass Integrated Gasifier Combined Cycle.

This technology extracts energy from biomass in a very efficient manner. The gasifier produces a gas containing mostly CO and H_2 at an elevated temperature. The gas may need to be scrubbed to remove particulate matter before being fed to a combustion turbine to produce power or used as a fuel source in a furnace. If the gas is passed through a turbine, the system captures the sensible heat from the turbine exhaust gases to heat water or some other process fluid.

The advantage of this process is that very little sulfur is emitted and the combined cycles promote efficiency. The process may be carbon neutral if the carbon factor assigned to the biomass is zero.

The process disadvantages are the transportation cost of biomass from the source to the gasifier and handling the gasifier ash, which may be alkaline. The bulk density and energy content of biomass are both less than those of coal which means more material must be transported to produce the same energy output.

5. Municipal Solid Waste (MSW) or Sewage Sludge Gasification Combined Cycle.

The MSW gasification combined cycle concept is similar to the biomass integrated gasifier combined cycle. The practice of incinerating MSW and sewage sludge to produce power (and avoid landfilling) is used throughout the country. Many of these plants were built in the 1990s as landfill space became expensive and the electrical market seemed poised to take off. A primary concern of MSW incinerators is the need for elaborate off-gas cleaning systems. MSW always contains a small amount of chlorine that can combine with products of incomplete combustion to form dioxins and furans, which are regulated substances. MSW may also contain metals that may be vaporized or remain in the bottom ash, complicating the disposal of the solid by-products. As the cost of landfilling has remained the same or eased, demand for electrical power has subsided, and cost of cleaning the off-gas has remained high, MSW incineration remains an expensive option for producing power.

In summary, industrial power consumption has been decreasing about 3% per year as industry has been implementing many of the ideas presented above. Nonetheless, there continues to be the need for breakthrough technologies that will significantly reduce the amount of power consumed. In addition, technology is needed to make a variety of fuels competitive from both a cost and environmental standpoint. A competitive environment for energy feedstocks is necessary to ensure that industry can thrive well into the future. Further investment in these and other technologies is needed to make this happen.

IV. ROLE OF INDUSTRIAL ENERGY DEMAND IN A CARBON-CONSTRAINED WORLD

A. Effect of Energy Efficiency

Like most nations the U.S. is using energy more efficiently. These trends are the result of improvements in processes that consume energy, the introduction of new technologies, and changes in the structure of the U.S. economy. All are a response to higher energy prices. In 2009, the U.S. used only 55% of energy per dollar of GDP relative to 1980. The manufacturing sector followed a similar but even steeper trend, using only 45% of energy per unit of output in 2009 relative to 1980.

Trends in natural gas intensity generally follow total energy use, with gas consumption per dollar of GDP in 2009 just 41 percent of the 1980 level[9]

- Total gas use per dollar of GDP declined at a 1.9% rate from 1990 to 2000, but accelerated to a 3.9% decline between 2000 and 2009[10]
- Industrial gas use per unit of output (IP) declined at a 3.0% rate from 1990 to 2000, but this decelerated to 1.9% between 2000 and 2009. However, 2007-09 has seen an uptick as low 2009 prices brought back some energy intensive industrial demand, and lower capacity utilization rates fostered less efficient energy use.[11]
- The chemicals sector is the largest industrial consumer of natural gas, followed by petroleum refining and food industries.[12]
- Use of gas as a feedstock (nonfuel use) in chemicals has declined, but this was due to the rise in natural gas prices, causing some off-shoring of nitrogen-based fertilizer manufacturing, and resulting in the U.S. importing over 55% of its nitrogen fertilizer, more than twice the amount imported in 1992.

U.S. industry also is using electricity more efficiently.

- Manufacturing is becoming more electricity intensive, but purchased electricity intensity is lower because of onsite generation and cogeneration.
- Industrial electricity purchases per index of output (IP) declined at a 2.4% rate from 1990 to 2009. This decline decelerated to 1.5% in the period since 2000.[13]
- Industrial use of all energy per index of output (IP) declined at a 2.8% rate from 1990 to 2009. However, the 2000-09 rate decelerated to 1.7%.[14]
- Chemical manufacture is the largest consumer of electricity, followed by the primary metals industries such as iron, steel, and aluminum.[15]
- Paper manufacture is the largest use of self-generated electric power due to the availability of black liquor and bio-waste by-products.

Future efficiency gains are dependent on the adoption of new technologies, fuel prices, and industrial policies. The AEO 2010 Reference Case estimates that industrial sector gas intensity will decline at an average annual rate of 1.5% between 2010 and 2035, based on value of industrial shipments. Conditions that result in the largest improvement from 2010-2035 are the tight shale case (highest gas prices) and the high macro case. The least improvement occurs in the low macro case. The preliminary AEO 2011

Reference Case also forecasts continuing efficiency gains in the industrial use of natural gas, but at a lesser pace. The AEO 2011 industrial gas intensity declines at an average annual rate of 0.9%, 2010 – 2035. A more moderate price outlook is the probable driver. The 2010 – 2035 rate of industrial gas price increases lessens in the new study to 3.8% from 4.7%,

For electricity, trends in future efficiency are smaller than for natural gas because of the change in the structure of the U.S. industry and the substitution of electricity for other fuels. Between 2010 and 2035, the AEO 2010 Reference Case estimates industrial sector electricity intensity will decline at an average annual rate of only 1.3%. Sensitivities show that the highest improvements in power use intensity are for the High Macro and the Frozen Technology cases, while the High Tech case shows the least improvement. The preliminary AEO 2011 Reference Case has the electricity efficiency quickening more than the AEO 2010 case, with electricity intensity declining by an annual average rate of 1.5% per year 2010 – 2035. The industrial electricity price increases also moderate in the AEO 2011 forecast, but not as dramatically as natural gas, averaging 1.8% per year versus 2.3% in the AEO 2010 forecast.

B. Effect of Replacement of Carbon-intensive Fuels

The carbon intensity of natural gas is more than 40 percent less than coal when comparing CO2 emissions per million Btus. If financial or regulatory incentives arise to reduce carbon emissions, industries that use coal as a fuel would be more inclined to substitute natural gas for coal where economically, technically and logistically feasible. This would include electricity generators along with any industry that burns coal in a kiln, furnace, or boiler.

Natural gas power generation has the advantage of being quicker to respond to demand cycles. Installing natural gas generating equipment is more costly, however, compared to maintaining existing coal fired generating equipment. Another potential barrier to using natural gas is availability. Proximity to existing pipelines should ensure supply reliability, but some locations would require additional pipeline infrastructure to replace coal fired electricity generation.

Should industries decide to substitute natural gas for coal for fuel use, this could raise the demand for – and increase the cost of – natural gas. While tapping into new U.S. gas reserves would alleviate such problems, it is questionable whether this can be done in a quick enough or sufficient enough manner to keep the cost of natural gas steady. Indeed, if prices were to rise, certain trade vulnerable manufacturing industries in the U.S. would face serious economic injury, including the fertilizer and chemical industries. For instance, natural gas accounts for approximately 70 to 90 percent of the cost of producing fertilizer. Many U.S. chemical producers are similarly reliant on natural gas as a feedstock. Increases in natural gas prices directly increase their production costs.

Furthermore, a few industries also need carbon from the coal as part of the manufacturing process. For example, the aluminum industry uses carbon electrodes in the smelting of bauxite, aluminum oxide ore, to produce metallic aluminum. Similarly, the blast furnace method of making iron uses the carbon in the coke, a product of calcining coal, which is charged into the top of the furnace with the iron ore. It should be noted that iron oxide can be reduced with reformed natural gas and melted in an electric furnace. However, the equipment required for gas-based iron making is expensive and is not currently widely used in North America because the current price difference between coal and natural gas is not great enough to encourage a switch.

C. Factors Impacting Industrial CO_2 Emissions

The competitiveness of the industrial sector and the resulting economic activity will be a primary determinant of the overall level of industrial CO2 emissions. For example, eroding competitiveness, partly because of high energy prices, resulted in industrial carbon emissions declining from 2000 to 2007. Manufacturing output growth slackened while energy intensity in the industrial sector declined. But the bigger reduction of emissions occurred during the 2007 to 2009 recession when industrial activity contracted (Figure 12)

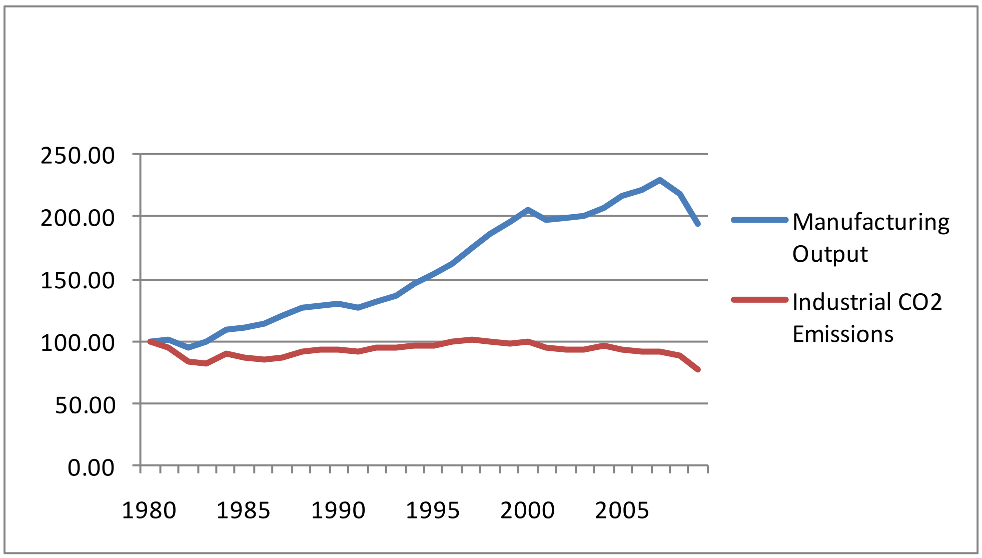


Figure 12. Manufacturing Output and CO2 Emissions

Projections of industrial CO2 emissions are included in the AEO 2010 Reference Case. Forecasts of industrial CO2 emissions are nearly flat following a post-2010 recovery as manufacturing growth is offset by continuing energy efficiency gains (Figure 13).

The largest variances of CO2 emissions around the Reference Case involve the high and low macro cases, where basic assumptions of GDP, labor force, and productivity growth are altered. Extreme cases of CO2 emissions in the industrial sector range from a resurgence to 2000 emission levels in the High Macro case, to a decline to below 2009 recession levels in the Low Macro case. Scenarios measuring the impacts of shale gas availability and technology advancement have relatively muted impacts on the overall level of industrial CO2 emissions.

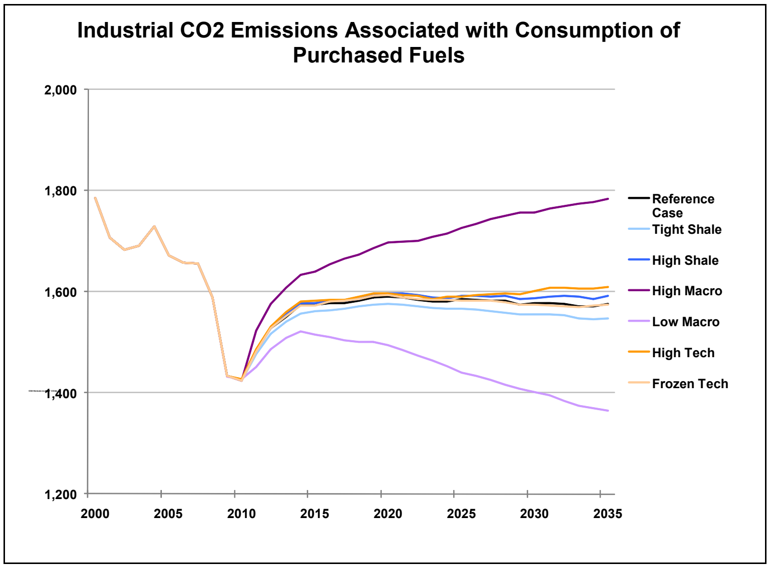


Figure 13. U.S. industrial carbon dioxide emissions associated with consumption of purchased fuels (2000-2035).

V. INDUSTRIAL ENERGY DEMAND AND NATIONAL SECURITY

During the last three decades, the trend toward expanding to what has become known as the global economy has been very dominant. The strong drive for opening new markets along with the freedom to move investments and capital around the world has undermined and weakened the American manufacturing base at home including industries that are very sensitive to national security. Since 2001, 26% of the 2.5 million jobs employed by the high tech sector have disappeared to other countries. Even the current export control rules are not adequate to fully protect national security, which promoted Defense Secretary Robert Gates to Declare " its rules, organizations, and processes are not set up to deal effectively with those situations that could do us the most harm in the 21st Century. We need sensible policy that guaranties our security but does not burden legitimate exports."

Robert Baugh, Executive Director of the AFL-CIO Industrial Union Council, testified on September 22, 2010 before the House Committee on Oversight and Reform Subcommittee on National Security and Foreign Affairs. The subject of the testimony was the effect of the decline of the American manufacturing base on both the economic security and national security. Mr. Baugh reported that during the last 10 years 57,000 manufacturing facilities have shut down. Since the boundaries between the defense industries base and the commercial manufacturing sector are blurred, the closure of these 57,000 facilities would force the US defense sector to rely on products manufactured in foreign countries.

In 2005, the National Research Council (NRC) study identified the following materials as important to national security: biomaterials, ceramics, composites, magnetic materials, metals, electronics and optical-photo materials, superconducting materials, polymers, and catalysts. The same NRC study concludes that the slow disappearance of the manufacturing of these critical materials is contributing to the decline of R&D activities in the U.S. The U.S. trade policy has created the business environments for companies such as Intel, Applied Materials, and other advanced technology firms to announce new huge investments in R&D and production facilities in China. In 2009, our trade deficit in advanced technology with China stood at $73 billion while we ran a $17 billion surplus with rest of the world. The other trend in the U.S. trading pattern is that the top fifteen imports from China are finished products and parts while the top fifteen U.S. exports are waste products such as aluminum, ferrous and copper scrap.

Among others, Mr. Baugh recommended the following actions to help the U.S. protect its national security and economic viability:

- Eliminate tax incentives for outsourcing and off shoring production and increase tax incentives for making stuff here
- Increase investments in large infrastructure projects. According to the American Society of Civil Engineers, the U.S. has a $2.2 trillion of unfunded infrastructure deficit.
- Invest in maintaining the U.S. global energy leadership in renewable technology, nuclear and advanced coal technology.
- Increase investment in the development of a skilled workforce.

VI. CANADA

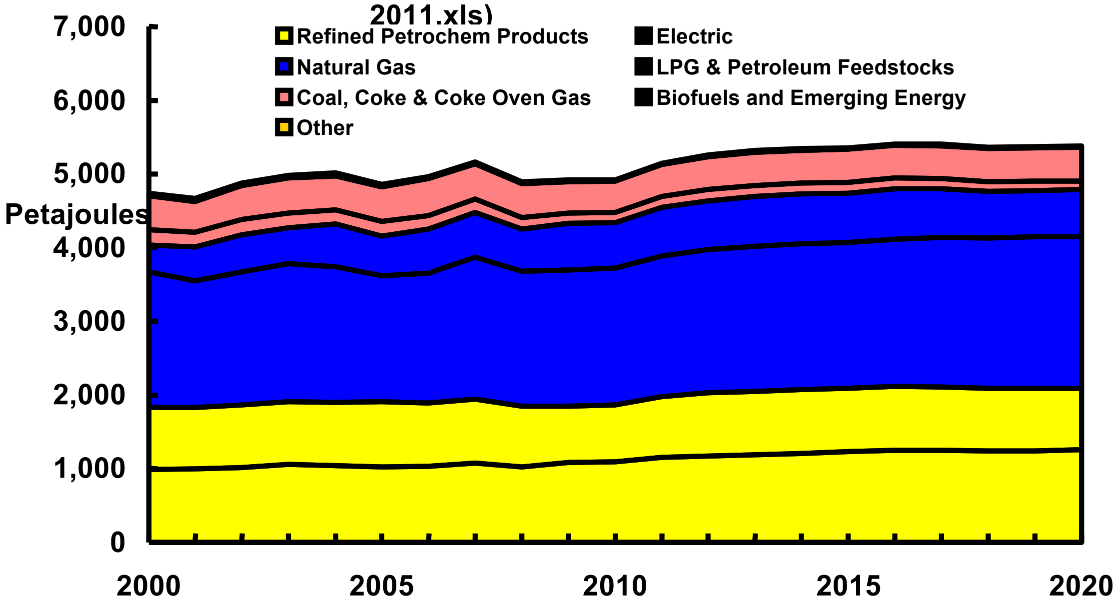
A. Canadian Industrial Natural Gas and Electricity Demand

Note – This section is primarily derived from the Canadian National Energy Board (NEB) publication: *Energy Briefing Note: Industrial Energy Use in Canada Emerging Trends,* November 2010.

Natural gas accounts for about 40% of the industrial sector fuel and electricity accounts for about 15%. Energy demand growth is always difficult to forecast in Canada, where all the major industries depend heavily on exports. The general state of the world economy, therefore, has a major influence on the Canadian energy consumption. The Canadian National Energy Board (NEB) is forecasting slower growth between 2008 and 2020 than seen historically. The principal reasons for this are increasing global competition in commodity markets and a higher Canadian dollar.

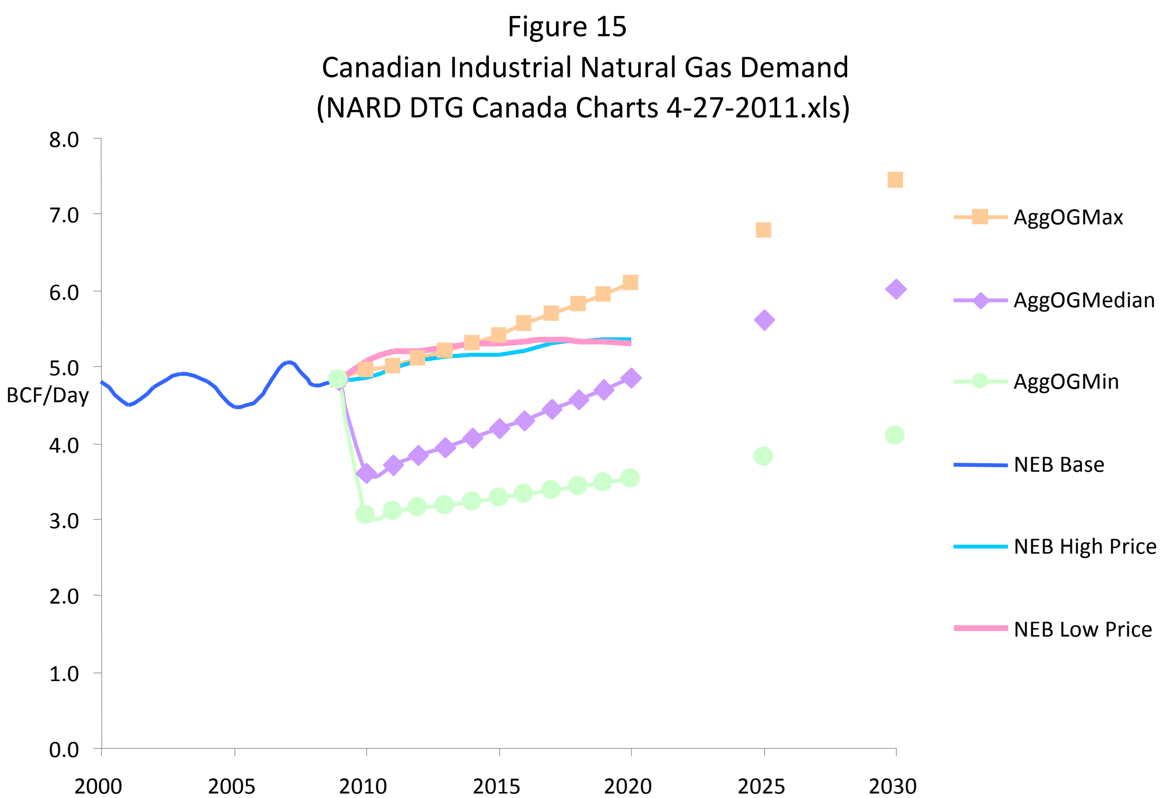
Given the above, the NEB believes that industrial energy demand will increase at an average rate of 0.8% annually between now and 2020. The natural gas share is expected to remain near 40% of the energy mix. No major fuel switching trend is seen in the next 10 years. (Figure 14)

Figure 14
Canadian Industrial Energy Demand
(NARD DTG NEB 5-2-2011.xls)



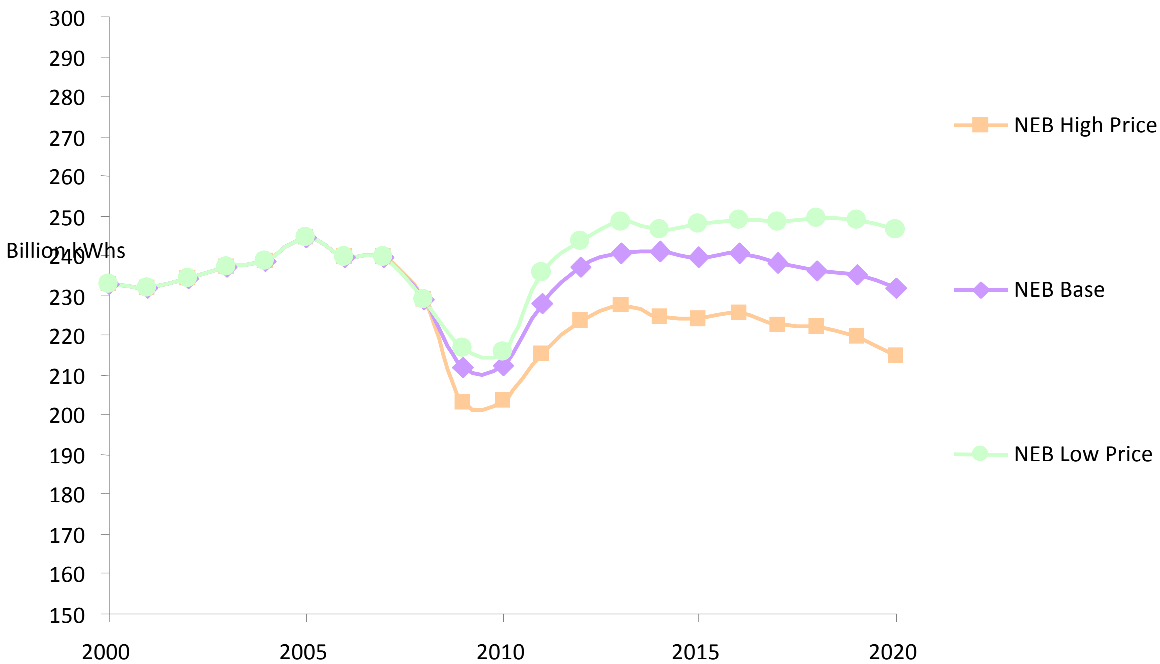
Source NEB 2009 Reference Case

The proprietary aggregated oil and gas company outlooks for Canadian industrial demand show a wide range compared to NEB outlooks. (Figure 15) The difference may be caused by where natural gas demand that is related to oil sands development is shown. The NEB includes oil sands demand for natural gas under plant fuel whereas other forecasters usually classify it as industrial demand.



The NEB outlooks for industrial electricity demand are relatively flat reflecting a slowing in the GDP growth rate and increasing value of the Canadian dollar. (Figure 16). Clearly, the recent recession caused a major dip in industrial electricity demand.

Figure 16
Canadian Industrial Electricity Demand
(NARD DTG Canada Charts 4-27-2011.xls)



Natural gas demand related to producing oil sands is expected to be the single biggest source of growth in Canadian natural gas demand. According to NEB, natural gas use in oil sands is expected to double between 2008 and 2020. By then it could account for approximately 10% of all industrial natural gas use in Canada. The Unconventional Oil Subgroup of the Resource and Supply Task Group estimates that oil sands natural gas demand could grow from 1.6 Bcf/d in 2010 to range of 2.6 to 5.2 Bcf/d in 2035. (Table 1)

Table 1
NPC Resource and Supply Task Group: Unconventional Oil Sub Topic Paper
[NARD DTG Oil Sands Demand 5-2-2011.xls]

Oil Sands Forecast (mbd)

	2010	2020	2030	2035	2050
High	1.5	3.3	5.1	6.0	8.0
Middle	1.5	2.7	3.9	4.5	5.0
Low	1.5	2.1	2.7	3.0	

Natural Gas Demand for Oil Sands (Bcf/d)

	2010	2020	2030	2035	2050
High	1.6	2.9	4.5	5.2	6.9
Middle	1.6	2.4	3.5	4.0	4.4
Low	1.6	1.8	2.4	2.6	

Source NARD RTG

The NEB expects industrial consumption of gas to grow 10.9% over the ten year period from 2010 to 2020.[16] This is a bit more than the total gas consumption growth for all Canadian demand outside of generation which is 10.0% (if generation is included, the gas demand growth is 14.0%). From the same data set, the industrial growth in electricity demand over ten years is 9.2% (slightly less than the 10.5% growth expected in total demand).

B. Canadian GHG Legislation Impacting Industrial Demand

Legislation or regulation that impacts energy costs will impact industrial demand. The following is brief summary of Canadian efforts to regulate GHG emissions.

The Canadian federal government currently has no measures actually in force for large GHG emitters. The federal government has full legislative authority to impose regulations on GHG emissions under emission intensity or cap and trade systems. This authority comes under the Canadian Environmental Protection Act (CEPA), which is roughly equivalent to the EPA. At Copenhagen, former Environment Minister Jim Prentice committed to reduce emissions 17% by 2020 relative to 2005 levels for all Canadian GHG emissions. However, since Copenhagen, the Canadian government has said it will only take broad measures once the United States sets a clear path. In the interim, the federal government has taken narrow, targeted measures including tougher emissions standards for cars and trucks to mirror the United States.

On June 23, 2010, the Canadian Government announced a proposed regulation requiring all coal-fired electric power plants to switch to natural gas or equivalent fuels based on capital stock turnover It is probable that the federal government may eventually defer regulation of GHGs at industrial facilities, other than oil and gas and electricity, to the provinces. Senior Canadian business leaders have raised concerns that this will lead to a fragmented regulatory approach. In consultation with industry, the government has stated that there needs to be special treatment for Energy Intensive Trade Exposed (EITE) Industries. Given that Canada is a resource based, export dependent economy, many industries other than oil and gas and electric power generation would qualify. As Canada is waiting on the U.S. to take action, the impacts on Canadian industrial consumption of gas and electricity are similar to that in the United States.

VII. OUTLOOK THROUGH 2050

A. Natural Gas Can Positively Impact Industry

The continued development of hydraulic fracturing will allow for the economic extraction of large quantities of natural gas from shale gas reserves. With a reliable supply of cheap natural gas, the industrial sector, and energy-intensive manufacturing in particular, can grow in the United States. This would reverse the trend of over the last decade where production facilities were built elsewhere in part due to high energy costs.

The U.S. industrial sector can be revitalized into a thriving global competitor utilizing its resources including the tremendous supplies of natural gas. Growth in the industrial sector would help the government meet its objectives of economic growth, environmental protection, and national security.

This future can be achieved if political and regulatory uncertainty is resolved with respect to access to on and offshore natural gas resources. In addition, policies must be created to lower the high cost of doing business in the U.S., and to remove barriers to re-industrialization using cleaner technology and efficiency.

Without U.S. policy support, and in light of foreign government policies of strongly supporting their own industrial sectors, the U.S. manufacturing sector will likely continue in its decline. If the supply of natural gas is not reliable and competitively priced, key U.S. industries that utilize natural gas as feedstock – such as the fertilizer industry (which is essential for maintaining food and agriculture security) – may suffer through additional off-shoring of manufacturing plants.

B. Electricity Consumption

To reduce industrial consumption below recent historical levels would require one of three things; a new fuel option, new ultra-efficient technology, or a reduction in U.S. industrial production. While the third of these options is undesirable, neither of the first two is easily predicted. Many facilities have yet to adopt the current, off-the-shelf efficient motor technology, thus leaving ample room for improvement. The challenges for improving industrial motor systems have existed for many years.[17] Barriers include apprehension toward complex advanced technologies and the attitude of "it's just one motor". As we look to the year 2050, it is in fact possible to envision the slow change in culture regarding electricity, technology and the importance of environmental issues to compel a more efficient industry, but this will always be tempered by financial concerns and overall market demands.

VIII. RECOMMENDATIONS

With appropriate policies, there is an opportunity for domestic natural gas to spur growth in the industrial sector helping the government to meet its objectives of economic growth, environmental protection, and national security.

As a general matter, the industrial sector needs six things to thrive: low relative cost of energy; reliable delivery infrastructure such as adequate storage and pipelines; low regulatory and tax costs; regulatory certainty; low capital costs; and investment in next generation breakthrough technology. Federal and state energy and environmental policies should encourage competition between and among all energy sources. When there is competition, consumers benefit. The result is lower energy prices, increased reliability and low levels of volatility.

The following recommendations address each of the key drivers supporting industrial energy demand; economic growth, legislation and regulations, carbon policy, and technology. Although price is not explicitly broken out, it is embedded in the recommendations for the other key drivers.

A. Economic Growth

1. Encourage the industrial sector to invest in energy efficiency - in the U.S. – by lowering the cost of capital by providing grants, transferable investment tax credit and low cost loan programs.

Providing the industrial sector with grants, transferable investment tax credits and a low cost loan programs focused on energy efficiency projects would spur private sector investment in the U.S. (versus offshore), reduce energy consumption, improve competitiveness, reduce greenhouse gas emissions, and increase economic growth and jobs. Lowering the cost of capital improves the return on investment of energy efficiency projects and increases the potential for investment in large projects that otherwise would not occur.

B. Legislation and Regulations

1. Resolve political and regulatory uncertainty regarding access to offshore natural gas production.

Access to offshore natural gas and crude oil is essential for U.S. energy security. If political and regulatory uncertainties are not resolved as soon as possible, companies will have no choice but to shift their capital investment and jobs to other countries.

2. Resolve environmental, regulatory, and public opinion uncertainties around use of the fracturing process. Increase transparency.

There is a growing public concern about the environmental impacts of the fracturing process and chemicals used to produce natural gas from shale formations. Public confidence and trust must be significantly improved and increased transparency will be essential. Without public confidence, the natural gas reserve and production forecast will remain uncertain.

3. Markets should dictate demand for natural gas in the electric generation or transportation markets.

Policymakers should not provide mandates or incentives to increase demand for natural gas for the power generation and transportation sectors. If natural gas provides an economic value to a given market, demand will occur naturally. In fact, since 2000, the vast majority of new power plants constructed use natural gas. (Figure 17) This has occurred without any special government incentives.

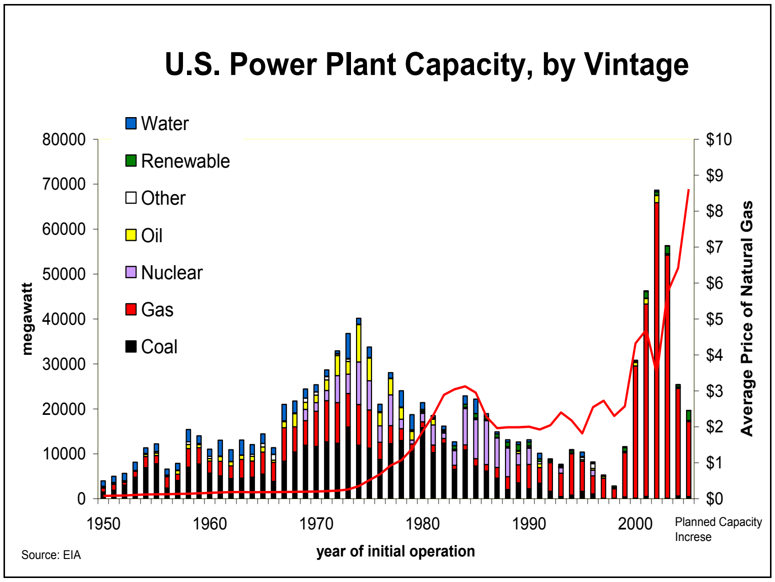


Figure 17. U.S. power plant capacity, 1950-2005.

It is disruptive to markets for policymakers to give advantages to one sector while penalizing another. It is also important for policymakers to be reminded that homeowners, farmers, and the industrial sector are all dependent upon the use of natural gas, and do not have economic alternatives. However, the electric power generation and transportation markets do have alternative sources of energy. Policy that increases demand for natural gas has the potential to increase the price of natural gas and electricity for all home owners, farmers and the industrial sector.

C. Carbon Policy

1. Energy-intensive, trade exposed industries should be exempt from a carbon price (and other environmental externalities) added to the price of the energy until such time that there is a global climate policy.

Environmental externalities increase the cost of energy and negatively impact global competitiveness. Such costs would not be absorbed by offshore competitors and would give them a competitive advantage, endangering U.S. jobs. When carbon and energy costs go up with time, less capital is available to invest in energy efficiency. Energy-efficiency projects become more and more expensive because the more immediate projects have already been done. This also means that energy efficiency improvement will not be able to neutralize the negative economic impact of higher energy/carbon costs, including higher costs for nonfuel use of primary fuel products, such as the use of natural gas as feedstock. The cost of carbon will also drive investment in projects to reduce carbon in lieu of projects that increase production. Higher costs by adding externalities leads to an industrial sector that is not sustainable.

2. The federal government should not create mandates or incentives that will result in the shutdown of coal-fired power plants.

The federal government should not determine whether a coal-fired power plant runs or not. The premature shut down of existing coal-fired power plants could result in the development of stranded assets (stranded costs) that would increase the price of electricity to ratepayers like the industrial sector. Today, coal-based power still satisfies over 40% of the nation's demand. Higher energy costs will result in the loss of global competitiveness. If gas remains plentiful and affordable, it will naturally compete with coal as it has done so for the past 25 years with clear history of growth in gas demand. Attempts to increase the rate of substitution from coal to natural gas before equipment and infrastructure is available to meet the additional demand could create natural gas price spikes that result in the loss of needed manufacturing jobs.

3. Federal and state policies should be enacted to encourage cost-effective recycling.

Recycling of energy-intensive products such as paper, steel, aluminum, glass, solvents, asphalt, concrete, and plastic is a very powerful tool for reducing energy consumption, greenhouse gas emissions, pollution and wastes. In 2009, the estimated avoided greenhouse gas emissions from recycling activities totaled over 142.2 million metric tons of CO_2 equivalents. This is the equivalent of the CO_2 annually emitted by 30.6 coal-fired power plants or the electricity used by 19 million homes in one year. The greenhouse gas emission reduction constitutes approximately 5% of the entire U.S. carbon inventory.[18] Despite these significant gains from recycling, there are still significant quantities of these products that are not recycled each year. Federal and state policy should develop policy that encourages cost-effective recycling.

D. Technology

1. Encourage industrial sector investment in RD&D breakthrough technology by providing full expensing of investment costs and increasing the funding of the DOE Industrial Technology Program.

The long-term key to revitalizing the industrial sector and enabling them to compete globally in a carbon-constrained world is the development of new breakthrough process technology for the energy-intensive industrial sector. Meeting target 2050 emissions levels is virtually impossible for current industrial processes without new breakthrough technologies. Long-term and high-risk research is too expensive for companies to do by themselves without matching grants by the public sector. The combination of full expensing of RD&D costs and increasing the DOE Industrial Technology Program from $100 million to $500 million would greatly increase the speed of technology development.

2. Remove federal and state electric utility regulatory barriers to significantly increase the use of combined heat and power (CHP) and waste heat recovery in the industrial sector.

Fully utilizing industrial waste heat to produce additional steam energy and power should be a top priority for the country. Doing so reduces energy consumption and air and carbon emissions, while increasing the supply stability of the grid, and improves the competitiveness of the industrial sector. Depending on the fuel used, CHP can produce power with energy efficiencies from 55% to 85%, while base load electric utility generation efficiency is only about 32%. Federal and state laws should be changed to allow for the full utilization of industrial waste energy. A major impediment to CHP and waste heat recovery project development are policies limiting market access, fair pricing, and access to longer term contracts. Greater flexibility is also needed to allow manufacturing facilities to sell power to one another.

3. Power produced from CHP or industrial waste energy should qualify as "renewable" under all state renewable electricity standards.

The produced power can be utilized internally by the industrial facility or sold to the grid at competitive prices.

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